

ORIGINAL ARTICLE

How do grand challenges determine, drive and influence the innovation efforts of for-profit firms?

A multidimensional analysis

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Abstract

While raising concerns, the recent proliferation of *grand challenges* has sparked interest in the role played by innovation in causing them, and in how the attempts made to fix them may cause even greater challenges that present themselves down the line. This article provides an analysis of the bibliographic metadata, published between 2002 and 2020, focusing explicitly on the private-for-profit sector. By identifying common themes from 66 documents, a framework highlighting the shared concerns and research trajectories was derived. Our results are illustrated and discussed along 11 research themes. We contribute theoretically by identifying the innovation efforts of for-profit firms that directly relate to grand challenges, through two cases of carbon capture and storage and deep-sea mining. We conclude that a more holistic understanding of innovation and its many possible consequences needs to be developed. We highlight the limitations of perspectives that do not always take full account of the potential divergence of interests between stakeholders, and, how fuller input by a greater cross-section of stakeholders may help identify any negative effects of innovations at an earlier stage. Informed by recent extensions of social innovation theory, we explore the potential for synthesis around a pragmatic understanding of institutions, stakeholders, and the nature and quality of ties that bind them.

KEYWORDS

for-profit firms, grand challenges, innovation, systematic bibliometric analysis

1 | INTRODUCTION

Grand challenges—defined as phenomena that typically transcend national boundaries, but may be potentially resolved through science, technology, and innovation—

have been garnering growing interest (Buckley et al., 2017). Their solution involves governments, private firms, and forms of cooperation between the public and third-sector organizations (Buckley et al., 2017). The relationship between grand challenges and innovation plays out in one

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of two ways that are not necessarily mutually exclusive: Exogenous challenges that may inspire innovations suited to deal with them, and innovations that may have unforeseen consequences resulting in new challenges.

In explaining firms' success in tackling grand challenges, the strategy literature focuses on their innovative performance (Calof et al., 2020; Mahto et al., 2020). However, the notion of innovation has moved beyond the traditional concepts of incremental or radical product and process innovation. Although these are still relevant, for-profit firms innovate along other dimensions, involving business models and different forms of relations with communities and societies at large. This includes the support of the host national and regional governments (e.g., via meaningful innovation policy), civil society, NGOs, supranational organizations, and of the capabilities of for-profit firms, small or large, that will enable long-lasting positive effects on the societies in which the firms and organizations operate.

The management literature (Bina et al., 2017; Tuazon et al., 2021; Yaghmaei, 2018) has hitherto mostly focused on multistakeholder firm initiatives in explaining why and how firms come up with solutions suited to tackle grand challenges, and what may stand in their way (Arslan et al., 2020; Forliano & Franco, 2020). Last but not least, the innovation-policy literature offers the most detailed studies on the particular innovative solutions aimed at tackling grand challenges across different industries and sectors (Fagerberg, 2018; Hayter & Link, 2020; Santiago et al., 2020) and any unexpected blowback (Biggi & Giuliani, 2021). Thus, the extant literature is diverse and scattered, which gives rise to a pressing need to consolidate it. The theoretical literature on social innovation may be one way of facilitating such a consolidation.

The current *grand challenges* include environmental degradation, climate change, social upheaval, and pandemics, as well as economic inequalities and recurrent financial crises (Doh et al., 2021; Verbeke, 2021). This poses challenges for governments, organizations of all sizes, individuals, and other stakeholders and to their capacity to take effective action both individually and in conjunction (Doh et al., 2021). Since the 2008 global financial crisis, governments across many countries have committed themselves (with a varying degrees of success) on more broadly based economic development, with the aim of transforming their countries into more competitive, responsible, and sustainable participants in the global economy, even if others have sought to turn the clock back to recreate the boom years of the market liberalism of the 1980s. These efforts have come on the back of government policy initiatives that encompass environmental, economic, cultural, and social standards in order

Practitioner points

- We highlight the differences in the innovation efforts of for-profit firms that directly relate to grand challenges, and how they might be analyzed and understood by portraying a case of carbon capture and storage and deep-sea mining by businesses.
- We also significantly contribute to uncovering what may constitute sustainable activities conducted by multinational enterprises, linked to their capacity and relative willingness to contribute to national development. Such contributions are claimed via the transfer of superior technology, innovation, and knowledge assets, and in deploying these to help ensure the enactment of sustainable practices and corporate social responsibility.
- At the macro level, we explored both the positive and negative impacts of the technological fixes of grand challenges. At the macro and meso levels, we introduced and explored institutional constraints and enablers of innovation. At the micro level, we explored when and how organizations respond to grand challenges, and why innovation in some areas may be matched by inertia in others.

to foster sustainable and innovative business practices suited to help in the fight against grand challenges.

The wide-ranging management and international business (IB) literature has increasingly focussed on the relationship between firm innovation, internationalization efforts, and grand challenges by means of research that is mostly based on qualitative methods and case studies (Ye et al., 2021); any good news is typically tempered by problems in operationalization and wider dissemination. However, recent accounts have taken a more quantitative perspective (Arslan et al., 2020; Sokolov et al., 2019). In this context, significant contributions lie in uncovering what may constitute sustainable activities conducted by multinational enterprises (MNEs), linked to their capacity and relative willingness to contribute to national development. Such contributions are claimed via the transfer of superior technology, innovation, and knowledge assets, and in deploying these to help ensure the enactment of sustainable practices and corporate social responsibility (CSR) (Kim et al., 2018).

For example, studies have highlighted instances of MNEs solving institutional weaknesses and voids (Khanna & Palepu, 2004) by offering goods services in

the infrastructure sector, education, and healthcare services as well as providing better environmental and labor practices. Kolk (2016) argued that MNEs are able to simultaneously be profitable and law-abiding, ethically and both directly and indirectly providing wider benefits to other stakeholders in a host region (see the review conducted by Kolk, 2016). However, this may also set things back through an excessive focus on short-termism in relation to value extraction, and involve the aggressive deployment of nonmarket strategies in order to undermine more principled competitors. In doing so, the “wrong” sorts of innovations may be deployed—that is, those that may enrich the firm, but impose unacceptable collective costs, or be designed to hamper the adoption of sustainable innovation by others (Biggi & Giuliani, 2021).

Here, the literature highlights the imposition of relentless cost-cutting on suppliers, which may result in recourse to the sweatshop production methods associated with the early 20th century in place of more advanced production paradigms (Baglioni et al., 2020). Again, the adoption of technology may help increase profits but also impose higher environmental costs and result in job losses, an example being automation in mining (Keenan et al., 2019). Hence, the literature has not only focussed on institutions, but has also explored the links between CSR, sustainable development, absorptive capacity, resource dependency, reverse knowledge transfer, global value chains, and production networks, which are part of an MNE's overall strategy to tackle grand challenges, or, indeed, opportunistic actions that may make things worse. These echo the previous theoretical concerns: on the relationship between stakeholders and contexts; the density of relational ties within settings; the possible divergence between the interests of firms and other stakeholders; the persistent usage of specific technologies after their costs outweighs their benefits; and the potentially ambivalent consequences of remedial actions (cf., van Wijk et al., 2019).

Research on innovative solutions aimed at tackling grand challenges also remains heavily focused on developed country contexts, and are depicted as models of best practice to be adopted by developing and emerging countries. Apart from the historically dismal environmental performance of developed countries, there is evidence that context-specific innovation is more effective in tackling the challenges of less developed countries. For example, Gold et al. (2013) portrayed and identified how sustainable supply chain management in the food industry can support for-profit firms in achieving their sustainability goals when poor communities are involved in their production processes. Similarly, Ansari et al. (2012) explored the ways in which for-profit firms can take a bottom-of-the-pyramid (BoP) approach to reducing

poverty by transferring social capital to those communities. By observing BoP business models in rural India, Sinkovics et al. (2014) uncovered how for-profit firms can learn to create social value. Locke et al. (2007) described how for-profit firms support their developing country suppliers in behaving more responsibly by improving their working conditions. Again, this would make the case for a closer look at what we know with respect to the developing world.

It has been noted that the vast majority of the extant studies have focussed on social enterprises and nonprofit firms, rather than on how the for-profit sector might improve its use of innovation (see, e.g., Kolk, 2016). Our review confirms this. Although the origins and rationales of nonprofit firms are more sensitive to environmental and social challenges, the shares of such firms in the populations of varied economies are very small. Therefore, a focus on for-profit firms becomes much more important and pressing in relation to understanding their links with grand challenges and how to tackle them within the firms' innovation efforts at the micro-, meso- and macro-levels. Hitherto, research has been classified or categorized to portray the evidence spread across the three levels. For example, we do not know whether macro-level studies outnumber meso- or micro-level ones, or vice versa. Therefore, the purpose of this article is threefold, as follows:

1. Making the case for and providing a systematic review of the interdisciplinary literature in order to document and map, for the first time, the existing knowledge base on the role that the innovation efforts of for-profit firms play in tackling grand challenges.
2. Reappraising the issues, opportunities, and pitfalls found in the innovation efforts made by for-profit firms directly in relation to grand challenges through the illustrative examples of carbon capture and storage, and deep-sea mining.
3. Linking back what the firm-centered literature tells us to the macro and meso theoretical literature on—or directly relevant to—innovation and grand challenges, as outlined in the opening paragraph of this article, with a view to contributing to the further development of theory.

In doing so, this article speaks to several areas of this special issue on innovation and firm responses to grand challenges. At the macro level, we explore both the positive and negative impacts of the technological fixes of grand challenges. At the macro and meso levels, we introduce and explore institutional constraints and enablers of innovation. At the micro level, we explore when and how organizations respond to grand challenges, and why innovation in some areas may be matched by inertia in others.

Utilizing the bibliometric technique, we summarize the empirical findings of the literature but also map the array of theories and models utilized by the various studies to underpin their findings of how innovation efforts are able to tackle grand challenges. These range from the resource/knowledge-based perspectives at the micro-level (Grin et al., 2018; Jensen, 2016; Kwakkel & Pruyt, 2015) to industry-specific and within-country-specific theories at the meso level, and to institutional and organizational culture-specific determinants across countries at the macro level. Our numerous findings cover both empirical and conceptual developments, which, in turn, partly originate in other disciplines/literatures. Knowledge of the interrelationships between literature strands and disciplines in regard to the relationship between innovation efforts and solutions to grand challenges offered us a rare insight into the complex nature of previous and ongoing research. From this, we draw a number of important implications for both theory and practice, as well as future avenues for research in several pivotal areas.

This paper contributes to the innovation and management literature in the following five distinct ways. The *first* contribution lies in the fact that it is the first to document, across several themes and disciplines, the evolving nature of the relationship between for-profit firms' innovation efforts and grand challenges. In doing so, it highlights where, how, and from which sources and origins the literature on this topic has emerged (i.e., the evolution and development of this important topic). Following more than a decade of diverse and mixed evidence, it is pertinent to have a systematic review article that shows the key linkages between the innovation activities, specifically conducted by for-profit firms in tackling grand challenges. The importance of this review lies in its consolidation of the evidence in order to uncover what is and what is not yet known, and any potential gaps in the literature. The *second* contribution lies in its multidimensional nature. More specifically, in the fact that it captures the evolution of the topic at five different levels of analysis ranging from (a) developed country versus emerging economies; (b) micro-, meso- and macro-level evidence; (c) interindustry evidence; (d) for-profit versus nonprofit firm evidence; and (e) inter-discipline evidence. The mapping of the evidence shows a rich and mixture of emerging, nascent, and mature, and fast-growing subdiscipline areas of research.

Its *third* contribution comes from the use of its findings to outline a number of important avenues for future investigation at the intersections of managing innovation, strategizing about innovation, innovating via business ethics and CSR, and various product/process innovation efforts in a quest to find solutions to in tackling the grand challenges that beset the world.

Its *fourth* contribution is in the way in which it portrays the complexities and nuances through a case of carbon capture and storage and deep-sea mining. In doing so, it brings to light the practical aspects of the 11 primary themes identified in the literature—that is, four base themes (national innovation policies and systems, sustainable development, social entrepreneurship and innovation, and transformative business models), two motor themes (corporate sustainability and stakeholder partnership), one transition theme (mission-oriented innovation policy), two niche or peripheral themes (complex technological solutions and employability and skill development), and two emerging themes (decision support systems and decision making and responsible research and innovation).

Its *fifth* and *final* contribution is in terms of developing theory, which it does by highlighting the limits and possibilities of innovation as a way of resolving grand challenges—and how we account for them in theoretical terms.

2 | METHODOLOGY

Our systematic literature review methodology leverages both the traditional content analysis and scientific bibliometric method in order to offer a more holistic review of innovation efforts and grand challenges (see Fetscherin & Heinrich, 2015; Sarkodie & Strezov, 2019). Bibliometric analysis has recently attained significant scholarly attention (Donthu et al., 2021; Vogel, 2012), and is well-recognized as a systematic and unbiased literature review technique (Zupic & Čater, 2015). It offers a systematic and rigorous assessment of a knowledge base by means of a multilevel strategy (Christofi et al., 2021; Turner et al., 2013), that is not just narrative or descriptive of selected literature. Bibliometric reviews evaluate and reveal the dynamic changes and evolution occurring in a given field of knowledge and further help in understanding the structure (exploration of themes and relationships between them) and leading trends of a knowledge base (Ghadimi et al., 2019; Lacka et al., 2020; Wang et al., 2019). Furthermore, this quantitative approach involves analyzing the bibliometric data of published literature by means of the relevant and valid application of statistical methods, which, in turn, helps in developing the knowledge map of a research field by capturing both qualitative and quantitative changes (De Bakker et al., 2005).

Bibliometric analysis thus helped us to visualize the entire innovation effort and the grand challenge research base in a for-profit business context from the perspective of its historical development, theoretical foundations,

and emerging themes. Our unique reviewing technique enabled us to uncover and map in detail how the cross-disciplinary literature strands have explored the relationship between innovation efforts and grand challenges and how they have developed to our current level of understanding, as well as to provide insights into the directions in which the literature is likely to head and develop henceforth.

In addition, our detailed screening yielded a few existing review articles found within the reliable and valid dataset in which we searched. Some notable ones, for example, were: a literature-based typology of mission-oriented innovation (Jütting, 2020); a review of the grand challenges pertaining to higher education (Nowell et al., 2020); and a review of the existing technologies in the food-energy-water ecosystem (Miao & Khanna, 2020). Whereas the latter two reviews (i.e., Miao & Khanna, 2020; Nowell et al., 2020) took a traditional approach, Jütting (2020) employed a bibliometric technique of literature review in pursuance of developing a literature-based typology of mission-oriented innovation. This reiterates the relevance of reviewing the extant innovation and grand challenges research by using structured and quantitative review techniques.

2.1 | Data retrieval process and data

The data for our analysis were retrieved from the Scopus® database by following the conventional wisdom pertaining to the data retrieval process for systematic reviews (Tranfield et al., 2003). Our data retrieval steps included; first, a clear and pre-planned identification of our aims and objectives; second, inclusion and exclusion criteria and methods; and, third, the manual screening and assessment of the selected data. The units of analysis for our review were research documents (i.e., journal articles, review papers, book chapters, books, editorials, conference papers, etc.) published within the selected research field. Hence, we retrieved the bibliometric data of all eligible and relevant research documents from the Scopus database. As a strategic choice, we chose Scopus over Web of Science as our primary and key source of our data as it is the largest multidisciplinary database of peer-reviewed literature within the social sciences domain (Bartol et al., 2014; Donthu et al., 2021; Norris & Oppenheim, 2007). Moreover, we also overcame any concerns about the quality of sources and research documents for this article by following a manual three-tier data screening process.

As the aim of the article was to analyze the entire body of research conducted within the innovation and grand challenges stream in the for-profit context, we first

developed the research objectives for the manuscript in order to develop the review protocol or strategy. The broad objective of this article was to bring together four distinct literatures and utilize any insights drawn from each to derive a map and framework suited to link them in explaining the innovation efforts made in direct relation to grand challenges. These research objectives and aims were the guiding force for our multitier data retrieval process. In the next section, we detail the data retrieval process, as shown in Table S1 and Figure 1 (please see online appendix).

2.2 | Data analysis

The retrieved data were analyzed using various bibliometric techniques such as keyword co-occurrence analysis, citation analysis, and historiography (Baker et al., 2021). More specifically, we conducted a performance analysis and employed knowledge mapping techniques following the conventional wisdom of performing bibliometric analysis (Donthu et al., 2021). Performance analysis techniques help in understanding the general description of a research field and these are popular techniques that measure the impact of various research constituents such as authors, sources, etc. (Cobo et al., 2011; Bamel et al., 2021). Science mapping techniques, which are mainly used to understand and unfold the conceptual and intellectual structure of a particular research field, include keyword co-word analysis, bibliographic clustering, and citation and co-citation analysis (Donthu et al., 2021). In terms of analysis, we used two open-source software packages: the Bibliometrix R package (Aria & Cuccurullo, 2017) and VOSviewer (van Eck & Waltman, 2010).

3 | RESULTS AND DISCUSSION

We show our results in two subsections. The first outlines the annual publication trends and the publication performance of the various constituents. The second shows the knowledge structure of the research field.

3.1 | Performance analysis of the innovation and grand challenges research

This section presents the general trends and a description of the research domain of innovation aimed at tackling grand challenges. We followed a protocol and retrieved the bibliometric metadata of 66 research documents. These documents included 58 research articles, 4 book

chapters, and 4 review papers published in 50 sources (i.e., journals and books). The publication timeline for these research documents was between 2008 and 2021. The citation average for these research documents was found to be 12.88 each. More details on the dataset are shown in Table 1.

Figure 2 (see online appendix) presents the annual publication trends in regard to innovation aimed at managing grand challenges in a for-profit context. It shows how the research stock in this field has grown with an annual rate of 27.65%. The first two articles dealt with issues of manufacturing technology (Manley et al., 2008; Molloy et al., 2009). Surprisingly, over the following 5 years, no research was published in this specific research stream; in comparison, research in the same

field in the not-for-profit and social sector streams increased substantially.

This observation allows us to draw the following conclusions. First, in the wake of the 2008 financial crisis, for-profit firms were viewed as unequipped or unwilling to deal with grand challenges, a perception confirmed by subsequent failures to take climate change seriously (Wright & Nyberg, 2017; cf., DesJardine et al., 2019). Therefore, there was little subject material to study. The second was that many micro-orientated studies had viewed external grand challenges in a very abstract sense and that the intrusion of major events, such as a global recession or depression, had transcended the analytical frameworks most in fashion at the time (Tourish, 2020).

The next article in this relevant field, which was published in 2014 in the journal *Business Strategy and Environment*, was on product innovation and energy efficiency (Gerstlberger et al., 2014). We observed that, from 2015 onwards, the number of publications had started increasing, with two articles appearing in 2015, three each in 2016, 2017, and 2018, eight in 2019, and more than four times as many (35) in 2020. As of March 2021, nine articles had appeared. This steep increase in the number of publications points to the increasing popularity of this research field.

Both management scholars and journals have become more receptive to more critical and ambitious accounts of trends in the global economic and physical ecosystem and of the role of firms in triggering and alleviating crises (Howard-Grenville, 2021). Also, the increasing consensus around issues led to much greater subject matter depth, such as climate change and the consequences of a long energy transition (Verbeke, 2021), which have been accompanied by an increasing volume of green innovations. Indeed, the research field has grown multifold and issues such as the use of crowdsourcing in tackling grand challenges (Cai et al., 2019; Porter et al., 2020); a value-sensitive absorptive capacity framework suited to solve grand challenges (Garst et al., 2019), are some key examples, as are risk translation and the ecology of risk (Hardy & Maguire, 2020); linking management theory with poverty alleviation (Kistruck & Shulist, 2020). Most of this research has been conducted by means of a case study approach; yet, the field is clearly growing fast.

Next, we identified the top 10 most impactful (most cited) individual studies in the field, as shown in Table 2. The most impactful article (Eisenhardt et al., 2016; 243 citations) was found to divide grand challenges into two distinct categories. The first included those that are discrete and have a clear closure, such as conducting a space mission to Mars or devising a new treatment for a particular malady. However, many grand challenges are much more open-ended, as they involve complex and

TABLE 1 Main information about the data set.

Description	Results
Timespan	2002–2021
Sources (journals, books)	50
Documents	66
Average citations per documents	12.88
Average citations per year per doc	2.806
References	5372
Document types	
Articles	58
Book chapters	4
Review papers	4
Document contents	
Keywords plus (ID)	140
Author's keywords (DE)	235
Authors	
Authors	174
Author appearances	181
Authors of single-authored documents	9
Authors of multiauthored documents	165
Authors collaboration	
Single-authored documents	9
Documents per author	0.385
Authors per document	2.6
Co-authors per documents	2.7
Collaboration index	2.89

Note: Authors: The authors' frequency distribution; Author appearances: The number of author appearances; Authors per document: The ratio between the total number of authors and the total number of articles; Co-authors per documents: Average number of co-authors per article; Collaboration index: Total authors of multiauthored articles/total multiauthored articles.

TABLE 2 Most impactful individual research in innovation for tackling grand challenges in a *for-profit* context.

No.	Title	Author and year	Journal	Summary	TC	TC/year
1	Grand challenges and inductive methods: Rigor without rigor mortis	Eisenhardt et al. (2016)	Academy of Management Journal	Inductive methods as most relevant methods while pursuing the research in grand challenging context	243	40.5
2	An inconvenient Truth: How Organizations Translate Climate Change into Business as Usual	Wright and Nyberg (2017)	Academy of Management Journal	Using grounded theory responds to the question that how and why corporate environmental initiatives deteriorate over time and develop a three stages model of corporate translation of climate change (framing, localizing, and normalizing for).	120	24
3	Frontiers in Green Chemistry: meeting the grand challenges for sustainability in R&D and manufacturing	Manley et al. (2008)	Journal of Cleaner Production	Promotion of Green Chemistry (an innovative, nonregulatory, economically driven approach toward sustainability) which is the design, development, and implementation of chemical products and processes to reduce or eliminate the use and generation of substances hazardous to human health and the environment	120	8.571
4	A multiagent competitive gaming platform to address societal challenges	Ketter et al. (2016)	MIS Quarterly	Utility of information systems innovation for developing a dynamic trading model for electricity consumption for promoting sustainable consumption of energy	44	7.333
5	Sustainable development strategies for product innovation and energy efficiency	Gerstlberger et al. (2014)	Business Strategy and the Environment	The paper develops three main areas of focus of new product development (efficiency considerations, market attention, and greening of innovation) for improving the energy efficiency of production facilities	43	5.375
6	Exploratory Modeling and Analysis, an approach for model-based foresight under deep uncertainty	Kwakkel and Pruyt (2015)	Technological Forecasting and Social Change	Use of system dynamics along with exploratory research design for in grand challenges research	38	5.429
7	How does a grand challenge become displaced? Explaining the duality of field mobilization	Grodal and O'Mahony (2017)	Academy of Management Journal	Answers the research question that when fields mobilized for a grand challenge, and what inhibits them from realizing	26	5.2

TABLE 2 (Continued)

No.	Title	Author and year	Journal	Summary	TC	TC/year
				their intended ambitions, using goal displacement approach in a nanotechnology field.		
8	Transformational business models, grand challenges, and social impact.	Martí (2018)	Journal of Business Ethics	Building a transformational business model based on the elements such as participatory forms of architecture; multivocal inscriptions; scaffolding; and proximity for addressing the grand challenges	23	5.75
9	Enhancing the role of human resource management in corporate sustainability and social responsibility: A multidimensional, multistakeholder approach to HRM	Stahl et al. (2020)	Human Resource Management Review	List the reasons why a firm's HRM failed in contributing the corporate sustainability and corporate social responsibility	17	8.5
10	Athena's birth: Triggers, actors, and actions preceding industry inception	Agarwal et al. (2017)	Strategic Entrepreneurship Journal	Details that what contribute to product commercialization and help in reducing the technological and demand uncertainties	15	3

Source: Authors analysis of bibliometric metadata of relevant papers retrieved from SCOPUS (October 2021).

seemingly intractable problems (Eisenhardt et al., 2016). In any event, grand challenges are multifaceted and defy easy solutions. This suggests that inductive approaches to theory building effected through qualitative methods may be particularly suited to better understanding such phenomena (Eisenhardt et al., 2016). In some manner, this challenges traditional enlightenment (and, later, Schumpeter [2017]) approaches to innovation and grand challenges, which are overly optimistic about the possibilities of easy fixes. Hence, there is a need for more evidence-based theorizing aimed at capturing the complexities and nuances of situations.

The second-ranked article (Wright & Nyberg, 2017), also published in the Academy of Management Journal, 120 cites, discusses how and why corporate environmental initiatives deteriorate over time. This article follows up on earlier work that had highlighted why sought-for-improvements diffuse unevenly and are often not widely adopted (Rogers, 2010). The third most impactful article proposed the idea, limits, and possibilities of green chemistry to meet the grand challenges of promoting human health and the environment (Manley et al., 2008); this is

in line with the broader theoretical accounts on this issue (Johnston, 2020). We view these articles as both seminal and milestones in studies pertaining to research on innovation aimed at tackling grand challenges. They also echo some of the wider theoretical concerns and controversies around grand challenges and innovation, but seek to link such meta-concerns to the practicalities of management and organizational life.

Next, to understand the role played by scholars in the evolution and growth of this research field, we identified and list the top 10 most productive researchers and their citation metadata—such as total citation, *h* index, *g* index, and publication/citation ratio (please see Table S2 in the online appendix). As the research field is in an evolving stage, only seven authors were found to have published two or more documents each; hence, we included three authors on the basis of the number of citations received by their single article. We would like to reiterate that an understanding of the most productive authors in a research field is essential as it helps in knowing how actively authors have engaged in a research field and their respective contributions to it. Moreover, such information is crucial in order to

understand the suitable outlets for research on innovation aimed at tackling grand challenges in a for-profit context.

Hence, we identified the top 10 such publication sources. These include the Academy of Management Journal (four publications); Journal of Business Ethics (four publications), Business and Society (three publications), and Research Policy (three publications). Thereafter, the list includes the Academy of Management Perspective, Australian Journal of Management, Journal of Cleaner Production, Journal of Industry Competitions and Trade, Local Economy, and Journal of Management Studies, all with two publications each. It is evident that this important topic is already being published in the top-tier journals within the business and management domain.

3.2 | Knowledge structure of the field

To understand the status and boundaries of the research base in the field of innovation aimed at tackling grand challenges in a for-profit context, we constructed the related knowledge structure. This details the ontology and taxonomy of a particular and relevant knowledge base, defined as the knowledge of how the concepts in a particular and relevant domain or field are interrelated (Jonassen & Wang, 1993). We performed an analysis of the bibliographic data, constructing a strategic map of innovation aimed at tackling grand challenges in a for-profit context using the Bibliometrix R package (Aria & Cuccurullo, 2017). Figure 1 shows the historiography or

historical direct citation network of the top 30 cited research documents.

3.2.1 | Strategic map of innovation for tackling grand challenges in a for-profit context

A strategic map is a two-dimensional graph based on two axes—that is, density and centrality rank values (Cobo et al., 2011). Centrality refers to the degree of interaction between various themes—that is the external strength—whereas density refers to internal tie strength among the keywords of a theme (Murgado-Armenteros et al., 2015). Thus, using a multidimensional scaling technique, we constructed a strategic map (see Figure 2)—that is, a four-quadrant matrix that visualizes the concepts in the research field (Cobo et al., 2011)—using the co-occurrences of each author's keywords from the research base (Aria & Cuccurullo, 2017). The technique employs natural language processing routines to extract terms from titles and abstracts and implements Porter's stemming algorithm to reduce any inflected (or sometimes derived) words to their word stem, base, or root form (Aria & Cuccurullo, 2017). We labeled the four quadrants as motor (upper right), base (lower right), peripheral themes (upper left), and emerging or disappearing quadrant (lower left). These quadrants include certain topics as clusters, based on their density (internal ties) and centrality (external strength) rank values, which are themes for further discussion (Cobo et al., 2015).

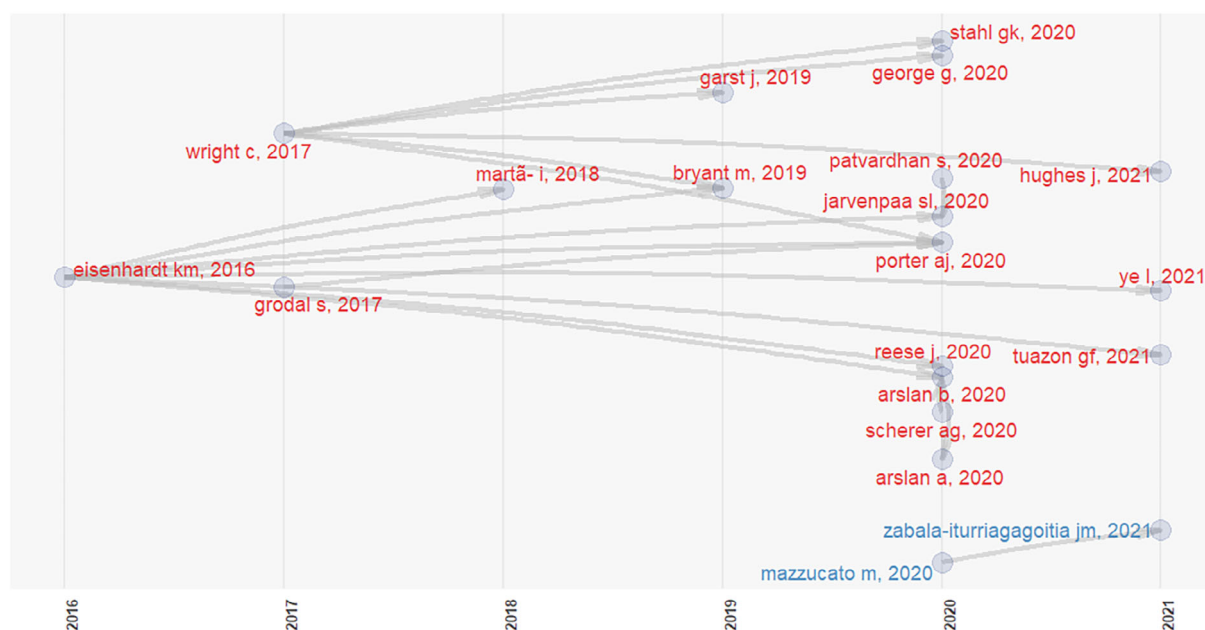


FIGURE 1 Historiography or historical direct citation network of top 30 cited research documents. Historical direct citation map reveals the direct citation of influential work in a periodic manner, that is, older to recent; the color code represents two major themes in present research domain.

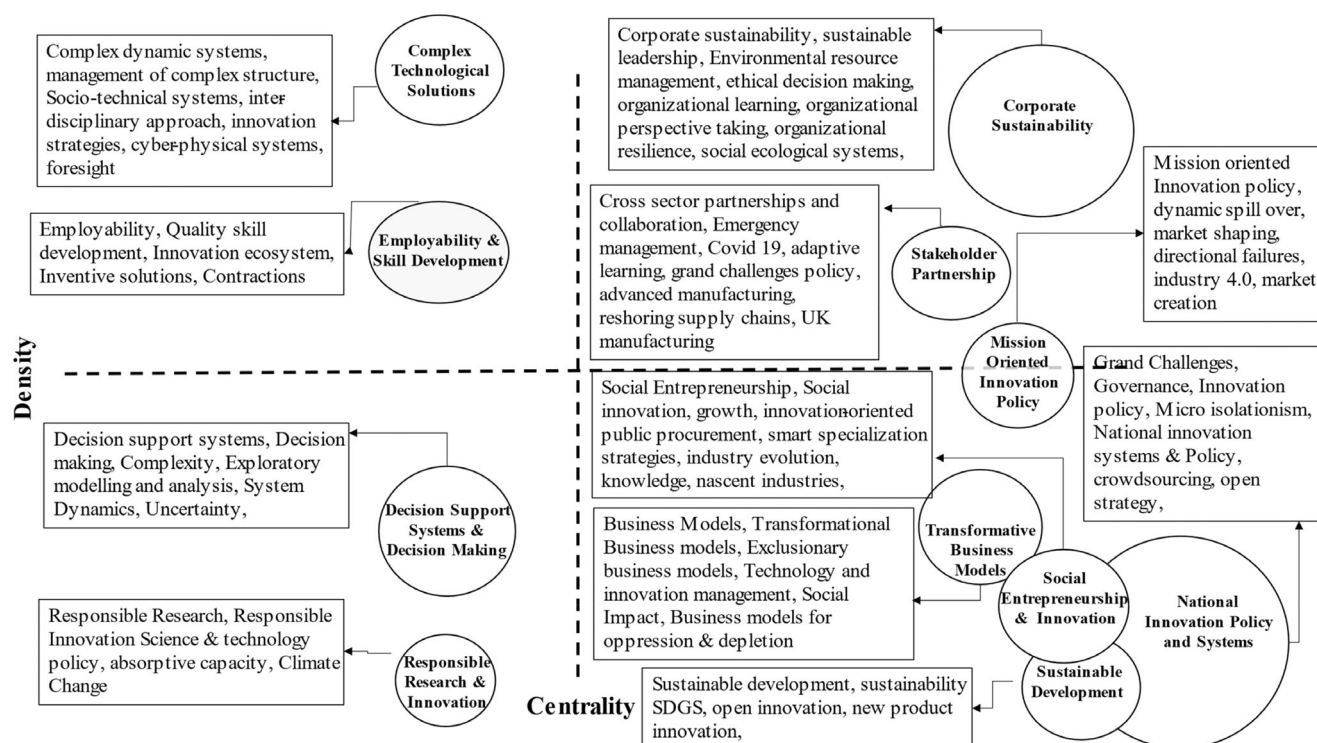


FIGURE 2 Strategic map of innovation for tackling grand challenges research in the for-profit context. Size of the circles represents the relative quantity of the research in respective theme.

Evidence from our strategic map suggests that innovation aimed at tackling grand challenges in a for-profit context involves 11 emergent themes (two motors; four bases; one peripheral, one emerging or disappearing, and one transformative from base to motor). These theme categories help in understanding the epistemological structure of our research domain (Giannakos et al., 2020). For example, motor themes—that is, those that have high degrees of centrality and density—are central and important to any research field. Such themes may be termed as the foundation of a research domain. Base themes, also called bandwagon themes, are central to a field but are not fully developed or require further research. Base themes are either past or are promising ones that may become motor themes in the near future. Base themes can better explain the nature of a research domain.

Peripheral themes have a high degree of density—that is, strong internal tie strength—but are, however, only loosely linked with the overall research field or the rest of themes. They are also called ivory tower themes, as they themes are highly specialized, overlap with other disciplines, and constitute autonomous sub-research fields within a domain, often promoting the diversification of a research field. Last are the emerging or disappearing themes. These are also known as chaotic or unstructured, as they have poor internal and external tie strengths. Over time, these either disappear,

move to the peripheral quadrant or become ivory tower themes. Alternatively, these themes move to the base quadrant and become bandwagon themes, depending on the research trends.

The research field exhibits two themes within the emerging quadrant, with the one named “Decision Support Systems & Decision Making” being more likely to develop as an ivory tower or peripheral theme. In contrast, “Responsible Research & Innovation” is more likely to move to the base quadrant. Thus, an understanding of the thematic structure of our focal research helps in revealing its current and probable future structure (Murgado-Armenteros et al., 2015; Giannakos et al., 2020). We present a detailed analysis of our identified themes in the following sections.

Motor themes

The strategic map features two main motor themes—namely, “Corporate Sustainability” and “Stakeholder Partnership.” These are represented by spheres, the size of which corresponds to the volume of research in each theme. The themes appearing in the motor quadrant are considered as the foundation of the structure of a knowledge base and are thus well-developed (Murgado-Armenteros et al., 2015).

The “Corporate Sustainability” theme is the second largest in the knowledge map of the field and the largest

in the motor quadrant. It is composed of key topics such as corporate sustainability itself, sustainability leadership, environmental resource management, ethical decision-making, social-ecological systems, organizational learning, and organizational resilience. Research on topics of corporate sustainability and ethical decision-making seems to have been conducted at the micro and meso levels. For example, it includes areas such as responsible management learning and corporate sustainability practices aimed at tackling grand challenges, and much of it is about taking better account of the full consequences of potential interventions and being able to learn from past experiences. This stream of research suggests that a shift is required from responsible management education to responsible management learning, wherein managers learn to take responsibility for the full range of their actions and outcomes, making for more sustainable organizations (Montiel et al., 2020).

Responsible management learning is seemingly a new realism in that it recognizes that even the best thought innovations may have negative outcomes (cf., Johnston, 2020); it is about sustainability, taking responsibility, and ethics pertaining to managerial decision-making (Laasch, 2018). An example of this would be Tuazon et al.'s (2021) article on "freshwater management," which was built on social-ecological systems theory to show how more sustainable leadership may help organizations in responding to grand challenges. Indeed, our analysis concludes that sustainable leadership, responsible management learning, and ethical decision-making are recurrent themes in micro-level research. At the same time, concepts such as organizational resilience, organizational learning, and corporate sustainability tend to be studied at the meso level, while organizational perspective-taking, meta-organizations, and socio-ecological systems are deployed as macro-level indicators. Corporate sustainability, as a concept, is seen to be mostly linked with all three levels of analysis but is dominated by the micro and meso ones. In terms of sectors, this theme is neutral and overarching, with a mainly conceptual angle.

The second main motor theme is "Stakeholder Partnership," analyzing partnerships among various stakeholders, including not only the corporation, but also the government, customers, other firms, and the community. This echoes the earlier theoretical work that found that innovations diffuse unevenly across systems, with varying consequences for different stakeholder categories (Rogers et al., 2014). The main argument and research objective emerging from this theme—which also includes topics such as adaptive learning, cross-sector partnerships, advanced manufacturing, and reshoring supply chains—is how cross-sector stakeholders (businesses, government, and not-for-profit organizations) could

collaborate while addressing grand challenges and emergencies, and thus create value for society (Arslan et al., 2020; Sheng et al., 2021). Similarly, research in this area also explores collaboration between national and local geographical units and possibilities they have for learning from each other, in helping organizations to respond to grand challenges and emergencies (Harris et al., 2020). This theme, which is prominently present at the macro-level, involves the manufacturing sectors of both emerging and developed economies. In terms of sector, this theme has addressed "Key Enabling Technologies" (Frietsch & Neuhäusler, 2018) and how certain macro-level collaborations/interactions help in tackling grand challenges.

A transitioning theme (from base to motor)—namely, "Mission-Oriented Innovation"—was found to include topics such as mission-oriented innovation policy, dynamic spillover, marketing shaping, directional failures, industry 4.0, and market creation. This theme is mostly researched at the macro level and explains why policy is being divorced from fixing directional failures, to create and shape new markets through mission-oriented innovation (Edquist & Zabala-Iturriagoitia, 2012; Mazzucato et al., 2020; Robinson & Mazzucato, 2019).

We found the scope of mission-oriented innovation policy to involve very niche and focused challenges or urgencies (Reale, 2021). Thus, we understand that mission-oriented innovation policies facilitate innovation and socioeconomic impact in a particular direction toward desirable transformative change (Mazzucato, 2011; Reale, 2021). These policies, which are focussed on the development of key technology enablers in order to achieve particular missions (complex and interdependent problems), embrace the idea of cross-sector collaborations. We found that this theme was mainly dominated by research conducted in developed country contexts.

Base themes

Our strategic map includes four base themes—namely, National Innovation Policies & Systems, Sustainable Development, Entrepreneurship & Innovation, and Business Models. These have high density and low centrality and are underdeveloped in terms of internal tie strength; hence, more research is required for their full development.

The "National Innovation Policies & Systems" theme reflects the overarching research topics of grand challenges, which include innovation policy, micro isolationism, national innovation policies and systems, crowdsourcing, and open innovation. The key debate emerging from this theme suggests that, in order to tackle grand challenges, organizations need to, on the one hand, keep an open mind and embrace the concept of continuity and, on the other hand, plan, design, and implement

innovation policies suited to solve the related complex and dynamic problems (Ulnicane, 2016).

Innovation policies represent a new form of economic policies that lead to the promotion of innovation activities; these, in turn, lead to economic growth and aid in solving grand challenges. In other words, they involve looking at both the inputs and outputs of innovation and recognizing the possibility for system transformation (Fagerberg, 2017). This research refers to the application of the “transition management perspective.” This theme is mainly based on innovation policy research, which has predominantly been conducted at the macro level and seems to have addressed national innovation policies and systems. An extension of this research involves the exploration of the governance of innovation at the policy level (Demircioglu & Vivona, 2021; DiVito et al., 2021; Fagerberg & Hutschenreiter, 2020).

The key research questions addressed in this domain of inquiry pertaining to the roles and types of governance mechanisms and to how these have evolved while governing innovation policies, including cross-sector collaborations. Interestingly, crowdsourcing emerged as an important concept within this theme as the “crowd” is viewed as an excellent source of both economic and intellectual capital. The argument here is that these concepts can help in solving grand challenges by providing access to data, funds, novel ideas, and evaluations of solutions (Bertello et al., 2021; Cai et al., 2019; Porter et al., 2020). This research has mainly been conducted within the context of developing markets and at the macro level. Some rare contextual exceptions are national innovation policies pertaining to the integration of immigrants into national innovation (Demircioglu & Vivona, 2021).

The second theme emerging in the base quadrant is “Sustainable Development,” which comprises research areas such as sustainable development, sustainable developmental goals, open innovation, and new product innovation. This theme emerges from the knowledge base as relevant in the context of our study. The prime debate here revolves around the research question of how to ensure sustainability within various domains; again, this takes into account not only of the immediate effects of innovations but also of their range of potential long-term consequences. These include areas such as sustainable energy consumption in manufacturing processes (Borsato, 2017; Ketter et al., 2016); R&D (Manley et al., 2008), new product performance (Zhao et al., 2021), and open innovation and collaboration for new product development aimed at tackling grand challenges (Bogers et al., 2020). Research within this theme, which has mainly been conducted at the meso level, details the various practices and architecture adopted for the promotion of sustainable development. Again, this theme

primarily pertains to manufacturing within a developed economy context.

The third base theme to emerge from the knowledge map is “Social Entrepreneurship and Innovation,” which includes research areas such as entrepreneurship, social innovation, growth, innovation-oriented public procurement, industry evolution, nascent industries, and smart specialization strategies. The key debate in this theme is mainly around the “triggers” of industry inception and product commercialization, with grand challenges having been identified as one such trigger, along with any unmet user needs and with technological and scientific discoveries (Agarwal et al., 2017).

Here, it is key to understand that the industry precursor will channel and promote cross-actor and cross-sector participation and mobilization of resources, and, ultimately, the incubation and growth of nascent industries. We envisage that cross-actor and cross-sector engagement will help in reducing any technological uncertainties (through such actions and resources as concurrent experimentation and development, the exchange of knowledge, and rules/standards for complex system development) and demand ambiguities, and help mitigate any adverse consequences. We argue that this occurs through actions such as identifying commercial uses, promoting an interest in technology through exhibitions, demonstrations, etc., and initiating demand through government procurement contracts and agreements, which will, in turn, promote societal well-being (Agarwal et al., 2017).

As this research has been mainly conducted at the macro level (national policies and various institutional levels), the involvement of governments (in partnership with for-profits, foundations, and research organizations) at the national, regional, and local levels promotes entrepreneurship and the growth of nascent industries (Zabala-Iturriagoitia, 2021). We found evidence that interactions between firms and broader institutions facilitate successful outcomes as the former's resource-capabilities compensate for any institutional voids and enable the useful delivery of any projects aimed at addressing grand challenges (Saka-Helmhout et al., 2021). We found that such research has foundations in the resource-based view (RBV) and the knowledge-based view (KBV) and institutional theories. There is also the argument that innovation policies play a key role in these activities through knowledge transfer, positive spillovers, and innovation-oriented public procurement (Saka-Helmhout et al., 2021; Zabala-Iturriagoitia, 2021). Research in this cluster is concentrated within the European continent and within the health and UAV manufacturing industry sectors.

The fourth theme emerging within the base quadrant is “Transformative Business Models,” wherein the main

research agenda includes the topics of transformational business models (as opposed to business models that result in oppression, depletion, and exclusion), their social impact, and the management of technology and innovation. In other words, we argue that the prevailing business models may not be fit for purpose in promoting the kind of innovation that limits any adverse consequences affecting other stakeholders.

The main research agenda within this theme pertains to how innovative business models (design and implementation) both positively and negatively affect user value creation while addressing grand challenges (Martí, 2018). The evidence suggests that traditional business models are unable to address grand challenges, which involve circular causality and a lack of well-structured solutions, and thus cause radical uncertainties (Ferraro et al., 2015). Hence, there is a strong argument in favor of the need for organizations that intend to tackle grand challenges to design innovative business models, rather than relying on structural patterns of business processes. As posited in this theme, transformational business models are possibly built on four elements—that is, participatory architecture, multivocal inscription, scaffolding, and proximity (Martí, 2018).

We argue that these key elements would encourage cross-sector and cross-actor participation and engagement in tackling grand challenges. We further posit that they would help promote the understanding of complex problems among various stakeholders with competing values and interests, which may help in finding common ground; for example, technology-driven innovative business models and their role in addressing grand challenges (George et al., 2020). Research within this theme has mainly been conducted at the meso level, again focussing on developed economy contexts, being mainly conceptual in nature, and being primarily built on the business model literature.

Peripheral themes

The upper left quadrant—peripheral themes—saw the emergence of the two key themes of Complex Technological Solutions and Employability & Skills Development. The main theme emerging within in this quadrant is “Complex Technological Solutions,” which comprises research topics such as complex dynamic systems, complex structure management, cyber-physical systems, and foresight as the key terms. The principal argument within this research is that solutions to nonlinear and complex problems can solely be found by creating systems built on dynamic complexity and nonlinearity principles (Mainzer, 2020). This theme also includes research that revolves around the research question of how foresight,

as a communication platform, can help solve grand challenges (Gokhberg et al., 2017).

We found that this theme is mainly limited to topics related to the technology field—such as information, cyber systems, etc.—and is limited to the macro and meso levels in both developed and emerging market contexts (Proskuryakova et al., 2018). This theme is more about how solutions are devised, and their potential for implementation; however, it tends to be rather focussed, and, even when dealing with grand challenges, to be short-term centered, with clearly demarcated system boundaries. At the same time, it does mark a clear starting point for downstream research aimed at evaluating any broader mid- and long-term socio-economic consequences.

The next theme in this quadrant is “Employability & Skill Development,” which addresses issues centered on the grand challenge of employability in large emerging economies (Shrotriya et al., 2018). Its key argument is that quality skill development initiatives would improve employability and thus help in tackling the grand challenge of poverty. Research on this theme was conducted at the macro level and through the theoretical lens of inventive problem-solving for quality skill development aimed at tackling the grand challenge of poverty and unemployment. Furthermore, we observed that research in the context of emerging markets has identified a huge potential for employment opportunities despite the employability index of the working population being underdeveloped, which makes this theme a rich and fertile space for future research.

Emerging themes

Within this quadrant, we see two key themes emerging—namely, Decision Support Systems & Decision Making and Responsible Research & Innovation. The largest theme in this quadrant is Decision Support Systems & Decision Making, the main argument of which is centered on the issue of the decision-making process and on assessing its quality in tackling grand challenges (Molloy et al., 2009). The studies conducted in this regards suggest that dynamically complex societal problems could be addressed by innovatively integrating system dynamics and exploratory modeling (Kwakkel & Pruyt, 2015). In addition, text mining is suggested as an effective method for the formulation of policies related to solving complex problems (Gokhberg et al., 2020). The evidence shows that this theme is immersed in case-based research conducted in the context of the metalworking industries and that it is related to natural resource and environmental management aspects. As this theme relates to decision-making, it can be categorized at the micro (managerial),

meso (organizational or firm), and macro (institutional and national) levels.

The second theme emerging in this quadrant is “Responsible Research & Innovation,” which addresses the key characters, roles, and needs of the innovation research aimed at tackling grand challenges (De Jong et al., 2015). As a guiding area of scientific research, responsible innovation encompasses product and service development and includes the following key characteristics: the engagement of multiple stakeholders for value creation, anticipation and adaptability, broadening, and new insights into impact and regulation (Bacq & Aguilera, 2021; Blok, 2014; de Jong et al., 2015).

One important topic emerging in this theme is the “absorptive capacity” perspective, which considers the preservation of the moral legitimacy and societal value of knowledge absorption (Garst et al., 2019). Another very important topic of research is “activist-driven responsible innovation,” which draws from social movement theory to promote innovations that are likely to benefit a broad cross-section of society and more accurately assess any potential downsides. It brings to fore the role played by activists in mitigating any information asymmetry between consumers and corporations (Waldron et al., 2019). Similarly, another important research topic is “cross-sector collaboration and responsible innovation” in the context of an abrupt shock (Arslan & Tarakci, 2020). In reference to the assumptions of institutional theory, this research explains why, in the presence of an abrupt shock/emergency, a shift occurs in terms of the investment of resources aimed at solving grand challenges.

In addition, the governance aspect of responsible innovation was found to have received due attention in the literature (Bacq & Aguilera, 2021; Doh et al., 2019; Scherer & Voegtlin, 2020). An example of this is provided by research conducted on external corporate governance rules and decisions pertaining to the allocation of any generated value (both economic and social) among heterogeneous stakeholders (Bacq & Aguilera, 2021). Furthermore, we found that the organizational decisions pertaining to the allocation of value among stakeholders positioned along the value chain need governance mechanisms, which promote the reach of generated value to solve grand challenges.

This line of research is centered on the stakeholder approach to governance and suggests the need for a more democratic framework of value allocation. Similarly, we identified “responsible innovation tension in international organizations” (i.e., the conflict between maintaining organizational legitimacy and creating a greater impact) as another important research area (Ambos & Tatarinov, 2021). Arguably, it is possible to reduce responsible innovation tension by fostering organizational capabilities

(i.e., competency development, structural alignment, and mission stretch) for responsible innovation (Ambos & Tatarinov, 2021).

This theme was found to be quite heterogeneous in terms of its scope of research and hence in need of further exploration through other theoretical paradigms, frameworks, or lenses, such as the RBV or KBV. However, it does point to the abiding themes around the need to take fuller account of the potential and consequences of innovation not only for shareholders but also for a wide range of stakeholders. Here too, the majority of studies pertain to the meso level and to the developed country context; future research inquiries would thus need to pay more attention to the emerging country one. Specifically, industrial sectors such as manufacturing, natural resources, mining, and environment require more attention.

It is well known that, owing to economies of operations and resources (labor, etc.)—most manufacturing establishments are clustered within emerging economies such as China, India, etc., which has multiple implications for the handling of grand challenges. An example of one such grand challenge is decent work, which has been impacted in multiple ways by the clustering of global manufacturing operations in emerging markets. Increasing wage rates, better working conditions, skill improvement, and other positive changes in industrial practices featured in these studies. Similarly, disruptive business models, the use of disruptive technologies, and other innovative approaches would enable businesses to tackle other grand challenges at the firm, industry, and national levels such as climate change also featured in the extant literature. This consequently would contribute to corporate sustainability.

From the ongoing discussion, we could make out that the research field of innovation aimed at tackling grand challenges may have come of age, but continues to evolve. Areas of enquiry such as responsible innovation, open innovation, social innovation, decision-making, management of complex technological systems, transformational business models, and social entrepreneurship will continue to develop, even as others emerge. An important research theme that has appeared very recently pertains to the possibility of “mission-oriented innovation policies” and their role in tackling grand challenges (Mazzucato et al., 2020). Also, calls have been made for research on “structural changes for innovation policy” (Zabala-Iturriagoitia, 2021). Such studies appeared more than others; hence, it could be suggested that future work on innovation aimed at tackling grand challenges will pick up and revolve around these key themes. Table 3 shows the emerging themes.

TABLE 3 Multicriteria knowledge structure of research in Innovation for tackling grand challenges.

Themes	Studies	Thematic areas	Emerging markets versus developed market (micro, meso, and macro)	Industry level, (agriculture, manufacturing, services) (micro, meso and macro)	Traditional versus newer types of innovation (micro, meso and macro)	For-profit versus nonprofit firm level	Discipline area(s)
Motor (upper right quadrant)	Murgado-Armenteros et al. (2015); Montiel et al. (2020); Laasch (2018); Tuazon et al. (2021)	Corporate sustainability; Adaptive learning (Micro); Grand challenges and project management, emergency management (Meso); Dynamic spillovers (Macro)	Micro mainly in developed market; Meso developed market; Macro level	Micro-level: conceptual, health; Meso level: Agriculture; Real estates and infrastructure	Micro level: traditional; Meso: traditional; Macro: mission-oriented innovation	Cognitive biases, lead user theory; Institutional theory, refugee integration, social innovation framing, R&D in defense and military, STI policy, aging society	Micro level: strategy, Organization science; Meso level: project management; Real estates, agriculture; Macro level: strategy, public policy
Base (lower right quadrant)	Mazzucato et al. (2020); Cai et al. (2019); Rogers et al. (2020); Borsato (2017); Agarwal et al. (2017); Marti (2018)	Sustainable development, grand challenges (Micro); Macro level: Grand challenges, social entrepreneurship, and innovation, food ecosystem, transformative business models	Micro level developed; Macro level: mainly developed	Micro level: consumer industry; food industry; Macro level: food industry, energy, technology	Micro level: Open innovation; Macro level: innovation-oriented public procurement	Renewable resources, sustainable water use, water policy, global problems, science policy, co-evolution and embeddedness, justice, responsible innovation and wicked problem, global health, fundamental change	Micro level: Strategy, ICT; Entrepreneurship; Consumer behavior; Macro level: Entrepreneurship, public sector, technology, energy economics
Peripheral themes (upper left quadrant)	Mainzer (2020); Shrotriya et al. (2018); Gokhberg et al. (2017); Proskuryakova et al. (2018).	Strategic imagination and shaping the future (Micro); Competitive benchmarking, patent documents (Meso); Complex dynamics, employability and skill development, dynamic capability	Meso level: developed; Macro: developed mainly and developing	Micro level: conceptual; Meso level: energy; Macro: IT, health	Micro level: traditional; Meso level: traditional; Macro: newer innovation	Intelligent and smart cities, sustainable cities, social enterprises, bricolage, resource mobilization scaling	Micro level: Strategy; Meso level: Information and decision science; Energy sector; Macro level: Socio-technical domain, strategy, skills development

TABLE 3 (Continued)

Themes	Studies	Thematic areas	Emerging markets versus developed market (micro, meso, and macro)	Industry level, (agriculture, manufacturing, services) (micro, meso and macro)	Traditional versus newer types of innovation (micro, meso and macro)	For-profit versus nonprofit firm level	Discipline area(s)
Emerging (lower left quadrant).	Arslian and Tarakci (2020), Waldron et al. (2019) Gokhberg et al. (2020); Molloy et al. (2009); Bo Bacq and Aguilera (2021)	Decision-making system dynamics (Micro and Meso); Rural development and farming innovation (Meso); Blockchain, responsible innovation, climate change	Micro level developed; Macro level: Developed	Micro level: SMEs; Meso: farming; Macro: R&D, manufacturing, ICT, natural resources and environment	Micro level: traditional; Meso: newer innovation; Macro level: responsible innovation	Immigrant entrepreneurship, big data analytics in solving grand challenges, systematic change, visual thinking, public R&D, civilian technology spinoff, product and service development	Micro level: Decision sciences, small business; Meso level: farming, rural development; Macro level: economics, Technology, strategy, climate change; corporate governance, knowledge-based view

In the next section, we portray a case involving carbon capture and storage and deep-sea mining, in order to unbundle the complexities and challenges for-profit firms face in their quest for innovation efforts directly related to grand challenges.

4 | THE CASE OF CARBON CAPTURE AND STORAGE AND DEEP-SEA MINING

Table 4 outlines complexities and nuances of innovation efforts made by for-profit firms through a case of carbon capture and storage and deep-sea mining, which is a form of disruptive innovation aimed at overcoming grand challenges. In doing so, we bring to light the practical aspects of the 11 research themes we identified above.

These cases highlight how efforts in fixing one problem may create new unforeseen ones in other areas (Diamond, 2019). For example, emerging research has highlighted how deep sea mining may irreparably damage the microbial organisms that constitute the building blocks of the marine ecosystem (Orcutt et al., 2020; Washburn et al., 2019) with further, open-ended, and as yet unknown consequences (Washburn et al., 2019). Despite its undoubted potential, carbon capture remains extremely expensive, and it can be argued that there has been much more interest in small scale demonstration or in indicative projects aimed at relieving pressure on carbon-intensive industries than in meaningfully scaling matters up to making any real difference (Alexander & Stanley, 2021). In part, this reflects the extent to which immediate financial exigencies and opportunism supersede what may potentially be done.

5 | CONCLUSION AND IMPLICATIONS

We have highlighted 11 primary themes found in the literature. One theme emerging in the literature consists of evidence-based accounts that increasingly challenge the Schumpeterian notion of technological progress as a prerequisite for economic renewal. Rather, although innovation is depicted as possessing desirable characteristics, there is a need for a more holistic understanding of its many possible consequences. The latter may vary from stakeholder to stakeholder, and between what is immediately visible and what may become clearer down the line. This would suggest the need both for the use of a range of methodological tools suited to capture a necessary complex picture and for an understanding of grand challenges that does not view them either as very exogenous or as something that can be easily alleviated without

TABLE 4 Case description.

Case	Description
<i>Carbon capture and storage (CCS)</i>	<p>Big for-profit businesses are seen to contribute to grand challenges we face, by emitting polluting carbon dioxide through their production, and are under pressure to find innovative ways to overcome them. Carbon capture and storage is one such recent initiative taken on by businesses, to minimize such large-scale pollution. Carbon capture and storage (CCS) includes an amalgam of different technologies that keep the carbon dioxide emitted by major manufacturing and power plants from escaping and reaching the atmosphere, this process thereby captures, contains, and stores it, which otherwise would escape and contribute to global heating (Bowen, 2011; McKinsey & Company, 2008). These captured carbon emissions are stored by pumping them into geological reservoirs, such as disused oilfields. According to the International Energy Agency (IEA), the energy emitting watchdog, there are only about 20 CCS projects operating commercially, with countries such as the United States, Canada, Norway, and China, leading on this technology (Ambrose, 2021—The Guardian). The article states that there are 30 new projects initiated in the past 3 years, which will help keep carbon emissions from heating the world to more than 1.5C above pre-industrialized levels, a hot topic at the 2021 (26th) United Nations Climate Change Conference (COP26) at Glasgow.</p> <p>However, there are reports that such initiatives were not fully successful. Reasons attributed to its failure include costs, lack of tools and robust technology, transportation and storage challenges, lack of incentives, and policy interventions. Additionally, other key reasons attributed to its failure include several CCS market failures such as (Krahé et al., 2013, p 755–756) (a) Negative externality failure to internalize the cost of greenhouse gas emissions; (b) Public good, that is, failure to appropriate returns generated by investment in innovation; (c) Capital market failures, that is, under provision of capital associated with information asymmetry and imperfect information; (d) Complementary markets, that is, undersupply due to dependency on complementary markets and coordination failure; (e) Imperfect competition, that is, market failure in CO₂ transport networks (potentially in the form of natural monopolies) and storage markets.</p> <p>Recently though, there is a renewal of CCS initiatives, that included oil and gas giants such as Shell and BP (Sullivan, 2021, Financial Times). It is quite ironic that both these huge firms extract oil and their products pollute the environment, on the one hand, and on the other hand, they are reinvesting in CCM. In fact, the above-cited Financial Times article further reports that Norway and Japan, at the country level are revisiting CCS, a decade after they abandoned it due to cost overruns, with Japan including CCS in its 2050 net-zero climate plans. The same article also reports that in northern England, a consortium hopes to create a net-zero cluster of companies that will utilize CCS and hydrogen power, with a goal to build a dual network of carbon and hydrogen pipelines. This proposed English proposal would serve electrical and industrial plants in the area, dumping its carbon outcomes into a depleted oilfield in the North Sea.</p>
<i>Deep-sea mining</i>	<p>Overall, the governing of the automotive transport is strict in terms of environmental regulations, including local, national, or international, with the European regulation for CO₂ emissions, being the strictest. Though the CO₂ emissions levels are very low in Europe, ranging from 130 g CO₂/km in 2015 to less than 95 g CO₂/km in 2020 (Dimitrova & Nader, 2022), the pressure to adhere to innovative alternative forms of fuel have led the automobile industry to move toward battery-driven cars. However, the manufacture of electric vehicles (EVs) is similar to fossil fuel-powered internal combustion engine, as for both, the purchase and reliance of components depends on a global supply chain of vendors and sources before these globally sourced components are then assembled at the respective automobile plant (Krishnan & Butt, 2022). Thus, the only difference is running of the automobiles, which is either fossil fuel or battery-operated. Thus, all major battery-operated automobile firms possess assembly facilities in various countries that produce different models available in their respective markets, thereby sourcing components and materials from vendors across the world. These could include firms such as Tesla, Chevrolet, or Polestar. Further, the raw materials required to manufacture batteries include mining of metals such as lithium, cobalt, and nickel.</p> <p>According to Krishnan and Butt (2022, p. 83), “mining sites are geographically disparate,” with major lithium deposits in Argentina, Chile, Bolivia, and Australia. Furthermore, the Democratic Republic of the Congo holds over 60% of the world’s cobalt reserves and there are extensive nickel reserves in Australia, Brazil, and Indonesia. Thus, to produce batteries as a replacement of fossil fuel in cars, there is a “race to the bottom,” as mining operations are resource-heavy affairs, controlled again, mostly by multinational corporations, such as the global lithium market, “dominated by a small handful of multinationals that form a noncooperative oligopoly” (p. 83). Thus, the automobile industry is under pressure to significantly innovative and improve lithium-ion batteries, especially so because manufacturing of such batteries</p>

TABLE 4 (Continued)

Case	Description
	<p>involves it being high energy density, and costly, and is fully dependent on these mined raw materials, within the battery value chain (Schmuck et al., 2018). Additionally, other key performance indicators when manufacturing batteries include areas such as its lifetime, safety, fast-charging ability, and low-temperature performance, which need to be enhanced, or at least sustained.</p> <p>Such a race to the bottom for automobile battery manufacturing has created many challenges, which surfaced, confirmed by Deutsche Bank's prediction that demand of lithium for batteries, utilized in global EVs will be 38% by 2025 (Horowitz & Coffin, 2018). Thus, there is going to be significant increases in the demand for lithium, cobalt, and nickel as key raw materials for batteries for automobiles, replacing fossil fuel, partially offset by recycling, will exert significant pressure on the existing infrastructure within the extractive industry. One of the many such challenges is that of exploitation within this global supply chain, wherein, continuous lithium mining has led to exploitation of natural resources that include water shortages, soil contamination, and the dispossession of local indigenous peoples living near these lithium extraction mines (Dominish et al., 2019). Other challenges include fierce opposition from local tribes and ranchers against Tesla's Thacker Pass lithium mining project in northern Nevada, in the United States, where there are threats to the water table and sacred land of the local indigenous populace (Hinkey, 2021). When it comes to cobalt mining, there have been strong human rights violations reported, in addition to child labor use and dangerous and unhealthy working conditions (Amnesty International, 2016). Recent reports from Human Rights Watch (2020) have also emerged during the COVID-19 of workers confined to mining sites.</p> <p>Such challenges in lithium and cobalt mining have led automobile giants such as Tesla toward procuring and mining nickel for their batteries (Calma, 2020). However, mining nickel too has its challenges, as seen in the case of Russian indigenous communities campaigning against US giant Tesla, because it contracted with a nickel-mining firm polluting their land (Stone, 2020). Similarly, nickel-mining companies in Indonesia witness ecologically waste disposal practices by large firms, which involve waste dumping into the sea (Morse, 2020). Apart from the production and mining challenges of electronic batteries for modern automobiles, we have also witnessed a large increase in electronic waste (e-waste), often disposed in poor emerging countries, which has devastating effects on the health and safety of the local populace. For example, there are reports from Ghana, where the e-waste disposal and recycling practices and sites used acid leaching and burning that have led to dangerous health issues to those in the vicinity, including workers, leading to kidney failure and cancer in children and pregnant women (Sovacool et al., 2020). Additionally, these mines destroy biodiverse rainforests and these processing plants run on coal-fired power, which again very detrimental to the environment.</p> <p>Another new disruptive innovation within this global electric car industry is the Chinese car manufacturers, led by Warren Buffet support and stake, the Chinese EV maker BYD (Sanderson, 2021, Financial Times). BYD has already entered Norway and are in advanced talks with Tesla, to supply them batteries, on the back of a joint venture with the Japanese automobile giant Toyota. Founded in 1995, initially BYD manufactured lithium batteries for consumer electronics and has now evolved as the largest producers of batteries for EVs globally. More recently, they manufacture electric cars, as they have sourced the technology of lower costs, high life, and sustainable batteries, but also electric car manufacturing. The Financial Times article (Sanderson, 2021) reports how BYD has the competitive advantage of both the largest car battery manufacturer and supplier, with its latest innovation called the "blade", and its large supply chain access. The name 'blade' is because of its long thin shape, and these BYD batteries use more environmentally friendly, cheaper, and abundant raw materials in the world such as lithium and iron, in comparison with other battery manufacturers who have traditionally relied on controversial metals such as cobalt and nickel, as discussed above.</p> <p>More specifically, BYD's batteries have innovatively overcome one of the key sourcing challenges, faced by its rivals, by mastering to manufacture a unique type of lithium-ion technology, invented and based on a discovery in the 1980s by Nobel Prize winner John Goodenough (Oxford University) and Indian-born scientist Arumugam Manthiram (Texas University) (Sanderson, 2021). Thus, BYD's "LFP" batteries use only environmentally friendlier raw materials such as lithium, iron, and phosphate, all abundantly mineable and available at a shallow level of the earth's crust, in comparison to the minerals/raw-material such as nickel or cobalt, used by their competitors, which have to be mined deeper, thus destroying nature. Additionally, during recent safety trials the BYD's "blade battery" did not emit any smoke or fire, reaching a temperature between only 30°C–60°C, whereas the temperature of other electric car batteries rose to 500°C. The Financial Times article (Sanderson, 2021) reports that with this competitive advantage, BYD has set a target of producing 100 gigawatt-h of batteries by 2025 and manufacturing 1.5 m vehicles.</p>

(Continues)

TABLE 4 (Continued)

Case	Description
	<p>BYD's bigger rival is also Chinese, Contemporary Amperex Technology (CATL), which is the world's largest battery maker, currently largest supplier to the global car industry, including Tesla, Daimler, and Volkswagen. It will be interesting to see how this automobile battery and electric car industry plays out in the near future in the context of destructive innovation, with the current leaders in automobile electric batteries emerging with these two Chinese firms BYD and CATL. Japan has a lot of catching up to do, and in contrast, Germany and the United States are more proactive in encouraging and incentivizing electric automobiles; similarly, South Korea, Thailand, and Singapore governments too are supporting this initiative, but Australia is an outlier, as a few states have increased taxes on electric automobiles, instead of decreasing it (Farrer, 2021, The Guardian).</p> <p>However, the latest disruptive innovation has witnessed deep-sea mining for previous metals found at the bottom of the sea, such as nickel, copper, manganese, and cobalt, a raw material needed to manufacture automobile batteries (McVeigh, 2021, The Guardian). The same article reports, because we are unable to extract "...from the land in a sustainable way, the companies behind deep-sea mining say we have no choice: if we want to make the transition to renewable energy, we must plumb the ocean depths." The Glasgow COP26 summit of November 2021 saw countries pledging to strive and meet the stringent carbon-emission targets they have set for themselves. However, on the other hand, global automobile companies plan to phase out combustion engines and replace them with 145 m EVs, within a decade, up from 11 m last year, 2020 (McVeigh, 2021). However, is deep-sea mining the last resort to our move from fossil fuel (combustion engines) to lithium batteries and more sustainable battery-powered automobiles? (Xu et al., 2020). There are already protests by NGOs and other interest groups seeking to protect the deep sea life, where it is said, "90% of the estimated 2.2 million species in the ocean remain undescribed" (McVeigh, 2021). Indeed this is the "race to the bottom," to both the earth and sea.</p>

costs in other areas. The literature furthermore increasingly challenges the view that Western MNEs are always more likely to come up with better solutions than their emerging market counterparts and, indeed, that Western-based innovation systems will always be superior in terms of their capabilities and of the solutions they can generate.

5.1 | Theoretical implications

The broad theoretical traditions that have sought to bring together innovation and grand challenges have tended to focus on broad macro issues and concerns, such as the inevitability of progress, and the role of technology in bringing about economic and societal renewal. Unforeseen consequences of technology; actor centered perspectives often depict innovation in benign terms, and do not always take full account of the potential divergence of interests between stakeholders, and, indeed, that fuller input by a greater cross-section of stakeholders, mediated through institutions, may help identify any negative effects of innovations at an earlier stage. As we have seen, grand challenges have reignited an interest in disruptive innovation theory.

Recent theorizing in innovation has sought to better explain why those consumers and competitors who are technologically lagging behind often do not work to respectively switch to or compete with innovators: it

portrays that both consumer tastes and organizational choices may be embedded (Reinhardt & Gurtner, 2018). This may help explain why actors often hang onto technologies long after the disadvantages greatly outweigh the benefits. Again, innovations in one area may be rendered completely obsolete by advances in another (Reinhardt & Gurtner, 2018).

In this article, we highlighted the differences between macro-, meso- and micro-level analyses and the emerging common ground. At the same time, recent work conducted on open innovation has taken fuller account of grand challenges not just through applied issues, as alluded to above, but also by further highlighting the value of synthesizing the insights drawn from the literature on co-creation (Dahlander et al., 2021). Responses to challenges may involve the contributions of many actors, which makes it challenging to allocate rewards, hence discouraging collaboration within or between organizations (Dahlander et al., 2021). Furthermore, recent work on innovation policies has highlighted the opportunities for countries to set new directions that are better informed by stakeholder needs in times of great crisis, and, indeed for more pragmatic and less ideological theorizing on what countries can do and actually do (Fagerberg, 2018).

Other recent work has sought to bridge the gap between the macro, meso, and micro levels by extending theory on transformational social innovation; this approach extends the application of social innovation theory to provide a framework that recognizes both

institutional hybridization and broadly distributed agency (Pel et al., 2020). This recognizes that broad continuities are offset by highly contingent transformations in social life; rather than focussing on a single disrupter, events may often unfold in multiple dimensions, which, in turn, would account for any counter-tendencies or for a lack of alignment in response to disruptions (cf., Pel et al., 2020).

The last of the four recent developments in innovation theorizing raises questions as to what further usage could be made of the recent theoretical developments occurring across the social sciences in order to better test and decipher the complex interactions between various stakeholders at multiple levels (Pereira, 2017). For example, recent developments and extensions of institutional theory have highlighted the relationship between variations in national sustainability, institutions, the wider political economy, and, indeed, unfolding political events. With this comes the view that institutions are nested at various levels: at transnational, local, and at the firm levels (Demirbag et al., 2017; Hollingsworth et al., 2019). Again, such thinking takes a more dynamic view of natural phenomena, rather than the traditional enlightenment model of something that can be infinitely remolded to suit human—and firm—needs. A large body of work ranging from psychology to economics has recognized the frequent inability of individuals or organizations to take meaningful action when confronted with too much bad news (Diamond, 2019); in turn, this may help inform a theoretical understanding of any inability to innovate at times of great crisis and need.

Unfortunately, much of the literature remains theoretically fragmented, although, as noted above, recent applications of social innovation theory may help build bridges between a wide range of accounts to provide a synthetic theoretical understanding (van Wijk et al., 2019). More specifically, such work highlights the tensions between contextual enablers and restrainers of innovation and individual actor autonomous action. It is held that the relative scale and scope of each varies according to time and locale and that the strength of relations between different stakeholders may help determine how pro-social innovations are, the relative balance between positive and negative effects, and the potential for remedial action (Scheidgen et al., 2021; van Wijk et al., 2019; Zhai et al., 2022).

Such approaches are broadly institutionalist (cf., Pel et al., 2020), but rather more pragmatic in their understandings of what institutions do than many traditional strands of institutional theorizing (cf., Hwang & Colyvas, 2020; Voronov & Weber, 2020). On the one hand, it could be argued that seeking to develop and

build theoretical common ground may come at the cost of rigor and depth. On the other hand, it may be that an emphasis on understanding tensions and contradictions within and between theories does not necessarily have to lead to getting bogged down in seemingly irreconcilable differences; rather it can be the basis for drawing together compatible and, indeed, complementary insights to better understand the innovation-grand challenges nexus.

5.2 | Managerial implications

Our review highlights two distinct challenges for management. An influential strand of the literature emphasizes the systemic element of innovation and how contextual circumstances and government policies may either enable or hinder specific strands of innovation (Fagerberg, 2018). In addition to this, stakeholder needs and concerns have to be taken into account in both the development and operationalisation of innovations (Pel et al., 2020). What this suggests is that it is quite unusual for firms to devise paradigms related to innovating in isolation; innovations emerge through a combination of actions and context, which may suggest that the capacity of firms to innovate during times of great change is to some extent molded, enabled, and constrained by circumstances.

Yet, although what managers can or should do is bound up with the settings, individual firms still make real choices pertaining to the relative utilization of technology. In turn, this will have both foreseeable and unforeseeable consequences, with the latter possibly resulting in open-ended costs for economies, societies, and, indeed, the planet itself. Seeking to help solve or alleviate one grand challenge may cause the emergence of another. To summarize, if what managers can do is bound to systemic dynamics, their choices may still have great systemic implications; although the scope of managerial decisions is limited, their choices in innovating still matter. Unfortunately, it is much easier to calculate the immediate benefits than it is to work out the costs that may be incurred down the line (Diamond, 2019).

5.3 | Limitations

As reiterated and observed, no design and synthesis of a body of literature can ever lead to a perfect scholarly piece devoid of limitations, and ours is no exception. Nevertheless, we strengthened the findings of our systematic review through a case, thereby bringing to light the challenges faced by businesses within the four identified

themes—that is, National Innovation Policies & Systems, Sustainable Development, Social Entrepreneurship & Innovation, and Transformative Business Models. However, we still identify some limitations of our article.

First, there are certain conventional limitations linked to the structure and quantitative literature review. In this article, we limited our scope to the context of the innovation aimed at tackling grand challenges enacted by for-profit organizations, albeit the need here was on purpose. However, it would be interesting to extend the scope of such a structured and objective literature review to the context of not-for-profit organizations and compare the findings. More specifically, such a review would provide a comparative analysis of the research stock in both contexts—that is, what are the similarities and differences, if any. Such an effort could improve the generalizability of our findings. Further, our article was focused mainly on select literature analysis techniques that were mostly quantitative, neglecting others such as citation and co-citation analysis. An additional and complementary investigation involving other techniques would certainly add to the body of knowledge, especially given that the field draws from a variety of interdisciplinary domains.

5.4 | Future research

Research conducted at the intersection of the innovation efforts made by for-profit firms in order to tackle grand challenges is still in its infancy. As such, the limited existing evidence outlined by our article emanates from multiple literature strands. However, the vast scope for future work (particularly inter-disciplinary research) could offer a chance for a real impact in bringing to the fore the innovative solutions of for-profit firms, which would help in changing the conventional but misplaced, wisdom that *doing good* comes at the expense of *doing well*.

On the one hand, there has been a renewed emphasis on sustainable innovation, precisely because it is needed to meet many grand challenges. On the other hand, any innovation that appears to contribute to the promotion of a more sustainable future may involve greater environmental costs down the line (Diamond, 2019). Our two case examples on carbon capture & storage and deep sea mining exemplify this; each has much potential to contribute to mitigating the costs of climate change—the former directly, the latter indirectly—by, inter alia, reducing the costs of battery production. Yet, many challenges remain in getting the former beyond the demonstration stage, and the latter may pose risks for marine ecosystems that may ultimately contribute to further climate

change. It could be argued that a wider stakeholder involvement may help in the earlier identification of risks, given the lower interest in immediate gains (e.g., alleviating pressure on polluting industries), and may provide access to a wider experiential and knowledge base. Hence:

FRP 1. *The open-ended costs and risks posed by innovation may be better identified and mitigated through broader stakeholder involvement.*

Recently, an emphasis has emerged on micro-foundational analysis in various contexts, such as the general strategy literature and, increasingly, the global strategy literature (Contractor et al., 2019), and in bridging the micro, meso, and macro levels (Pel et al., 2020). This type of analysis enables researchers to delve deeper into the decision-making processes enacted at the individual level, and into how and why they are enabled or constrained. Accordingly, we make a case for the need for research aimed at investigating the many unique and complex micro-foundational characteristics that influence a firm's sustainability decisions and link them to wider contextual and systemic dynamics. This could include work on the integration of innovative business practices by for-profit firms from emerging markets, and on how these not only impact a focal country and community but also reorientate the mindset of a firm to think more globally across its network of partner firms and foreign subsidiaries.

More specifically, how does the challenging emerging country context drive the uniqueness of for-profit firms' efforts to achieve their CSR and sustainability goals? How could this context impart advantages of its own? Do these new practices have the potential to become global best practices? Can current emerging market experiences motivate for-profit firms to learn to become more agile and adaptive to other foreign markets, with their specific contexts and challenges?

FRP 2. *Any divergence in the national innovation capabilities that can be deployed in response to grand challenges may be mitigated through denser ties between firms, and within and between contexts.*

FRP 3. *Any national and regional variations in comparative innovative advantages are subject to change, which may be accelerated by grand challenges.*

Finally, interdisciplinary research aimed at attempting to tackle such complex research questions may offer a positive outlook suited to uncover solutions to some of the most pressing grand challenges faced by the world. Inter alia, this may help better understand both the contextual bases of innovation and the relative ability of actors to produce and cope with innovation (see Table S7 in the online appendix, for details on FRPs).

ETHICS STATEMENT

The authors have read and agreed to the Committee on Publication Ethics (COPE) international standards for authors.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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