

Strategies for net zero: A configurational approach

ABSTRACT

Firms face complex temporal challenges in achieving decarbonization progress, requiring them to align short-term emission reductions with long-term net-zero strategies. While prior research has explored environmental reporting and emission reduction targets, little is known about how firms manage and resolve the inherent tensions in implementing decarbonization strategies. This study adopts a configurational perspective and employs Qualitative Comparative Analysis (QCA) to investigate the temporal interplay between governance mechanisms and (collaborative) innovation efforts in corporate decarbonization journeys. Our findings contribute to the literature on climate change management and innovation in two key ways. First, we demonstrate how firms at different stages of their decarbonization pathways utilize distinct combinations of governance and innovation strategies, each addressing temporal tensions in unique ways. Second, we highlight the pivotal role of collaborative innovation in complementing internal efforts, enabling firms to simultaneously advance short-term and long-term decarbonization objectives. By integrating governance and innovation perspectives, this study provides novel insights into the temporal dimensions of corporate decarbonization and offers actionable strategies for firms pursuing ambitious emission reduction targets.

Keywords: Managing climate change, innovation, governance, long-term strategy, decarbonization, temporality

INTRODUCTION

Anthropogenic climate change is the most pressing grand challenge of this century (Howard-Grenville et al., 2014; George et al. 2016). Mitigating climate change requires fast and deep decarbonization of the global economy to reach net-zero emissions by 2050 (IPCC 2022). Correspondingly, climate change is becoming increasingly important to organizations as they need to develop strategies for reducing carbon emissions (Nyberg & Wright 2022). Incumbents need to progress on their decarbonization trajectories by reducing the emissions of products, services, and processes within and across value chains (Stern and Valero 2021). Yet, progress has been limited, and it remains unclear how firms can successfully navigate their decarbonization efforts to reach net-zero emissions by the year 2050 (Nyberg & Wright 2022).

With rising stakeholder pressure (e.g. Murillo-Luna et al. 2008) and physical climate risks (Pankratz et al. 2023), many firms have initiated their journey to decarbonize to reach net-zero by 2050. Correspondingly, extant research has begun to uncover how businesses respond to climate change by, for example, reporting on environmental information (e.g. Flammer et al. 2021, Guenther et al. 2016), setting emission reduction targets (e.g. Ioannou & Serafeim 2016, Nimer et al. 2024), or adopting environmental standards (e.g. York et al. 2018). Yet, we know surprisingly little about the “implementation” part of firms’ decarbonization journeys (Nyberg & Wright, 2022). As firms scale back in their net-zero ambitions (Carbon Tracker, 2023) and fail to deliver on their targets (Cenci et al. 2023), we require a better understanding of how firms can manage their decarbonization journey effectively.

Given its complexity and systemic nature, it is unlikely that there is one clear pathway to corporate decarbonization. Transitioning to net-zero involves multiple temporal issues, as firms are urged to front-load emission reduction in the near future while also ensuring continuous emission reduction in the more distant future (Fankhauser et al. 2021). Especially in hard-to-abate industries, emission reduction is dependent on low-carbon technologies, of which some

are already available, enabling a limited amount of emission reduction in the short-term (Bumpus and Comello 2017). Achieving continuous and deep emission reduction in the long-term however, involves a high degree of uncertainty as many key low-carbon technologies and systems do not yet exist or are currently not commercially viable (IEA 2024). It is therefore unclear which combinations of solutions for decarbonization will successfully enable companies to reach net-zero (Bumpus & Comello 2017, Pinkse et al. 2024). This uncertainty demands companies to carefully consider the implications of their strategic actions for both the short- and long-term dimension of their decarbonization journey.

However, catering to both the short- and long-term dimensions of the decarbonization journey may demand (1) resolving current uncertainties while anticipating future risks and opportunities, (2) dedicating resources to the optimization of the old system while investing in its abolishment, and (3) creating diverging short- and long-term incentives (Wang et al. 2018). These complexities create temporal and organizational tensions (Slawinski & Bansal 2015; Wang et al. 2018), which companies may try to escape e.g., by focusing on short-term reduction efforts without a longer-term strategy or prioritizing long-term innovation while neglecting short-term reduction opportunities. Nevertheless, to successfully progress towards net-zero, companies need to resolve the intertemporal tensions inherent in their decarbonization journey and combine short-term emission reduction with long-term decarbonization strategies (Slawinski & Bansal 2015, Fankhauser et al. 2021, Nyberg & Wright 2022). It is not yet well understood, which organizational and managerial levers are most effective, and how companies can combine them, to resolve this tension and successfully navigate their emission reduction efforts towards reaching net-zero. In this study, we therefore conceptualize high corporate decarbonization progress in terms of long-term decarbonization targets and the extent to which these are (relatively) ambitious and completed in the short-term (see also Ioannou et al. 2016).

Specifically, we include two dimensions of actions firms apply to progress on their decarbonization journey. First, firms can leverage *corporate governance*, to translate carbon emissions as well as reduction efforts into short-term economic impact (Keum 2021, Flammer & Bansal 2017). Exemplary mechanisms include linking executive compensation to CO₂ emission reductions (Flammer et al. 2019) or setting an internal price for carbon (Zhu et al. 2022). Second, for most firms, progress towards net-zero necessitates *innovation* in low-carbon technologies, processes, and business models (Stern & Valero 2021). While some progress can be made in the short-term by adopting readily available low-carbon innovations, such as renewable energy plants, for many industries reaching net-zero requires developing and scaling novel and systemic innovations which are likely to reduce emissions only in the long-term (Pinkse et al. 2024). Given the systemic nature of many low-carbon technologies, both adopting and developing innovations may depend on collaborative efforts with partners within and across value chains (Falcke et al., 2023).

So far, the literature streams on governance and innovation for environmental performance have been largely developing in parallel, with limited understanding of how firms can combine governance and innovative efforts in their corporate decarbonization journey. Since prior work points to important interdependencies between short-term oriented governance mechanisms and long-term oriented innovative effort (e.g. Flammer & Bansal 2017; Keum 2021), it is unclear how the two dimensions can be utilized to alleviate the intertemporal tensions within corporate decarbonization. Do governance mechanisms and innovative efforts compete for a short- or long-term focus in the decarbonization journey? Or do they complement each other? Furthermore, it is likely that firms that have just begun their decarbonization journey, thus able to exploit the reduction potential of available low-carbon technologies, utilize governance mechanisms and corporate innovation differently than more advanced companies, which may already approach the current technological limits of emission reduction.

Given the multi-faceted nature of corporate decarbonization, its inherent temporal tension and intricate role of governance and innovation, it is unlikely that there is one clear recipe for successful decarbonization. As such, investigating decarbonization progress is theoretically and empirically challenging as it encapsulates multiple interdependent dimensions. In this study, we therefore adopt a configurational perspective (Fiss 2011, Furnari et al. 2021, Ragin 2008) and draw from the perspectives of governance and (collaborative) innovation to address the following question: *Which configurations of governance mechanisms and (collaborative) innovative efforts unlock high corporate decarbonization progress?* Based on Qualitative Comparative Analysis (QCA), we empirically examine multiple configurations of relevant governance and innovation dimensions and their joint impact on decarbonization. We further investigate how these configurations differ between firms that are in the early- and more advanced stages of their decarbonization journeys.

THEORETICAL BACKGROUND

Decarbonization through corporate governance

A well-established body of work has investigated how, in the absence of public governance, private governance might induce companies to engage in decarbonization-related activities. While public governance refers to rules, regulations, and frameworks established by governments and regulatory authority which would then call for compliance by firms, we understand private governance as the internal mechanisms and frameworks that firms establish to regulate their own operations. For instance, shareholder activism – as one particular form of private governance – is effective in eliciting corporate disclosure of climate change risks (Flammer et al. 2021). Furthermore, female representation on the board has been associated with the setting of emission reduction targets (Nimer et al. 2024), innovations that are likely to reduce

emissions only in the long-term (Pinkse et al. 2024) and that may depend on collaborative efforts with partners within and across value chains (Falcke et al., 2023).

Another private governance mechanism is the integration of environmental performance criteria in executive compensation (Flammer et al. 2019). Such incentives can serve as an effective tool to influence corporate action. The underlying mechanism is that these tools help direct managers' attention toward issues that may not immediately deliver short-term financial performance, such as investing in the development of clean technology, sustainable energy, and other environmental initiatives (Flammer et al. 2019). When incentivized accordingly, managers may overcome their focus on short-term financial results and adopt a more systemic perspective (Flammer & Bansal 2017), which is necessary for achieving decarbonization in the short- and long-term (Pinkse et al. 2024). Though, incentives coupled to long-term strategies could create ambiguity when not aligned with other internal control systems and short-term financial incentives, thus creating divergent objectives reinforcing intertemporal tensions (Deckop et al., 2006; Wang et al. 2018).

A further prominent instrument or tool for driving decarbonization efforts via private governance mechanisms is carbon pricing. Governmental institutions are increasingly implementing mechanisms such as carbon pricing that account for the “true” damage (i.e., the externalities) of CO₂ emissions (e.g., Delmas & Toffel, 2004; Flammer, 2013). Corporates have begun to mimic this mechanism by adopting internal carbon prices. Internal carbon pricing is a mechanism by which companies can place a monetary value on their carbon emissions in a way that drives business towards sustainability (Zhu et al. 2022, Ben-Amar et al. 2022). It is a voluntary method for companies to internalize the implicit (actual or expected) cost of carbon under various policies and regulations even when all or part of their operations are not currently subject to external carbon regulations (Bento and Gianfrate 2020). Prior work shows that

internal carbon prices are positively associated with a firm's environmental performance (Zhu et al. 2022).

The effect of setting an internal carbon price may be twofold. First, the additional cost factor may sensitize managers to emission-intensive process steps that can be mitigated in the short-term. Second, the resulting levies can be used to secure funding for (long-term) emission reduction efforts. At the same time, however, economically quantifying carbon emissions through a one-dimensional price factor can distract from the complex long-term impact on society (Slawinski & Bansal 2015) and may thus encourage incremental innovation more than systemic innovation.

Following prior work, we would thus expect direct associations between private governance mechanisms – in the form of executive incentives coupled to emissions and internal carbon prices – and corporate decarbonization progress, as these internal mechanisms direct managerial attention to climate change and drive decarbonization efforts. However, there might also be indirect effects if we consider governance mechanisms in conjunction with innovation efforts. For instance, an internal carbon price might encourage managers to think more deeply about how to use this money for leveraging low-carbon innovations. Similarly, executive compensation tied to environmental performance shifts managers' attention toward a longer-term orientation, which is essential for innovation (Flammer and Bansal 2017). Thus, private governance mechanisms may help facilitate and capture more benefits from low-carbon innovation through greater attention to and increased efforts in decarbonization efforts. Given these potential interplays between private governance and low-carbon innovation, we discuss the role of innovation for corporate decarbonization progress.

Decarbonization through (collaborative) innovation

Progressing towards net-zero requires firms to innovate their existing products, services, and processes (Demirel and Kesidou 2019, Varadarajan 2017). Thus, scholars have been calling for

more research on the role of firms and their innovative efforts to tackle climate change (e.g. Chandy et al. 2021, Eisenhardt et al. 2016, Howard-Grenville et al. 2014). A related stream of literature has begun to investigate the importance of firm-internal innovation in addressing environmental problems – also called sustainable or environmental innovations (e.g. Slotegraaf 2012, Varadarajan 2017, Watson et al. 2018). Through internal innovation efforts – e.g. investments in research and development – firms may optimize the emission efficiency of their existing assets and processes in the short-term or generate novel solutions for achieving their long-term decarbonization targets. Yet, sustainable innovations may require integrating low-carbon technologies, which are characterized by novelty and complexity, thus often unfamiliar to the focal firm (Barbieri et al. 2020). Sustainable innovations therefore often build upon a green knowledge base and green capabilities that may be distant to the traditional industry knowledge and not internal to the firm (Barbieri et al. 2020, De Marchi 2020, Ghisetti et al. 2015). The time and effort needed to build these capabilities may be a barrier to benefiting from available low-carbon solutions in the short-term.

As such, companies are increasingly turning to collaborative forms of innovation for sustainable development (McGahan et al. 2021, Zobel et al. 2023). Collaborative innovation enables firms to augment in-house capabilities by leveraging external sources of knowledge (Zobel 2017), which are becoming more widespread than ever (Chesbrough 2020). Insourcing external knowledge through collaboration can therefore enable firms to broaden their understanding of emission reduction opportunities and solutions, which may help them in adopting a more systemic and long-term perspective on their emission reduction (Slawinski & Bansal 2015). The literature on collaborative and open innovation has made progress in understanding how firms utilize purposeful inflows and outflows of knowledge across firm boundaries via various forms of collaboration (e.g. Chesbrough and Bogers 2014, West and Bogers 2014, Lu and Chesbrough 2022). More recently, it has paid attention to how knowledge flows and inter-

organizational collaboration can help to address grand challenges such as climate-change (e.g., McGahan et al. 2021). Tapping into external knowledge sources can, for instance, increase the environmental sustainability of products (Bogers et al. 2020), scale the impact of robust action strategies against ocean polluters (Porter et al. 2020), facilitate best practice sharing for sustainable development in Sub-Saharan Africa (Valente and Oliver 2018), or help firms align with partners in open innovation ecosystems that contribute to the Sustainable Development Goals (Falcke et al. 2023).

Progressing towards net-zero entails the decarbonization of entire value chains which requires coordination amongst multiple partners (Stern and Valero 2021). Further, decarbonization challenges often span entire sectors, increasingly blurring industry boundaries and requiring collaboration between unlikely allies (Falcke et al. 2023). An example is the decarbonization of mobility which requires innovation and coordination in the automotive sectors – e.g. improvements in the performance of EV batteries – and the energy sectors – e.g. novel solutions for vehicle-to-grid charging infrastructure. Furthermore, novel low-carbon technologies are often developed by startups (Bumpus and Comello 2017). This calls for more startup-incumbent engagement models (Weiblen and Chesbrough 2015), as adopting low-carbon solutions from startups has the potential to accelerate incumbents' decarbonization efforts (Falcke et al. 2023). In addition to the reduction potential of the solutions, engaging in startup collaborations may positively influence the incumbents decarbonization journey by creating periodical technological milestones during the development phase which can serve as short-term evidence for progress towards long-term goals, potentially reducing intertemporal tensions (Hernes & Schultz 2020).

As such, complementing internal innovation with external knowledge sources and paths to market may put more firms on a net zero trajectory and advance their progress in the short- and long-term (Zobel et al. 2023). In the following, we develop two distinct mechanisms that

may help to explain a positive association between collaborative innovation and corporate decarbonization progress.

Collaborative innovation may facilitate corporate decarbonization progress through ***knowledge access and transfer***. Knowledge access and transfer have been well established as the underlying mechanisms of why collaborative approaches lead to higher innovation performance (e.g. Laursen and Salter 2006, Zobel 2017, West and Bogers 2014). We posit that these mechanisms may also operate in the context of corporate decarbonization. First, firms often find it challenging to understand and measure how their carbon footprint is formed, who (up and down the value chain) contributes to it, and what capabilities in- and outside the organization could materially impact the carbon footprint (Comello et al. 2022). By opening up the innovation process – i.e., collaborating with a larger number of external partners – firms can access knowledge, data and best practices, and collectively make sense of carbon reduction targets. This may help companies understand the complex structure of their emission sources, enabling them to identify potential reductions. Especially, it may allow them to outline and adjust non-critical processes to achieve efficiency gains for short-term progress. Second, corporates face uncertainty in their decarbonization journey as it is often unclear with what kind of technologies, processes, or business model changes decarbonization can be achieved (Zobel et al. 2023). Collaborative innovation reduces technological uncertainty (Parida et al. 2012) as it enables firms to experiment with a larger portfolio of technologies, learn from others, and reduce the risks and costs associated with such experimentation. By mitigating the risk of exploring different low-carbon technologies, collaborative innovation might thus alleviate the intertemporal tensions inherent in corporate decarbonization progress. Finally, even if suitable solutions are identified, corporates often lack the capabilities to generate or adopt novel solutions at an adequate pace (Eklund and Kapoor 2019). Collaborative innovation can help build new capabilities (Zobel 2017) and thus, accelerate decarbonization journeys in the short-term

and broaden the solution space for long-term strategies (Slawinski & Bansal 2015). As such, we would expect knowledge access and transfer through collaborative innovation to enable more sound and ambitious long-term carbon reduction targets, facilitate the short-term adoption of low-carbon technologies, and help build the capabilities required for implementing a long-term corporate decarbonization strategy.

In addition to knowledge access, *social influence mechanisms* among collaboration partners influence strategic decisions and actions (Gerges-Yammine and ter Wal 2023). Although social influence dynamics – triggering patterns of imitation – have been documented in a variety of collaborative contexts, such as investment syndicates (Gaba and Terlaak 2013) or exits from open multiparty alliances (Gerges-Yammine and ter Wal 2023), it is important to understand whether, and under what circumstances, such mechanisms also manifest when it comes to corporate decarbonization. Prior work seems to suggest that social influence dynamics play an important role in environmental strategies. De Mendonca and Zhu (2019), for instance, show that laggard (environmental) companies are more likely to invest in proactive environmental strategies when their leading peers display higher sustainability orientations. We expect this effect to be amplified if a focal firm engages in collaborative innovation relationships with such leading peers. As such, open innovation may not only facilitate corporate decarbonization progress through knowledge access and sharing but may reinforce social dynamics whereby we would expect focal firms who partner with low-carbon leaders to strive for own corporate decarbonization progress. Preliminary anecdotal evidence of social dynamics in the context of decarbonization journeys can be found in “joint pledges” such as the “Climate Pledge”, initiated by Amazon and joined by more than 300 organizations. Joint pledges may not only enhance pledge credibility but also leverage inherent peer pressure in the achievement of the joint goal. The effects of these social influence mechanisms might be twofold: (1) companies could feel pressured to quickly demonstrate emission reductions through short-term strategies, neglecting

the long-term dimension of their decarbonization journey (Bansal & DesJardine 2014), or (2) they might be motivated to confront the challenges and tensions inherent in decarbonization, juxtaposing both short- and long-term implications (Slawinski & Bansal 2015).

In sum, we argue that corporate decarbonization progress is facilitated by internal and collaborative innovation efforts as well as by decarbonization governance. The joint effect of these three elements is, however, less apparent. Prior studies on the joint influence of internal and external innovative efforts on innovation performance are inconclusive regarding whether the two innovative efforts are substitutes or complements (Berchicci 2013, Hagedoorn and Wang 2012). Furthermore, it is unclear how the implementation of decarbonization governance influences this relationship and the intertemporal tensions within both forms of innovation. Reducing the complexity of climate change's implications into simple monetary structures through decarbonization governance mechanisms may lead managers to adopt a business case frame of corporate sustainability, potentially making them utilize innovation differently than managers embracing the multifaceted implications of sustainability (in a paradoxical frame) (Hahn et al. 2014). Thus, a pressing question remains: what is the joint effect of decarbonization governance and (internal and external) innovation efforts on corporate decarbonization progress?

A configurational perspective: governance, innovation, and temporal considerations

We argue that we need to better understand whether governance- and innovation-related efforts compete or complement each other in the pursuit of high corporate decarbonization progress. The substitutive or synergetic relationships may also differ considering temporal considerations regarding the companies' decarbonization pathway. For instance, companies in the early stages of their decarbonization pathway may benefit more from internal governance mechanisms as these can steer the adoption of short-term solutions that are already widely available and may shift the attention towards exploring long-term strategies internally. However, when collaborating with ambitious partners, quantifying carbon emissions through governance mechanisms

internally might lead to more myopic reduction strategies aiming at celebrating quick wins in the effort to close the perceived performance gap with these partners.

Firms that have already made significant progress may find it increasingly difficult to advance through decarbonization governance mechanisms alone. Instead, they may need to adopt more collaboratives approaches to innovation to access new knowledge, broaden their solution space, and co-develop novel solutions (Slawinski & Bansal 2015). Collaborative innovation strategies could therefore help companies in more advanced stages to achieve continuing emission reductions in the short-term and to solidify long-term ambitions, further blending the short- and long-term dimensions of their decarbonization journey. Decarbonization governance mechanisms might even amplify intertemporal tensions in this stage by over-emphasizing internal financial aspects which may lead to favoring short-term thinking (Bansal & DesJardine 2014) and adding a bureaucratic layer possibly impeding both short- and long-term efforts. Hence, in addition to the importance of investigating the combination of multiple dimensions (i.e., conjunction), and the possibility of multiple pathways (i.e., equifinality), understanding corporate decarbonization is also characterized by causal asymmetry as some dimensions (e.g., decarbonization governance) could play a facilitating or limiting role. In the following, we therefore conduct a configurational analysis of how different combinations of governance- and innovation-related dimensions enable corporate decarbonization for firms who are in the early-stage vs. advanced stages of their decarbonization journey (see Figure 1).

METHODS

Sample and Data

To study the relationship between governance mechanisms, (collaborative) innovative efforts and corporate decarbonization, we constructed a sample of U.S companies in the energy sector. We chose this empirical context for the following reasons: The energy sector is

responsible for approx. 25% of total GHG emissions in the U.S. (EPA 2023) and is under increasing pressure to transition from fossil-fuel based and emission-intensive energy sources to renewable and low-carbon alternatives. In fact, the U.S. government has issued the goal of “achieving a carbon pollution-free power sector by 2035” (The White House 2023). We can therefore expect a wide range of energy companies to have already started their transition towards net-zero. By focusing solely on U.S. companies, we avoid heterogeneity in country-level policies potentially affecting our analysis. Finally, through prior research and academic engagement, our research team has developed practical knowledge of the energy sector, which can guide further case interpretation and qualitative analysis.

 Insert Figure 1 about here

Our dependent variable is constructed from a dataset compiled by the Carbon disclosure project (CDP). Therefore, our sample is limited to energy companies voluntarily reporting their target progress to the CDP in 2022. By filtering the CDP database for U.S. companies in the sectors “Energy utility networks” and “Thermal power generation”, we built a sample of 26 companies. In our sector selection, we intentionally excluded companies with the primary sector tag “Renewable power generation”, as these companies can already be considered low-carbon and are not required to pursue net-zero strategies (as much). For constructing our dimensions and outcome variables for the Qualitative Comparative Analysis (QCA), we then compiled a unique dataset based on the following data sources.

CDP Data. The CDP is a non-profit organization with the aim of enhancing the transparency of the environmental impact of companies, cities, states, and regions through disclosure of (inter alia) their climate-related actions. The CDP sends out annual surveys on climate change-related issues. The survey comprises over 100 questions covering topics such as risks

and opportunities of climate change, emission targets and performance, carbon-emission governance, and climate-related engagement with external partners. In the year 2021, 13,126 firms across industries and countries submitted their responses to the survey, including many of the world's largest firms across different industries such as Apple Inc., Microsoft, Walmart, or Volkswagen. Thus, CDP data is often considered one of the most comprehensive and useful sources for generating insights into sustainability management in several prior studies (e.g., Flammer, 2021; Ioannou et al. 2016).

Factiva. For collecting data on open innovation partnerships, we followed best practices for using Factiva (e.g., Zobel et al., 2016). Factiva is a search engine and database for full texts from over 32,000 sources, such as newspapers, journals, industry publications, and press releases run by Dow Jones (ProQuest 1).

Science Based Target initiative (SBTi). The Science Based Targets initiative (SBTi) is a collaborative effort between the CDP, the United Nations Global Compact (UNGC), the World Resources Institute (WRI), and the World Wide Fund for Nature (WWF). The initiative aims to drive and support companies in setting ambitious greenhouse gas emission reduction targets that align with the goals of the Paris Climate Agreement. The SBTi provides a clear, scientifically grounded methodology and guidelines for companies to set their science-based targets. It involves setting targets for reducing greenhouse gas emissions across various scopes (i.e. including direct emissions – Scope 1, indirect emissions – Scope 2, and emissions occurring in the upstream and downstream supply chain – Scope 3). By adopting science-based targets, companies demonstrate their commitment to taking meaningful climate action and to aligning their business strategies with the transition to a low-carbon economy. Importantly, SBTi publishes a list of companies that have a SBTi verified target that we could draw from for our data collection.

Methods

Data Analysis: Qualitative Comparative Analysis (QCA)

As we are interested in the interplay of governance- and innovation-related efforts and their role in achieving corporate decarbonization progress, we apply a qualitative comparative analysis (QCA) (Fiss, 2011; Ragin, 2008). QCA draws from Boolean algebra and set theory to enable a systemic comparison of cases. Specifically, it allows us to investigate how the conjunction of multiple dimensions (e.g., decarbonization governance, internal low-carbon innovation, and collaborative innovation) consistently leads to an outcome of interest (i.e., high corporate decarbonization process). QCA is well suited to address research issues characterized by causal complexity (i.e., equifinality, conjunction, and causal asymmetry) that also fits the research issue at hand (Furnari et al., 2021). Achieving corporate decarbonization process is challenging, and it is likely that there are multiple “recipes to success” (equifinality) that QCA can identify. Finally, it can deal with causal asymmetry. Causal asymmetry refers to situations where a dimension, under certain conditions (e.g. for a company in the more advanced stages of their decarbonization), can contribute positively to an outcome of interest but, under other conditions (e.g. for an early-stage company) could not be relevant at all or even detrimental. So far, it is unclear whether and under which conditions engaging in collaborative innovation, for example, contributes to or might even hinder corporate decarbonization progress.

We follow the crisp-set QCA approach where both the conditions (i.e. decarbonization governance, internal low-carbon innovation, collaborative innovation, and decarbonization ambition of partners) as well as the outcome of interest (i.e. corporate decarbonization progress) can only take the values of 1 – indicating full membership in a given set (i.e. decarbonization governance mechanisms are in place) – or 0 – indicating full non-membership in a given set (i.e. decarbonization governance mechanisms are not in place) (Ragin 2008). Following this logic, cases are calibrated by coding each case regarding its membership in the condition sets and the outcome set. Calibration of the cases into these sets requires both theoretical knowledge

and case knowledge (e.g., Greckhamer et al., 2018). We developed theoretical knowledge through engagement with prior literature on governance and (collaborative) innovation. We developed in-depth case knowledge through (1) manual coding of large text data from press releases, the CDP data, and public websites and prior practical engagement and research field work within the energy industry, including with companies that constitute cases in our database.

Combining long-term and short-term perspectives of decarbonization in our outcome set, we measure corporate decarbonization progress in terms of the (long-term) ambition of corporate decarbonization targets and the extent to which these are completed (in the short-term) (see also Ioannou et al. 2016). Based on the theoretical background, we include the following 5 conditions in our analysis of the outcome set “high corporate decarbonization progress”: decarbonization governance, internal low-carbon innovation, collaborative innovation, decarbonization ambitions of partners, and early vs. advanced-stage decarbonization (see table 1).

Calibrating the outcome set. To construct the outcome set, we draw from question C4.1. in the CDP questionnaire: “Provide details of your absolute emissions target(s) and progress made against those targets”. We consider firms as successful in progressing towards net-zero (i.e., high corporate decarbonization progress) when they are both (relatively) ambitious in their targets (in the long-term) and report (relatively) high progress on the target (in the short-term). To define the threshold for ambitious targets, we draw from recent net-zero projections of the Intergovernmental Panel on Climate Change (IPCC, 2022), experiences from our own engagement in the industry, and descriptive statistics in our sample. We consider firms as ambitious that indicate a target of 50% emission reductions or higher by 2030-2040, in line with current science-based trajectories to achieve net-zero in 2050 (e.g., IPCC, 2022). Following the same logic, we consider firms as successful in progressing on their targets if they have completed at least 50% of their targets. Thus, if a firm has a reduction target of 50% or higher and

has completed as least 50% of the target, we code the outcome (high corporate decarbonization progress) as 1 – otherwise as 0.

 Insert Table 1 about here

Calibrating the condition sets. To calibrate all conditions, we again draw from our theoretical knowledge and in-depth understanding of the energy industry and case companies. To calibrate the early vs. advanced-stage decarbonization condition, we use data from the CDP and firms' sustainability reports on the share of renewable electricity generation in a firm's overall electricity generation portfolio. We consider a share of 25% and higher as (relatively) "advanced" in terms of their decarbonization pathway (coded as 1) and a share of less than 25% as (relatively) "early-stage" in their decarbonization pathway.

To calibrate the decarbonization governance set, we used data from CDP questions C1.3a and C11.3a that indicate whether or not firms implemented (1) incentive mechanisms (e.g., bonuses) for their top management (i.e., board-level) related to progress on emission reduction and (2) internal carbon prices, respectively. As there is a high correlation between the two indicators, we combined both governance mechanisms into one aggregated decarbonization governance condition. A case is coded with 1 for this condition if it has implemented both emission-related top management incentives and internal carbon prizes. We assign a 0 if there is only one of the two mechanisms in place or no mechanism is in place.

To calibrate the internal low-carbon innovation condition, we draw from CDP question C-EU9.6a which details the firms' low-carbon R&D projects. Drawing from this data, we count the number of internal R&D projects on low-carbon innovation that do not involve external partners (as they would be captured in the collaborative innovation condition). We assign a 1 if

case companies had a least 1 purely internal low-carbon innovation project. We assign a 0 if a case company does not have any purely internal low-carbon innovation projects.

To calibrate the collaborative innovation condition, we draw from all press releases related to partnerships on Factiva for the respective focal company. We manually coded 750 press releases from the last three years to identify the number of partnerships of each company in our sample. These can include collaborations with industry partners, startups, universities, and other relevant actors. We only count a partnership as relevant if it is related to innovation, applying coding schemes detailed by Zobel et al. (2016), excluding, for instance, philanthropic engagements. We use the average number of partnerships (5) to define the threshold for this condition. We consider a firm as having (relatively) high number of collaborative partnerships (i.e., coded with a 1 for this condition) if they have 5 or more partnerships. We consider a firm as having (relatively) few collaborative partnerships (i.e., coded with a 0 for this condition) if they have less than 5 partnerships.

When manually coding the partnerships for each firm, we noted down the names of each partner organization. This information was crucial for calibrating the partners' decarbonization ambitions condition. This condition captures whether a not a firm collaborated with partners that have ambitious decarbonization targets themselves. Thus, for each firm, we looked up how many of their partners have issued SBTi targets. We assign a 1 for this condition to firms that have two or more open innovation partners with registered SBTi targets. We assign a 0 if they have one or no open innovation partners with SBTi targets

After this calibration, each case (i.e. firm) has a 1 or 0 assigned for each of the five conditions. Introducing five conditions – which can be either true or false – implies that there are 32 logically possible configurations. Prior work suggests that one can include up to five conditions for a sample size of 26, indicating that per design the maximum coverage of possible configurations would be only about one fifth (Greckhamer et al., 2013). However, QCA is suited to

overcome this limited diversity in empirical instances through counterfactual analysis (Fiss, 2011).

Finally, we applied the truth table algorithm to identify configurations of these conditions that are consistently associated with an outcome of interest (i.e. high corporate decarbonization progress). In line with prior work, we apply a consistency threshold of 0.8. This indicates that the algorithm only includes configurations in which at least 80% of cases are also part of the “high corporate decarbonization progress” set for calculating the complex solution (Ragin 2008, Greckhamer et al. 2018). From there, the truth table algorithm calculates a parsimonious solution and an intermediate solution, which allow us to extract core and peripheral causal conditions, i.e., the conditions that explain (relatively) high progress in (Fiss, 2011).

RESULTS

The QCA yields three configurations that are consistently associated with (relatively) high corporate decarbonization progress. Table 1 displays the three configurations. We use black bold circles to indicate the presence and crossed circles to indicate the absence of a condition. Bigger (smaller) circles represent a stronger (weaker) link between the respective condition and the outcome. Empty fields in the table indicate that the condition can be either absent or present (i.e. “don’t care”). The “Overall Solution Coverage” indicates that the three configurations jointly account for 73.3% of the cases that were rated with a high contribution to corporate decarbonization progress. The measure of “Overall Solution Consistency” indicates that 91.6% of the cases that are part of the three configurations in Table 1 (those that fulfill the identified conditions) are also part of the high corporate decarbonization progress set (those assigned with a 1 in the outcome). In the following, we first describe the configurations. Then, following best practices in QCA (e.g., Furnari et al., 2021), we return to our case knowledge to better illustrate and make sense of the identified configurations. For this, we selected one case from each configuration to better illustrate the mechanisms of the decarbonization strategy.

 Insert Table 2 about here

Configuration 1: Governance to harness low-hanging decarbonization fruits for early-stage firms

The first configuration that is consistently associated with high corporate decarbonization progress is characterized by (1) the presence of decarbonization governance, and (2) the absence of a large share of renewables (i.e. early-stage decarbonization) as well as (3) internal low-carbon innovation. The consistency score of 0.857 implies that 85.7% of those configurations that fulfil these characteristics are also in the high corporate decarbonization progress set. The raw coverage score of 0.4 indicate that out of the 15 cases that are part of the high corporate decarbonization progress set, 40% (i.e. six cases) are described by this configuration. The result implies that for firms in the early stages of their transition towards net-zero, a focus on internal decarbonization governance rather than (internal) low-carbon innovation projects is an effective means for initiating their corporate decarbonization. When there is no internal low-carbon innovation, collaborative innovation, and ambitious partners are less relevant. As such, this configuration describes a strategy for firms that are in the early stage of their decarbonization journey which focuses on decarbonization governance rather than low-carbon innovation.

To illustrate and better explain this governance-focused decarbonization strategy, we use the case of the energy utility Vistra Corp. Vistra Corp's generation portfolio encompasses natural gas, coal, nuclear, and renewable energy, and they deliver energy to residential as well as commercial customers. Their reduction target is to reduce emissions by 60% by 2030 with a base year of 2010. We consider this an ambitious target. Currently, they have already reached 71.2% of that target, illustrating good progress on the target. However, importantly, the portfolio of their installed capacity entails less than 2% of renewables, thus we consider them as early-stage

in their pathway towards net-zero. Given the small share of renewables in their portfolio, they might focus their internal resources on adopting readily available low-carbon technologies rather than on pursuing low-carbon R&D projects. This lends some support and additional explanation to the absence of the internal low-carbon innovation condition in this configuration.

Instead, in this early stage of the decarbonization journey, they benefit from a focused governance strategy. Their top management is incentivized with a 10% weight in their annual incentive plan for ESG initiatives and all employees receive a bonus if annual climate-related targets are met. Additionally, they installed an internal carbon-price which further directs attention towards the implications of their carbon emissions.

Focusing attention on the financial implications of their carbon emissions, Vistra can likely fuel long-term net-zero strategizing by aiming at celebrating quick wins. Consequently, with their governance-focused strategy, they target “low-hanging fruits” such as the reduction of air travel and the implementation and operation of established renewable energy generation capacity, which yields immediate short-term progress in their decarbonization journey. Accordingly, Vistra Corp set a target to reduce corporate air travel by 20% and announced to reduce emissions by increasing their portfolio of zero-carbon generation assets. Furthermore, Vistra has made considerable progress in their reduction efforts by retiring coal power plants, which directly affects their carbon emissions and further emphasizes their ambition to transition towards net-zero in the long-term.

Configuration 2: Tapping into the knowledge of ambitious partners to advance early-stage decarbonization

The second configuration that is consistently associated with high corporate decarbonization progress is characterized by the presence of (1) internal low-carbon innovation and (2) collaborative innovation with (3) partners with high decarbonization ambitions, and the absence of (4) a large share of renewables (i.e. early-stage decarbonization). The consistency score of 1

implies that all configurations that fulfil these characteristics are also in the high corporate decarbonization progress set. The raw coverage score of 0.2 indicates that out of the 15 cases that are part of the high corporate decarbonization progress set, 20% (i.e. 3 cases) are described by this configuration. The result implies that there is another path to corporate decarbonization for companies in the early stages that, so far, have only a (relatively) small share of renewables. They can leverage the benefits of innovation when they combine internal with collaborative innovation that entails relationships with partners that have ambitious decarbonization targets themselves. Having decarbonization governance in place is not required. Jointly, this configuration describes a strategy for firms in the early stage of their decarbonization pathway that leverage innovation through collaborative innovation with ambitious partners.

An illustrative example of this collaborative innovation-focused strategy for early-stage firms is Duke Energy, based in North Carolina, Charlotte. They have a mix of renewable, fossil fuel and nuclear energy generation, and deliver electricity to residential and industrial customers. In CDP, they report a 12% share of renewable energy in their portfolio as their main sources are hard coal and gas. They can thus be considered early-stage in decarbonization pathway. Their target is a 50% reduction until 2030 with 2005 as the base year. In 2021, they reported a progress of 89%. Thus, we consider them as successful in their early-stage decarbonization journey. In contrast to Vistra Corp, Duke Energy's decarbonization strategy is more innovation focused. For instance, they report internal R&D initiatives for piloting different smart grid technologies for a coordinated renewable energy system, which they also pursue in collaborative innovation relationships with an ambitious partner (i.e., Siemens). Additionally, Duke is engaged in several renewable energy implementation projects with Kruger Co. Siemens and Kruger have both committed to SBTi targets and can thus be considered ambitious partners that may provide Duke Energy with access to crucial decarbonization knowledge which companies are typically lacking in the early stage of their decarbonization journey (Barbieri et al. 2020). In addition,

these collaborations may provide social pressure for Duke to catch up with their partners in terms of their net-zero pathway.

To summarize, the combination of external knowledge access and social influence mechanisms may reinforce internal low-carbon innovation which translates into accelerated early-stage decarbonization progress towards an ambitious target. In the case of Duke, high decarbonization progress is driven by the expansion of their renewable power plant portfolio in the short-term, both internally and in collaboration with ambitious partners. Simultaneously, Duke is pursuing innovative initiatives aimed at developing solutions complementing existing renewable energy technologies (i.e., energy storage solutions and digital grid coordination mechanisms) to extend their reduction potential beyond the short-term and fuel long-term strategizing. This way, Duke's innovation-focus decarbonization strategy benefits both the short- and long-term dimension of their decarbonization journey, yielding high decarbonization progress on their ambitious target.

Configuration 3: Holistic collaborative innovation and governance strategy for advanced-stage decarbonization

The third configuration that is consistently associated with high corporate decarbonization progress is characterized by the *presence* of (1) decarbonization governance, (2) internal low-carbon innovation, (3) collaborative innovation and (4) a high share of renewables (i.e. advanced-stage decarbonization). The consistency score of 1 implies that all configurations that fulfill these characteristics are also in the high corporate decarbonization progress set. The raw coverage score of 0.133 indicates that out of the 15 cases that are part of the high corporate decarbonization progress set, 13.3% (i.e. two cases) are described by this configuration. The result implies that decarbonization strategies for advanced-stage companies that already have a (relatively) larger share of renewables are different. At a more advanced stage, companies might already experience the limits of existing technologies' reduction potential and therefore face

different challenges than companies in the earlier stage. Thus, it is noteworthy that firms must reconsider their innovation or governance focus and complement it with other mechanisms to maintain momentum and ensure effectiveness as they progress in their transformation. Consequently, configuration 3 depicts a strategy which leverages the combination of decarbonization governance, internal innovation, and collaborative innovation. Importantly, in this configuration as well as configuration 2, internal R&D needs to be combined with collaborative innovation to make substantial decarbonization progress. However, interestingly, and in contrast to configuration 2, the focal company's decarbonization success does not depend on the ambitions of their partners. To summarize, this configuration describes a holistic transformation strategy for firms in more advanced stages of their decarbonization journey that leverages both governance and innovation through collaborative innovation partnerships.

To illustrate this strategy, we use the example of Sempra Energy, a utility company headquartered in San Diego, California, USA. This company has a share of renewable energy of about 30% in its portfolio. Thus, Sempra Energy can be considered as relatively advanced in its decarbonization journey. From 2019 as the baseline year, they target a 50% reduction until 2030 and report 84% progress in 2021. Thus, we consider them as (relatively) successful in their decarbonization progress. As Sempra has presumably amassed own low-carbon knowledge in their advanced stage, they are likely to benefit from investment in internal R&D related to long-term low-carbon innovations such as technology for clean generation and transportation of hydrogen. These benefits are further enabled by their large network of partners which they leverage to collaboratively pursue micro-grid projects, which might play a central role in their long-term net-zero strategy and complement internal projects. Importantly, in addition to their innovative efforts, they report an 8% weight of ESG performance for executive compensation and leverage an internal carbon price to calculate compliance costs for California's cap and trade program. These governance mechanisms are likely to elevate the benefits

of internal and collaborative innovation efforts as they provide additional incentives and funds to complement long-term innovation projects with short-term scaling of existing low-carbon technologies. As the case of Sempra further illustrates, a holistic decarbonization strategy, leveraging both (collaborative) innovation and decarbonization governance, is essential to balance short- and long-term reduction activities and to ensure ongoing decarbonization progress.

DISCUSSION & FUTURE DEVELOPMENTS

Discussion

Based on a qualitative comparative analysis, we have uncovered three configurations of corporate decarbonization governance and (collaborative) innovation efforts that facilitate corporate decarbonization. Our results suggest that decarbonization requires both: governance and innovation, but that the effectiveness of their interplay depends on the company's stage in its decarbonization pathway. Our findings furthermore highlight how companies utilize innovation and governance mechanisms in different ways to resolve the intertemporal tensions within their decarbonization journey and achieve high short-term emission reduction progress in line with long-term net-zero strategies.

In that context, we uncover the crucial role of collaborative innovation for facilitating corporate decarbonization in the short- and long-term. In fact, in both configurations including innovation related dimensions, internal innovation must be complemented by collaborative innovation to contribute to high decarbonization progress. Our empirical insights therefore suggest that companies benefit from collaborative innovation and a resulting broader low-carbon solution scope (Slawinski and Bansal 2015) both in the early stages as well as in more advanced stages of their decarbonization journey. This finding again emphasizes the complex and systemic nature of low-carbon solutions (Pinkse et al. 2024, Falcke et al. 2023), which likely overburdens the internal innovation unit of incumbents and impedes both short-term adoption and long-term development of viable emission reduction strategies. The foundational mechanism of knowledge-

transfer within collaborative partnerships might therefore be crucial for incumbent firms to build the required capabilities to engage in and progress towards a net-zero transition.

Interestingly, in the early stages of a firm's decarbonization pathway both a focus on decarbonization governance and low-carbon innovation (internally and collaboratively) independently enable the incumbents in our sample to achieve high-short term progress on a long-term ambitious target. This finding suggests that both mechanisms facilitate firms to consider both the short- and the long-term dimension of their net-zero pathway. Potentially, a strong focus on decarbonization governance that concentrates organizational attention on the initialization phase of the decarbonization journey can allow the exploitation of 'low-hanging fruits' in emission reduction. This, in turn, may fuel motivation and confidence to further engage in long-term strategizing. A focus on low-carbon innovation together with ambitious partners might follow a similar logic. Through low-carbon knowledge transfer and the social influence of their partners, incumbents can successfully engage in both short- and long-term innovation projects. These projects not only facilitate emission reduction but also the development of novel capabilities. Successfully developing these capabilities, incumbents may then pursue more concrete long-term strategizing.

More advanced companies on the other hand, may need both strong decarbonization government and (collaborative) low-carbon innovation for two reasons: (1) having achieved (relatively) high decarbonization progress, incumbents may reach a plateau of emission reduction gains through available low-carbon technologies. In order to pursue ongoing emission reduction in the short-term, they may need to implement novel complementary technologies (such as large-scale energy storage solutions). As many complementary solutions are currently not yet fully cost competitive and technologically optimized, strong decarbonization governance mechanisms are needed to drive their adoption as companies could otherwise shift their focus on their high-impact long-term projects, losing sight of short-term reduction potential. (2) As

the implementation of available low carbon technology becomes more complex and may be dependent on further technological development, engaging in innovation may become a prerequisite for incumbents to further engage with robust long-term strategizing. Our research setting provides a vivid example for this case. As electricity generation from renewable energy generation is volatile, an energy system becomes more susceptible to frequency variations with an increasing share of renewable power plants, raising the risk of blackouts. Advanced grid management technologies, hydrogen-based energy storage and micro-grid applications for instance, which are still in their infancy, are therefore indispensable components of renewable energy systems. Without these grid-stabilizing technologies, after reaching a certain share of renewable energy generation in a system, adding new renewable power plants becomes riskier, more cost-intensive or not feasible at all. Without gaining knowledge on and engaging with the most promising long-term technological developments as well as their dependencies on other technological or regulatory developments, any long-term strategizing would remain unfruitful.

To summarize, our findings showcase, that companies can strategically utilize (collaborative) innovation and governance mechanisms to successfully manage their decarbonization journey but must consider their individual status quo. In this regard, our three configurations hint at the fact that (collaborative) innovation and governance mechanisms fulfil different functions in resolving the intertemporal tensions inherent in decarbonization, which are furthermore evolving as the company progresses towards net-zero. To further uncover the underlying mechanisms enabling companies to commit to long-term decarbonization strategies and make substantial progress towards net-zero, we plan to refine our research setting as well as theoretical framing.

Future Developments

To further deepen our contribution to literature, we first aim to embed our theorizing more into the temporality literature, further investigating the concepts of temporal ambidexterity and intertemporal tensions (e.g., Wang et al., 2018; Slawinski & Bansal, 2015). Diving deeper into the tensions imposed by the short- and long-term dimensions of decarbonization, may serve fruitful in explicating underlying mechanisms of how configurations of innovation and governance facilitate decarbonization progress. We aim to revisit these concepts, investigating how companies overcome the tensions imposed by the short- and long-term dimensions of their decarbonization journey. In this regard we focus on emission reductions not as merely part of the ‘triple bottom line’, as prominent in sustainability research (e.g., Slawinski & Bansal 2015), but considering that the implications of climate change nowadays pose tangible financial and existential risks to companies, especially in hard to abate industries.

Second, we aim to modify our research setting. Given that the pathway toward net-zero in the energy industry is relatively certain—namely, increasing the share of renewables and stabilizing the grid with complementary technologies as previously mentioned—the transition is well underway across the industry. Consequently, there might be fewer tensions between the short- and long-term dimensions of the decarbonization pathway. We identified three other industries as fitting for our research: cement, steel and chemicals. All three industries have relatively high scope 1 emissions which requires them to actively transform their own processes and assets. Furthermore, when focusing on European rather than U.S. companies, the three industries experience similarly high regulatory pressure to achieve net-zero emissions, driven by the EU Emission Trading Scheme (EU ETH). Though, in all three industries there is no clear consensus which technology will enable a transformation towards producing the proprietary product with drastically reduced emissions. Companies are therefore under pressure to invest into uncertain technological developments while realizing emission reduction as soon as

possible to avert the costs of rising certificate prices of the EU ETS, which may result in higher intertemporal tensions between the two objectives.

A shortcoming of our study lies in the fact that our dependent variable only captures the long-term dimension of corporate decarbonization indirectly through the ambition of the set target. As companies frequently change targets, manipulate their emission reporting and omit negative environmental developments (Callery & Kim 2024), this measure may not adequately reflect a company's long-term strategic focus to reach net-zero in 2050. We therefore aim to capture the amount of attention and resources a company dedicates to secure long-term progress on a science-based net-zero trajectory more holistically. First, we reconceptualize our dependent variable as “high progress along a net-zero trajectory” to further emphasize its two inherent dimensions: (1) how well does the companies utilize existing technologies to set themselves on a trajectory projected to reach net-zero in 2050 (2) how much effort and resources does the company dedicate to ensure long-term progress along this trajectory?

A suitable proxy for the short-term dimension of our new dependent variable may be absolute emissions divided by revenue to account for the effect of company growth or decline. As our sample of European steel, cement and chemical companies is below $n=100$, we aim to measure the long-term dimension of our dependent variable “high progress along a net-zero trajectory” qualitatively. Twelve explorative expert interviews within these industries have revealed that there is not one measure to capture the long-term efforts of companies but multiple: (1) receipt of public funding for large-scale low-carbon projects (2) filed patents for promising low-carbon technology (3) elaborateness of net-zero transition plans and (4) net-zero targets. Based on our gained expertise of these industries and additional expert interviews to inform and validate our findings we aim to gather data on these 4 dimensions for our sample and classify our dependent variable based on small-scale case studies.

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TABLES AND FIGURES

Figure 1. A configurational framework of corporate decarbonization progress

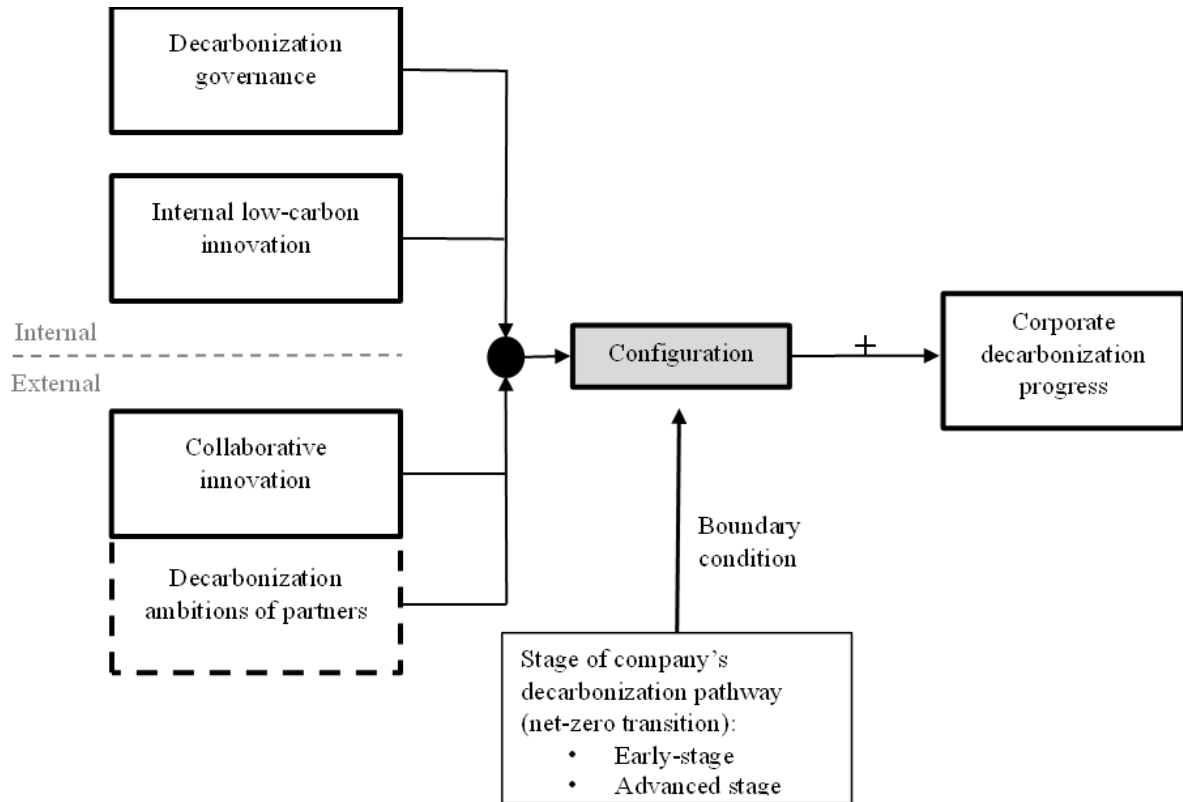


Table 1: Calibration of dimensions

Dimension	Calibration	Data source
High corporate decarbonization progress	>50% progress on a target with >50% targeted emission reduction by 2030-2040	CDP
Advanced stage decarbonization	>25% share of renewables in electricity generation portfolio	CDP, Sustainability reports
Decarbonization governance mechanisms in place	Both incentive mechanisms for top-management and internal carbon price in place	CDP
Internal low-carbon R&D innovation projects running	>1 purely internal low-carbon R&D project running	CDP
High number of collaborative partnerships	5 or more innovative partnerships in the last 3 years	Factiva
Partners with ambitious targets	2 or more partners with ambitious decarbonization targets	SBTi

Table 2. Configurations of governance and innovation dimensions associated with high decarbonization progress

	<i>High corporate decarbonization progress</i>		
	Configuration 1	Configuration 2	Configuration 3
Advanced stage decarbonization (High share of renewables)	⊗	⊗	●
Decarbonization governance mechanisms in place	●		●
Internal low-carbon R&D innovation projects running	⊗	●	●
High number of collaborative partnerships		●	●
Partners with ambitious targets		●	
Consistency	0.857	1	1
Raw Coverage	0.4	0.2	0.133
Unique Coverage	0.4	0.2	0.133
Overall solution consistency		0.916	
Overall solution coverage		0.733	