Acknowledging the water-energy nexus as paradox: antecedents and consequences

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People often ask, "What is the single most important environmental/population problem facing the world today? A flip answer would be "The single most important problem is our misguided focus on identifying the single most important problem!"

Diamond, J. (2005), *Collapse – How Societies Choose to Fail or Succeed:* Penguin, NY (p. 498)

Abstract

Climate change amplifies water quality and quantity crises through the shifting of precipitation patterns around the planet, causing an increasing number of extreme weather events with every passing year. This link has sparked growing interest over the past decade in how water and energy are connected throughout nature as well as in the design of industrial production, commonly referred to as *the water-energy nexus.* However, most of the academic discussion on the nexus has been confined to environmental sciences and has not been broached by management researchers to date. My dissertation constitutes a pioneering effort to examine the nexus from a managerial perspective.

Paradox is a fitting lens because it accommodates the relationship between water and energy as simultaneously interdependent and contradicting. Using this lens, I define two research questions regarding the antecedents and consequences of paradox acknowledgment, both of which currently understudied despite their importance. In the first study, I propose that paradox acknowledgment can be traced to the configuration of organizational attention. I examine my hypotheses using data gathered by CDP, a leading purveyor of sustainability management data. In the second study, I use the same dataset to analyze the effect of paradox acknowledgment on subsequent environmental performance. In addition to exposing the organizational impacts of the nexus, my findings exemplify that paradoxical relationships need to be explicitly acknowledged before they can be managed. On the societal level, grand challenges such as water and climate change need to be addressed as mutually dependent.

Key words: attention, climate change, environmental performance, nexus, paradox, water

Résumé du document

Le changement climatique amplifie les crises liées à la qualité et à la quantité de l'eau en modifiant le régime des précipitations sur la planète, ce qui entraîne un nombre croissant de phénomènes météorologiques extrêmes chaque année. Ce lien a suscité un intérêt croissant au cours de la dernière décennie pour la façon dont l'eau et l'énergie sont reliées dans la nature ainsi que pour la conception de la production industrielle, communément appelée le lien eau-énergie. Toutefois, la plupart des discussions universitaires sur ce lien se sont limitées aux sciences de l'environnement et n'ont pas été abordées par les chercheurs en gestion jusqu'à présent. Ma thèse constitue un effort pionnier pour examiner le lien d'un point de vue managérial.

Le paradoxe est une lentille adaptée parce qu'il tient compte de la relation entre l'eau et l'énergie comme étant à la fois interdépendante et contradictoire. En utilisant cette lentille, je définis deux questions de recherche concernant les antécédents et les conséquences de la reconnaissance du paradoxe, qui sont actuellement sous-étudiées malgré leur importance. Dans la première étude, je propose que la reconnaissance du paradoxe soit liée à la configuration de l'attention organisationnelle. J'examine mes hypothèses en utilisant les données recueillies par CDP, un des principaux fournisseurs de données sur la gestion de la durabilité. Dans la seconde étude, j'utilise le même ensemble de données pour analyser l'effet de la reconnaissance du paradoxe sur les performances environnementales ultérieures. En plus d'exposer les impacts organisationnels du lien, mes conclusions illustrent le fait que les relations paradoxales doivent être explicitement reconnues avant de pouvoir être gérées. Au niveau sociétal, les grands défis tels que l'eau et le changement climatique doivent être abordés comme étant interdépendants.

Mots clés: attention, changement climatique, eau, lien, paradoxe, performance environnementale,

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Introduction

Organizations typically frame environmental challenges as a set of compartmentalized issues (Hoffman & Ventresca, 1999; Milne & Gray, 2013). For example, the Global Reporting Initiative (GRI), an NGO that encourages business disclosure of socio-environmental performance (Etzion & Ferraro, 2010), offers a list of eight related, yet distinct domains, ranging from materials and biodiversity to supplier environmental assessment. Similarly, the Sustainable Development Goals (SDGs) that were adopted by the United Nations (UN) in 2015, offer a set of seventeen different goals, ranging from global poverty to food security.

Both GRI and SDG thus frame the otherwise nebulous concept of sustainability as a list of separate missions and goals. While overall helpful for the cause of sustainability management, such lists inevitably undermine the mutual dependencies between various goals. For instance, issues related to plastic use - which are currently classified by GRI solely under materials, have profound implications on many other topics including biodiversity, emissions, waste, and supply chain. More in general, environmental challenges take place within overlapping spatial and temporal boundaries, thereby inevitably affecting one another (NOAA, 2020; Schumacher, 2012; Whiteman, Walker, & Perego, 2013).

Against this background, a more inclusive approach to environmental sustainability is emerging (Ike, Donovan, Topple, & Masli, 2019; Schad & Bansal, 2018). The recent report by the Intergovernmental Panel on Climate Change (IPCC) delineated synergies and trade-offs between SDGs (IPCC, 2018), and research has suggested that analyzing their interactions can foster priority setting for policy and planning (Etzion, 2018; Le Blanc, 2015; Weitz, Nilsson, & Davis, 2014; Zhenmin & Espinosa, 2019). In line with this nascent trend, my dissertation sheds light on the interplay between two of the most prominent issues that humanity will be facing throughout the rest of the 21st century: climate change and water crises.

It is by now well-known that climate change means not only average warming of the atmosphere but also fundamental destabilization of global precipitation patterns, thereby reinforcing water quantity and quality crises (Howard-Grenville, Buckle, Hoskins, & George, 2014; NOAA, 2020; MunichRE, 2020; Whiteman et al., 2013). As a result, arid regions in North Africa and the Middle-East will become even drier, while cities closer to coastlines will experience frequent flooding and groundwater pollution (Montgomery, Lyon, & Zhao, 2018). According to the World Economic Forum (WEF), extreme weather events (MunichRE, 2020) and failure of climate change mitigation and adaptation are now among the top three global risks, whereas water crises are among the top five (WEF, 2019).

The fused threat of climate change and water shortage has sparked interest in the *"Water-Energy Nexus",* a term indicating the complex relationship between water and energy in civil and industrial infrastructure design (Bazilian et al., 2011; Cook & Bakker, 2012; Schnoor, 2011). At its core, the nexus expresses the idea that water and energy systems are tightly intertwined. Water is used in all phases of energy production and electricity generation, and energy is required to extract and deliver and treat water to support basic human needs (Smajgl, Ward, & Pluschke, 2016). However, academic discussion on the nexus has been largely confined to environmental sciences, with little spillover to other fields such as public policy, urban planning, industrial ecology and environmental sociology (Khavul & Bruton, 2013; Kilkis & Kilkis, 2017; Pacetti, Lombardi, & Federici, 2015; Vieira & Ghisi, 2016).

My thesis constitutes a pioneering effort to add a managerial perspective to the nexus literature. Many sectors, and especially heavy industries like oil & gas, utilities, and mining, are now subject to increasing physical disruptions such as storms, floods, and droughts, that originate in climate change yet feed water shortages (Schaefer, 2009; Sneddon, Harris, Dimitrov, & Ozesmi, 2002). Climate change also heightens the sociopolitical sensitivity surrounding the transportation, distribution and pricing of water. Managerial frameworks that consider climate change and water as intertwined rather than separate may allow actors to develop a long-term capacity to cope with these challenges simultaneously.

My thesis is comprised of four chapters. The first chapter lays out the theoretical foundation for the empirical studies conducted in chapters 2 and 3, and the fourth chapter summarizes. In chapter 1, I provide more background on the nexus and its relevance to critical sectors. I explain how it fits an *organizational paradox* perspective based on the definition of the latter as two elements (water and energy) that are simultaneously interdependent and contradicting (Smith & Lewis, 2011). In contrast to the current body of literature emphasizing paradox-related strategizing, I focus on paradox *acknowledgment*. I provide a formal definition of this concept and define two broad research questions around it: 1) What are the antecedents of paradox acknowledgment? 2) What are the organizational-level outcomes of paradox acknowledgment?

In chapter 2 I examine the first research question. I review the literature on how paradoxical relationships become salient (Schad, Lewis, Raisch, & Smith, 2016) and conclude that it had overlooked the role of attention in fostering paradox acknowledgment. I propose an Attention-Based-View (ABV) model of *paradox attendance*, relating attentional quantity, quality, and coherence (Rerup, 2009; Weick & Sutcliffe, 2006) to the acknowledgment of the nexus as paradoxical. I derive several hypotheses which I then test empirically. To this end I use a longitudinal dataset of firms' responses to the CDP water and energy surveys between 2010-

2018. This dataset is suitable because the water survey directly inquires respondents regarding their approach to the relationship between water and energy. In chapter 3 I examine the second research question. I review the literature on paradox management and conclude that there is no empirical evidence regarding the effects of paradox management on environmental performance (Hahn, Figge, Pinkse, & Preuss, 2018). I derive another hypothesis targeting this gap which I test using the same dataset as chapter 2.

Findings from both chapters suggest that the nexus is under noticed, supporting my overarching claim about the importance of paradox acknowledgment. In chapter 4, I summarize and discuss my contribution. My research unravels the organizational implications of the water-energy nexus, points to the importance of explicitly acknowledging it, and suggests pathways of doing so. Furthermore, it heeds recent calls to examine paradox in the context of sustainability using a large-N sample (Hahn et al., 2018).

Chapter 1: Theoretical framework

1.1 The water-energy nexus

"Nexus" can mean either a center, focus, connection, link, or otherwise a connected group or series (Merriam-Webster, 2002). The water-energy nexus refers to the intertwined relationship between the water used for energy production and distribution on the one hand, and the energy consumed to extract, purify, deliver, heat/cool, treat and dispose of water – on the other hand (Hussey & Pittock, 2012; Scott et al., 2011). This notion (henceforth: the *nexus*) first appeared in environmental science journals in the early 2010s, as part of a broader discussion regarding the Water-Energy-Food nexus (Albrecht, Crootof, & Scott, 2018). According to Web of Science (2019), the nexus has been cited more than 300 times between 2009-2018 compared to only a few dozen times before. Al-Saidi and Elagib (2017) proposed several drivers for this trend, including an increase in resource interconnections due to growing scarcities, and failures of sector-driven management strategies. My dissertation focuses on water and energy because these are amenable to organizational-level management and analysis through common measures such as water withdrawals (Hogeboom, Kamphuis, & Hoekstra, 2018) and carbon emissions (Lewandowski, 2017). In contrast, food-related metrics are more indirect and long-term. What follows is a succinct review of nexus-related literature. My underlying argument is that there is currently no academic knowledge of how water and energy interact within organizations.

1.1.1 Managerial literature on water

As the social and environmental implications of the looming water crises unfold, it is increasingly identified as a key point of vulnerability affecting a multitude of organizational aspects (CDP, 2019). At the same time, Kurland and Zell (2010) note that "sustainable resource management has not yet entered the collective psyche of business scholars" (p. 342). In the decade that had passed since their review of water and business research, only a handful of additional papers have been published in top management journals.

Fan and Zietsma (2016) examined the bridging of logics across multiple fields in a water-related context. Montgomery et al. (2018) studied the contextual and institutional factors that influence drinking water management and quality, and Bowen, Bansal, and Slawinski (2018) analyzed water as a collective action problem. Montgomery and Dacin (Forthcoming) pointed to the dynamic nature of institutionalization processes surrounding the Detroit water shutoffs. The sub-fields of water-related innovation (Wehn & Montalvo, 2018) and water accounting (Christ & Burritt, 2017; Sengupta, 2017) have also seen some initial coalescence. Despite this growing interest (Andrus et al., 2019), there are still critical gaps in researching the role that organizational actors (should) play in a water-constrained reality.

First of all, water is an integral part of the natural environment domain, which is still outside the mainstream of business literature (Etzion, 2018). Moreover, water is characterized by unique features that set it apart even within this domain. First, managing water is typically a highly localized endeavor since they are bulky and not easily transportable (Savenije, 2002). This is unlike carbon emissions, which are amenable to summation and offsetting across remote locations (MacKenzie, 2009). Second, water is flowing, whereas energy commodities such as coal, fuel, and natural gas are typically contained or extracted. Therefore, water often involves fundamentally unique pricing and usage models. Third, water is characterized by a special societal status that embodies cultural, spiritual and religious meanings (Solomon, 2010), further complicating their management and governance. Overall, given that water research is still in such a nascent stage, it is not surprising that water-energy interactions have also remained under the scholarly radar.

1.1.2 Managerial literature on energy

In comparison with water, management literature on energy is somewhat more developed, albeit not yet on par with the urgency of the environmental predicament. As noted by Howard-Grenville et al. (2014), while climate change is already shifting both water and energy demands across the supply and value chain, research in this field is still only gaining traction. As with water, this is symptomatic of the slow progress of natural environment concerns from the margins to the core of the academic agenda. One subject that did receive relatively more attention is carbon accounting, possibly because it has been identified as a major pathway through which organizations can mitigate climate change (Hahn, Reimsbach, & Schiemann, 2015).

Furthermore, actors operating in the energy sector have recently been subject of research on social movements (Hiatt, Grandy, & Lee, 2015), nonmarket strategy (Georgallis, Dowell, & Durand, 2019) and grand challenges (Etzion, Gehman, Ferraro, & Avidan, 2017). For example, Hiatt et al. (2015) found that petroleum companies responded differently to political pressures depending on whether the source of pressure was internal (private) or external (public). These findings emphasize the role of environmental activists in swaying firm behavior. Georgallis et al. (2019) found that state support for the emergent photovoltaic industry in Europe was dependent on the industry's identity coherence in each country, particularly as opposed to more traditional industries with contrasting identity such as fossil fuels. In a similar vein, Ion B. Vasi's book on the global development of the wind energy industry (reviewed in Eesley & Hannah, 2012) brought forth the role of the surrounding social fabric in the institutionalization of such emerging sectors. The success of wind power in Denmark had inspired research on the use of non-conventional management strategies in the face of grand challenges (Etzion et al., 2017). However, much like with water, energy has been considered so far as a standalone issue.

1.1.3 Non-managerial literature on the nexus

Water and energy interactions are prominent across various industries and in many cutting-edge technologies. The June 2011 Special Issue of the Environmental Science & Technology Journal (Schnoor, 2011) was the first collection of peer-reviewed articles dedicated to the nexus, which explained how it plays out in hydraulic fracturing ("Fracking"), reuse of wastewater for drinking supplies, feedstock irrigation for the production of biofuels (Gopalakrishnan et al., 2009) and the provision of cooling water for electric power stations (DeNooyera, Peschel, Zhang, & Stillwell, 2016).

The public policy sphere saw the emergence of discussions on the social and institutional implications of the nexus and on the need to promote integrated water/energy decision-making (Bazilian et al., 2011). For instance, Scott et al. (2011) claimed that energy policies are usually determined on a national or regional scale, whereas water decision-making is more geographically fine-tuned due to their local boundedness. Rather than being coupled at the endpoint of resource use, the water-energy dyad thus reveal[s] "a broader set of institutional relationships and highlight[s] decision-making challenges faced by society" (Scott et al., 2011: 6623). Al-Saidi and Elagib (2017) pointed to the need for "nexus governance" to permeate decision-making across all levels. To this end, Hussey and Pittock (2012) suggested applying key concepts and tools from system dynamics such as accumulation, feedback, and causal loop diagrams. The nexus was also addressed in the context of urban planning (Kahrl & Roland-Holst, 2008; Siddiqi & Anadon, 2011). For example, Kenway, Lant, Priestley, and Daniels (2011) pointed to the lack of unifying frameworks and consistent methodology upon which to set trans-city comparisons.

1.1.4 Literature review summary

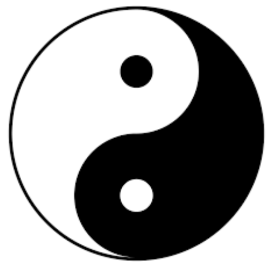
Notwithstanding some industry-specific literature (Elimelech & Phillip, 2011; Hasanbeigi & Price, 2015), water and energy have been so far studied as standalone issues. A managerial perspective regarding the nexus is overall missing. At the same time, critical sectors such as mining and utilities are already subject to nexus-related disruptions (Slawinski & Bansal, 2012). For instance, Hurricane Sandy (NOAA, 2020) demonstrated that vital water infrastructure can be impaired when it loses power, and severe droughts throughout the United States constrained the operation of power plants and other energy production units (Siddiqi & Anadon, 2011).

In addition to its practical relevance, the nexus is theoretically interesting because it demonstrates that environmental sustainability challenges are tightly linked (IPCC, 2018; Weitz, Carlsen, Nilsson, & Skånberg, 2018). Over the next section I propose paradox as a perspective that provides theoretical traction for exploring such interrelations (Schad & Bansal, 2018; Williams, Kennedy, Philipp, & Whiteman, 2017).

1.2 The nexus as organizational paradox

Paradox has roots in both eastern and western philosophy (Schad et al., 2016). Eastern teachings viewed the nature of existence as a series of opposites that are also interdependent, e.g., day-night, male-female, and life-death, and often employed the Taoist symbol of Yin Yang (Figure 1) to express this idea. The black and white poles in this symbol are contrasting, yet at the same time fit each other and create an inseparable whole.

Figure 1: Yin Yang as a metaphor of organizational paradox



Western thought on paradox began in ancient Greece, as implied by the word's etymology (*para* – contrary to*, Doxa* - opinion). Socrates sought to "solve" paradox, e.g., to find a way out of the loop generated by the statement "I am lying", as a means of exploring the nature of truth and logic. In the modern era, the Socratic dialogues were further developed by Hegel (1969) who posited "thesis" and "antithesis" as two elements subject to a natural conflict. Paradox is also embedded in western phycological thought. Jung (1965) suggested that embracing interwoven opposites (such as trust-distrust and love-hate) is good for mental health, and Anna Freud (1937) developed psychoanalytic practices to counteract unhealthy responses to paradox such as avoidance, splitting, and projection.

Early organizational theorists built on these philosophical and psychological foundations to shape the meaning of paradox for management science (Poole & Van de Ven, 1989). Schad et al. (2016)'s definition of paradox as a persistent contradiction between interdependent elements, reflects the common understanding that the core characteristics of paradox are contradiction and interdependence, in line with the origins of the term. Contradiction happens when two demands, e.g., individual differences and collective cohesion, appear logical in isolation but absurd when juxtaposed (Lewis, 2000). Interdependence means that these elements are in fact two sides of the same coin so that one cannot exist without the other. Another element of paradox is its persistence. Despite their dynamic relationship, the Yin Yang duality is forever resistant to any one-sided solution. This implies a processual perspective on paradox whereby the two elements continuously form and reform each other.

Smith and Lewis (2011) noted four categories of organizational work that are typically permeated by paradoxes: learning, belonging, organizing, and performing. For instance, exploration/exploitation, stability/change, and short-term/long-term have all been studied as representing paradoxical poles in the context of learning (Schmitt & Raisch, 2013). Consequently, paradoxical phenomena have been studied under ambidexterity (Raisch & Birkinshaw, 2008), change (Farjoun, 2010), innovation (Smith & Tushman, 2005), governance (Sundaramurthy & Lewis, 2003), social enterprise (Jay, 2013), identity (Ashforth & Reingen, 2014), culture (Fang, 2012) and routines (Pentland, Feldman, Becker, & Liu, 2012). Paradox has also inspired research in the field of corporate sustainability, mostly around the tensions between competing yet interrelated economic, environmental, and social concerns (Hahn et al., 2018) and between short term and long term goals (Slawinski & Bansal, 2015).

Although most of the work on paradox pertains to the organizational level, it is relevant to additional levels of analysis. At the individual and team level, it often takes the form of dilemmas around leadership and everyday work (Hahn, Preuss, Pinkse, & Figge, 2014; Miron-Spektor, Ingram, Keller, Smith, & Lewis, 2018) and it can also manifest as tensions at the inter-organizational or field level, for example between academics and practitioners (Bartunek & Rynes, 2014). Under data availability limitations that are further clarified in the empirical chapters, I henceforth focus on organizational-level dynamics, thereby excluding the inter-organizational, team, and individual levels from further analysis.

Of note, in their natural form water and energy are not paradoxically related but fundamentally different. Water is a specific chemical compound that is bulky, fungible, nonsubstitutable and location bound (Savenije, 2002), whereas energy comes in many forms, including gas, liquid, light, heat and wind. The relationship between the two becomes paradoxical when they are co-managed by organizational actors, as I show next (Schad et al., 2016).

1.2.1 Water and energy are interdependent

Water and energy must be managed interdependently and in consideration of their reciprocal effects. This is most conspicuous in heavy industries such as utilities, oil & gas, and mining, where vast amounts of water are needed for mining coal, drilling oil, refining gasoline, and generating and distributing electricity whereas energy is needed to pump, transport, treat and distribute water (Hussey & Pittock, 2012).

Furthermore, improving the efficiency of water usage along the production line can often lead to energy-related benefits and vice versa. Bazilian et al. (2011) noted several fields where such synergies are most prevalent: irrigation efficiency, soil and farm management, and the incorporation of renewable energy in water treatment plants. On the other hand, they noted that a positive correlation between water and energy oftentimes means wastefulness in both, as in the case of badly positioned hydropower plants (see Table 1).

1.2.2 Water and energy are contradicting

Water and energy are also opposing in the sense that improving the balance on one front often comes at the expense of the other. For instance, operations such as expansion of hydropower, groundwater pumping, and desalination increase freshwater balance at the expense of heightened carbon emissions. In contrast, the expansion of bioenergy production, carbon capture and storage, and shift from coal to gas – all translate to decreasing energy footprint at the expense of water use.

Co-managing water and energy is also a source of spatial tensions. Water interactions are typically location bound (Kennedy, Whiteman, & Schwedler, 2017; Mair, Wolf, & Seelos, 2016), whereas energy-related impacts, such as carbon emissions, can be measured globally (Bansal, Kim, & Wood, 2018). Another source of tension is temporal asymmetry. While energy concerns such as carbon emissions are already addressed by many, water issues are still nascent, so that their incorporation is likely to destabilize existing routines (Wehn & Montalvo, 2018).

1.2.3 Summary: The nexus as simultaneity of interrelations and contradictions

Table 1 below exemplifies the simultaneity of interrelations and contradictions between water and energy. The upper left and lower right quartiles show contradictions, i.e. technologies whose implementation saves either water at the expense of energy (upper left) or energy at the expense of water (lower right). The upper right and lower left quartiles show interrelations, i.e. technologies whose implementation either saves (upper right) or wastes (lower left) both.

Table 1[1]: Interrelations and contradictions between water and energy

Saving water at the expense of energy (Contradictions) • Water and wastewater treatment plans • Decentralized rainwater harvesting systems • Groundwater pumping • Inter-basin transfers • Desalination	**Saving both water and energy (Interrelations)** • Energy and water conservations • Irrigation efficiency, soil management, better farm management practice • Combine renewable energy + water treatment plants
Wasting both water and energy (Interrelations) • Bioenergy production (net negative energy generation + increase in water consumption) • Badly positioned hydropower plants • Inappropriate agricultural crop production	**Saving energy at the expense of water (Contradictions)** • Expansion of hydropower • Expansion of bioenergy production • Shift from coal to gas in urban areas • Underground thermal energy systems for urban households • Concentrated solar thermal

[1] Adapted from Bazilian et al. (2011)

To summarize, managing the relationship between water and energy can be depicted as handling both interdependencies and contradictions, in line with the definition of organizational paradox (Schad et al., 2016). Furthermore, since this relationship is embedded in the laws of nature, it is also enduring, coinciding with paradox being persistent. Energy will always be required to withdraw, transport and treat water, and water will remain immanent to power generation, mining and oil drilling. As climate change and water crises continue to dominate the environmental agenda, nexus-related challenges are bound to become increasingly present in organizational life.

1.3 Research questions

The purpose of this research is to explore the organizational implications of the water-energy nexus, using the paradox theory as a theoretical lens (Weick, 1996). To find a hook within the paradox literature, I used Schad et al. (2016)'s review of 133 paradox articles from the period 1990-2015. Two topics that were found particularly dominant are approaches to paradox management (40% of the articles) and their outcomes (36%). In contrast, only 15% of the articles examined how paradoxical relationships become noticed in the first place. This is important because, as noted by Schad and Bansal (2018), a paradox can exist ontologically without being epistemologically present, i.e., remain under the organizational radar despite its relevance.

My first broad research question directly counters the bias towards outcome-driven research on paradox. Instead, I ask *what are the drivers of paradox acknowledgment?* In the context of the nexus this translates to asking how actors come to realize that water and energy in their own jurisdictions are indeed interdependent yet contradicting. In chapter 2 I define *paradox acknowledgment* and explore this question further.

My second broad research question is *what are the organizational outcomes of paradox acknowledgment?* While well-represented within the current body of research, this question should not be dismissed. This is because ultimately, a paradox perspective is meaningful only to the extent that it allows actors to come up with innovative strategies for meeting complex challenges. I examine this question further in chapter 3. Together, the two questions correspond to the antecedents and consequences of paradox acknowledgment, like previous work in our field that examined various phenomena from both ends (Kraatz & Zajac, 1996; Raisch & Birkinshaw, 2008; Rindova, Williamson, Petkova, & Sever, 2005).

Chapter 2: The antecedents of paradox acknowledgment

In line with the first research question, in this chapter I explore what we currently know about what makes organizations acknowledge paradox, leading up to the formation of hypotheses concerning the nexus. I begin by providing a formal definition of paradox acknowledgment, followed by an overview of the literature regarding its antecedents. I conclude that the literature has overlooked the role of attentional structures in catalyzing paradox acknowledgment. I then explicitly define paradox attendance and propose a theoretical model to explain how it pre-empts acknowledgment (Figures 2 & 3). I derive four research hypotheses (H1-H3b) and examine them. The empirical sections include the research context, data, final sample, analytical method, findings, and summary.

2.1 Paradox acknowledgment

To give background to my definition of *paradox acknowledgment*, I introduce two closely related concepts from the literature: paradox acceptance and paradox resolution, which are not synonymous with acknowledgment despite their similar notations. As shown in Figure 2, both acceptance and resolution represent strategies that organizations employ to *cope* with paradox once it has been recognized, i.e. they *follow* acknowledgment. Over the next section I explain the remaining strategies depicted in Figure 2 (i.e., spatial and temporal separation) in the context of paradox attendance. All four strategies originated in Poole and Van de Ven (1989).

Paradox acceptance has been defined as "*embracing* paradoxical tensions via a strategy of working through" (Smith & Lewis, 2011 p. 389 – italics added), in other words finding tactic ways to contain the paradox and live with it. For example, Lüscher and Lewis (2008) found that middle managers could more effectively live with the tensions between stability and change by adopting day-to-day improvisation practices that allowed them to move forward, rather than getting stuck in the face of recurring tensions.

In contrast, *paradox resolution*, also sometimes referred to as *synthesis* (Ivory & Brooks, 2018), has been defined as "*confronting* paradoxical tensions via iterating responses of splitting and integration" (Smith & Lewis 2011, p.389 – italics added), i.e., managing the paradox pro-actively via the identification of a novel solution. In a study of model changeovers at Toyota, Adler, Goldoftas, and Levine (1999) found that the company nurtured interwoven organizational structures to allow workers to contribute to nonroutine tasks while working in routine production. Andriopoulos and Lewis (2009) discovered that firms facing new product design cultivated a paradoxical vision through iterating between project constraints and freedom as well as purposeful improvising. Birkinshaw, Crilly, Bouquet, and Sun Young (2016) showed that setting-up a unique dual headquarters structure facilitated employees' orientation towards simultaneously addressing global integration and local responsiveness.

Both acceptance and resolution revolve around tensions that are immediately apparent. The Danish Lego company was going under extensive restructuring when examined by Lüscher and Lewis (2008), and the Dutch software company studied by Birkinshaw et al. (2016) needed to expand to Asia while maintaining its customer base in mid-Europe. There seems to be no equivalent term in the literature to signify the formation of collective cognition of paradox.

To this end and following the previously quoted definition of paradox by Schad et al. (2016), I denote *paradox acknowledgment* as organizational noticing of two elements as simultaneously interdependent and contradicting. I use the term "noticing" to imply the role of attention (Ocasio, 1997) in pre-empting acknowledgment as elaborated over the next section. I use the term "acknowledgment" rather than "awareness" to imply a somewhat positive (rather than neutral) inclination towards paradox that is not as sweeping as implied by the notions of acceptance and resolution.

2.1.1 Current knowledge on paradox antecedents

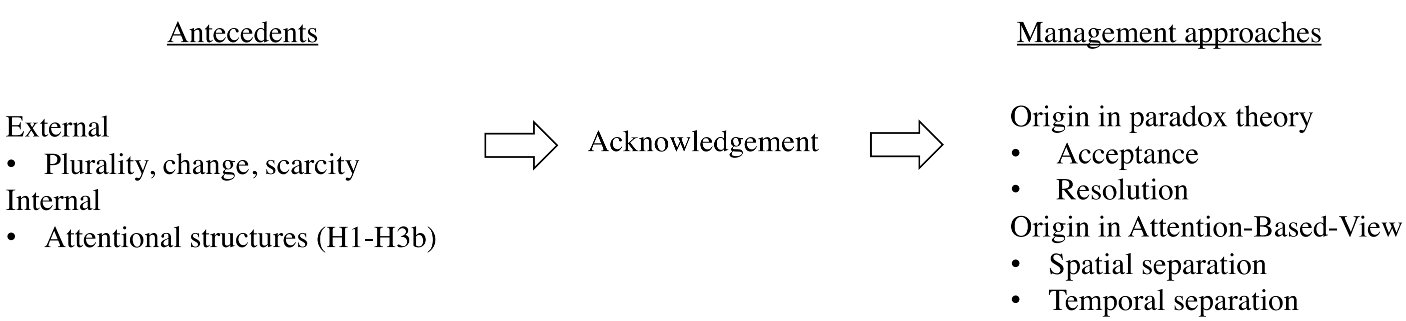
Although paradox acknowledgment was not previously defined, there is a common understanding in the literature that paradoxical relationship are more likely to become salient during turbulent times, and especially under conditions of plurality, environmental change and resource scarcity (Smith & Lewis, 2011; Wry & Zhao, 2018). A *Plurality of opinions* has been associated with multiple stakeholders raising competing demands, pulling in different directions, and surfacing strategic conflicts in the process (Crilly & Sloan, 2014; Denis, Langley, & Sergi, 2012; Donaldson & Preston, 1995). *Environmental change* involves the creation of a future distinct from the present, thereby inciting further conflict between the exploitation of existing competencies and the exploration of new opportunities (Raisch & Birkinshaw, 2008). Finally, *resource scarcity* further intensifies the recognition of tensions by challenging the ability to meet competing demands (Schmitt & Raisch, 2013).

Whereas all three conditions are related to environmental turbulence, only a handful of studies have considered other organizational dynamics as potentially leading up to paradox acknowledgment. Zimmermann, Raisch, and Birkinshaw (2015) found that an organization's decision to adopt an ambidextrous orientation involved frontline managers taking the initiative to anticipate changing requirements that were unnoticed by higher-level officials. Ivory and Brooks (2018) proposed a conceptual model of how certain dynamic capabilities may lead to paradox awareness. They defined *strategic sensitivity* as "…deep involvement in the ecosystem and preferential relationships with providers of [relevant] knowledge" (p. 351). Paradox acknowledgment in their model is thus achieved through first-hand familiarity with stakeholders such as suppliers, regulators and nearby communities (Weber & Tarba, 2014).

2.1.2 Main gaps

The literature on paradox antecedents has focused primarily on environmental turbulence, while seemingly ignoring other potentially important factors. In particular, although both water crises and climate change certainly entail environmental turbulence, some actors still fall short of noticing either (Bansal et al., 2018). As alluded to in the preamble, this might be the case because natural environment issues are still considered marginal in comparison with “traditional” business concerns even among management scholars, let alone among practitioners (Hiatt et al., 2015; Kurland & Zell, 2010). Therefore, another necessary condition for paradox acknowledgment presumably involves the explicit assignment of organizational resources for ongoing attendance of the issues involved. In the following section I develop a theoretical model to explain how the configuration of organizational attendance can play out in the process of nexus acknowledgment.

Figure 2: The paradox engagement chain



2.2 Paradox attendance

In this section I develop a theoretical model to explain how paradox attendance may lead to paradox acknowledgment (Figure 2), from which I derive nexus-specific hypotheses. The generalizability of the model (Lincoln & Guba, 1985) is discussed in chapter 4. Attendance was so far discussed as following acknowledgment rather than preceding it. As shown in Figure 2, spatial and temporal separation, which originate in Attention-Based-View (ABV) and organizational design, represent two additional strategies for paradox management, alongside acceptance and resolution.

Spatial separation was originally coined by Poole and Van de Ven (1989) to mean working with paradox through structural segregation of competing yet co-existing demands, for example, clarifying levels of reference between upper echelons and the line workers of the organization. Bradach (1997) illustrated how separating associated tasks into different operating units allowed management of tensions between a firm's need for internal alignment and market pressures for adaptation. Distinct organizational units were also previously shown to have successfully handled exploration and exploitation (Boumgarden, Nickerson, & Zenger, 2012; Tushman & O'Reilly, 1996).

Temporal separation involves allocating competing demands to sequential periods. Early studies of ambidexterity recommended a shifting focus between exploration and exploitation depending on current demands for efficiency versus change (March, 1991; Tushman & Romanelli, 1985). Similarly, Chung and Beamish (2010) described temporal separation between cooperation and competition in joint ventures facing multiple ownership changes, and Klarner and Raisch (2013) demonstrated how organizations balance the opposing forces of change and stability through the sequential approach.

To summarize, separation of attention along place and time has been proposed as conducive for controlling the conflicts associated with paradox. While beneficial for paradox management, these strategies might nevertheless hamper its recognition. For example, if water and energy are pre-assigned to separate units, the likelihood of nexus acknowledgment might diminish because of various communication shortages and bureaucratic gaps (Kim & Davis, 2016). Over the next section I lay out a theoretical foundation to account for how attendance precedes acknowledgment. I begin by noting the general emphasis in ABV on the structural distribution of attention (Pinkse & Gasbarro, 2019).

2.2.1 Attention Based View (ABV)

Ocasio (1997) initially proposed ABV as a combination of perspectives from the Carnegie school (Simon, 1945 [1976]), issue selling & agenda management (Dutton & Ashford, 1993) and enactment (Weick, 1979). He positioned it around three main principles: 1) that decision-makers act based on given sets of issues and answers upon which they focus their attention, 2) that such focus is subject to changes depending on the situational context in which they operate, and 3) that such focus can be molded throughout the organization using a *structural distribution of attention*, i.e., through the use of procedures, rules and other communication channels that govern attention flow.

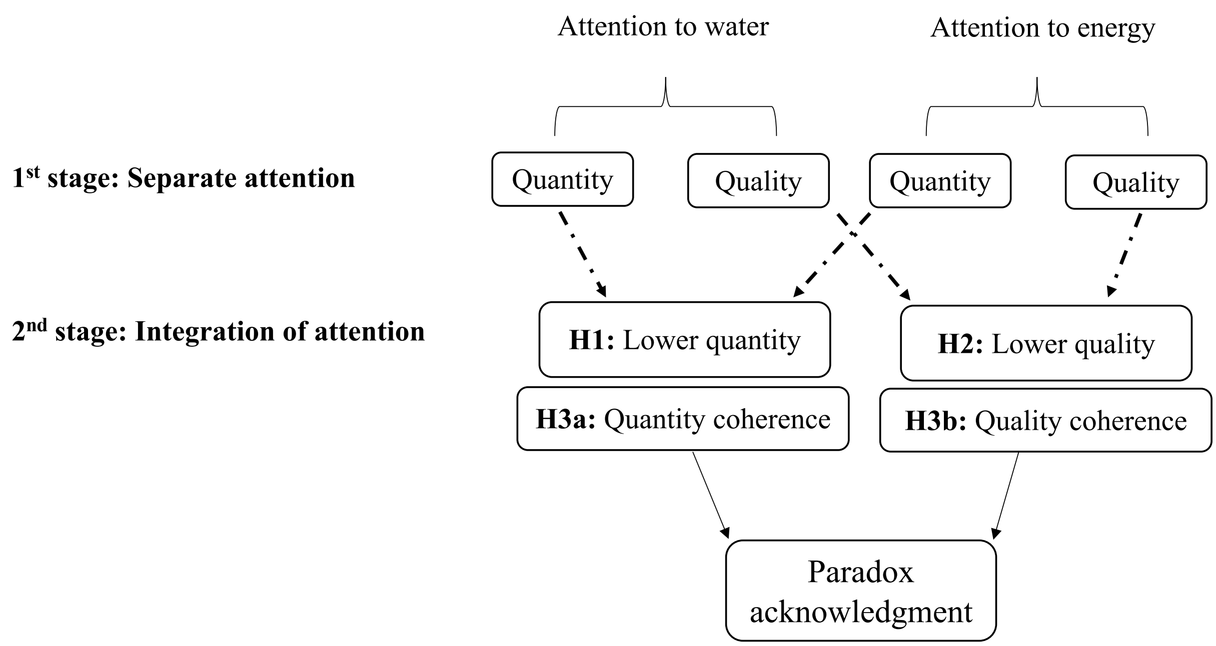
Ocasio (2011) later reviewed ABV research concerning the structural distribution of attention as comprised of attentional perspective, attentional engagement, and attentional selection. *Attentional perspective* is a top-down *structure*, e.g., mental templates and cognitive frames (Shepherd, Mcmullen, & Ocasio, 2017; Walsh, 1995) that governs attention flow. In contrast, *Attentional engagement* concerns the *process* of sustaining attention on a given set of stimuli as prescribed by the top-down perspective. Finally, *attentional selection* has been related to the outcomes of engagement and to the mechanisms that allow the choice of specific stimuli to the exclusion of others.

As a problem of *attention allocation* (Haas, Criscuolo, & George, 2015), i.e., dynamic prioritizing between water and energy, the nexus is especially relevant to attentional engagement and selection. Greve (2008) used the term *sequential attention* to denote how actors attend size-related goals at certain times and performance goals during other periods to avoid having to settle contradictory requirements (Joseph & Wilson, 2018). Sullivan (2010) examined competition for attention between problems from different domains and found that attention was paid first to the domain with the greatest number of problems. Stevens, Moray, Bruneel, and Clarysse (2015) noted several environmental factors whose presence tilted actors' towards attending social rather than financial goals. While these sources offered sequential attention to explain how actors address multiple cues, little is currently known on how other features of attendance play out in the process. Next, I develop a model that explains how attentional quantity and quality combine to generate simultaneous recognition of water and energy, i.e., paradox acknowledgment.

2.2.2 A two-stage model of paradox attendance

My model is comprised of two stages (Figure 3): In the first stage water and energy are attended separately. I characterized the attention assigned to each topic in the first stage by its quantity and quality, corresponding to two broad perspectives in the attentional engagement literature (Levinthal & Rerup, 2006; Ocasio, 2011; Weick & Sutcliffe, 2006). It is the dynamics that take place in the second stage that ultimately drive paradox acknowledgment, and correspondingly where ABV meets paradox in my model. In this stage, attentional qualities and attentional quantities combine to form four different constructs which ultimately determine paradox acknowledgment. I provide an example in Figure 4 below.

Figure 3: A two-stage model of paradox attendance



Attentional quantity: Early organizational scholars viewed attention as a limited resource, and decision-makers as having bounded capacity (Cyert & March, 1963 [1992]; March & Simon, 1958). In the following decades, this notion has garnered considerable support (Gavetti, Levinthal, & Ocasio, 2007; Levinthal & March, 1993; March, 1991). For example, a positive relationship was found between actors' slack resources in terms of time and money and their ability to attend multiple goals (Stevens et al. 2015).

Since water and energy are complex in and of themselves, I suggest that the likelihood of paradox acknowledgment is positively correlated with the amount of attentional resources assigned to each topic (Ocasio, 1997). Specifically, the chances of acknowledgment in my model are determined by the amount of resources assigned to the less-attended topic. As long as either water or energy is under-attended, actors may develop a unidimensional or otherwise superficial approach to it, and paradox as a whole is more likely to eschew the agenda.

Supporting this line of thought, Weaver, Trevino, and Cochran (1999) have shown that structurally disaggregating ethics and social responsibility from the rest of the organization minimized their influence on strategic decision making. In turn, subsequent socio-economic dilemmas were less likely to be seen as an opportunity for constructive inquiry. I use the notation *lower quantity* (Figure 3) to refer to whichever is lower between the level of attentional quantity (e.g. time, money and other organizational resources) assigned to water and the respective level for energy.

Hypothesis 1: *The higher the attentional quantity assigned to the less attended topic (water or energy), the higher the likelihood of paradox acknowledgment.*

Attentional quality: Weick and Sutcliffe (2006) challenged prior scholars' perspective of attention as a limited resource, arguing that it reduces attendance to a technical procedure involving semi-automatic screening of cues based on pre-existing schemas. Novel or otherwise unusual stimuli challenge the rationale guiding such readymade templates and are therefore likely to be ignored. In contrast, these authors proposed to interpret attention as *mindfulness* and traced this concept back to its roots in eastern philosophy. Mindful attendance involves the acknowledgment of any pre-existing systems of interpretation and classification (such as thoughts, concepts and emotional reactions) as essentially temporary and fleeting, thus allowing for the new and unfamiliar to emerge. The authors further suggested stability and vividness as two necessary conditions for achieving a high quality of attention.

Stability is important because it is a measure of the discipline exercised throughout the practice of mindfulness. High quality is only attainable to the extent that attention has been sustained persistently over time. *Vividness* has to do with the level of concentration that is reached in the practice, in terms of allowing the breaking-down of past habits in favor of new information flows. Weick and Sutcliffe (2006)'s emphasis on quality thus complements the more traditional view of organizational attention as essentially resource-bound.

Increasing the stability and vividness with which a given topic is attended is expected to allow the noticing of new and unfamiliar details surrounding it. However, according to my model, this on its own will not increase the likelihood of paradox acknowledgment. Such effect will only be realized to the extent that the level of quality with which the *other* topic is attended has not been exceeded. In other words, just as it is bounded by the lower level of attentional quantity, my model predicts that paradox acknowledgment will be bounded by the lower level of attentional quality (Figure 3).

Hypothesis 2: *The higher the attentional quality assigned to the less attended topic (water or energy), the higher the likelihood of paradox acknowledgment.*

Attentional coherence: In his research on the role of attention to weak cues throughout an organizational crisis at Novo Nordisk - a multinational pharmaceutical enterprise - Rerup (2009) defined *coherence* as "how similar or compatible attention to issues is across levels, units, and people" (878). He looked at the attentional quality (i.e., stability and vividness) in the company towards several precursors of the coming crisis, and across hierarchical levels ranging from senior management to shop floor. The findings pointed to a causal link between incoherence of attention towards some of the issues and the crisis that ensued. The author proposed the coherence of attention across communication channels (Ocasio, 1997) as a means of preventing future crises.

Coherence of attention is especially important in big and complex organizations such as the ones dealing with paradoxical challenges. This is because longer chains of command and supply entail a higher risk of miscommunication, emphasizing the need for integration and coordination across hierarchical levels (Bechky & Chung, 2018; Kim & Davis, 2016). Therefore, I posit that attentional coherence has a distinct role in fostering paradox acknowledgment on top of that of quantity and quality (Figure 3).

I further suggest *quantity coherence* and *quality coherence* as corresponding to attentional quantity and quality, respectively. Maintaining quantity coherence involves balancing the amount of attentional resources between water and energy, whereas maintaining quality coherence is related to balancing discipline, depth and creativity of attendance between water and energy. The balance is expected to promote paradox acknowledgment. For example, allocating similar resources such as time and money to both water and energy would mean that the organization has both issues on the same footing. While not guaranteeing acknowledgment, this is an important step towards recognizing the relationship between the two as intricate.

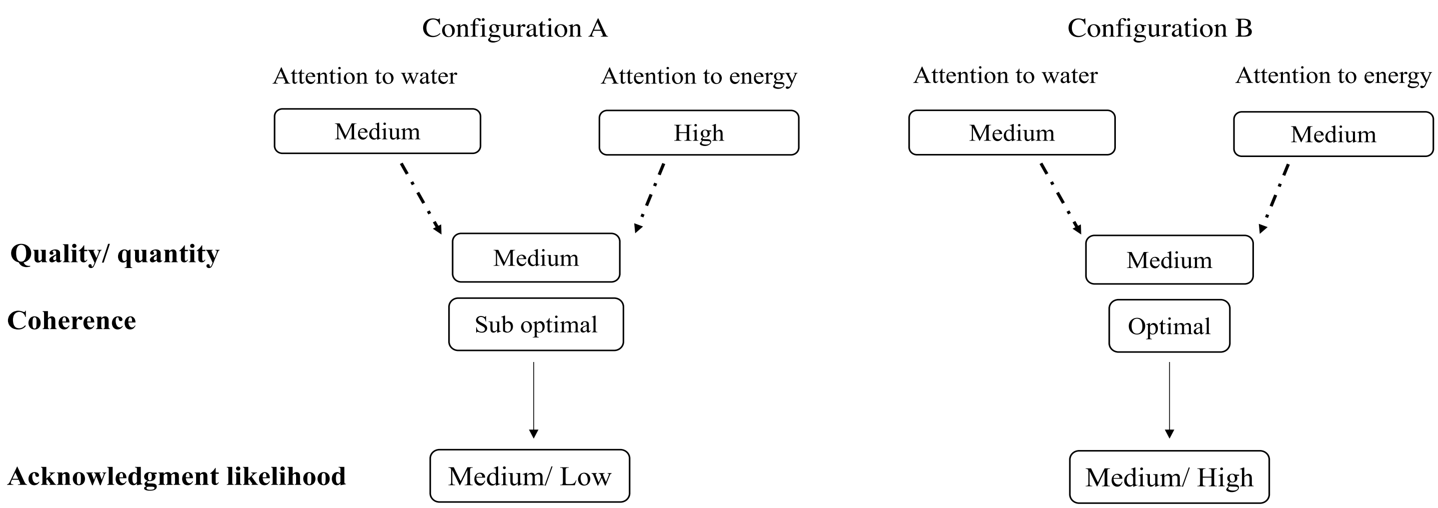
Hypothesis 3a: *The higher the coherence between the levels of attentional quantity with which water and energy are attended, the higher the likelihood of paradox acknowledgment.*

Similarly, paradox acknowledgment is more likely to the extent that both water and energy are addressed with similar levels of discipline, depth and creativity. Such synchronization is likely to foster the noticing of points of connection and mutual dependencies, even if the overall quality of attendance is not particularly high. In contrast, a mismatch of formats might hinder paradox acknowledgment even if both poles are relatively well attended. For example, if economic performance indicators are discussed in depth whereas socioenvironmental indicators are only glanced upon briefly, managers are neither likely to address the two concurrently nor to realize their reciprocal effects. As a result, they are also less likely to perceive the ongoing conflicts between these goals as symptomatic of deep paradoxical relationships and more likely to experience them as a recurring problem (Sharma & Bansal, 2017).

Hypothesis 3b: *The higher the coherence between the levels of attentional quality with which water and energy are attended, the higher the likelihood of paradox acknowledgment.*

Of note, the notion that balance between water and energy attendance is important for acknowledgment is already somewhat embedded in the previous hypotheses (H1 & H2). Indeed, high gaps between the levels of attentional quality with which each topic is attended imply not only low coherence but also a relatively low minimum. Nevertheless, the introduction of coherence to the model explicitly changes its predictions as illustrated in Figure 4 below. For simplicity, I assumed two configurations and unidimensional attention (defined by either its quantity or quality). Configuration A involves a “Medium” level of attention to water and a “High” level of attention to energy, whereas B involves a “Medium” level of attention to both. When evaluating each configuration based on the lower level of attention between water and energy, the result is a “Medium” for both. However, because of the discrepancy between water and energy under A, its coherence is sub-optimal. In contrast, B involves no discrepancy between the two, thus optimal coherence. Although A and B are identical in terms of their attentional quantity/quality, the overall likelihood of acknowledgment is higher under B due to its coherence advantage.

Figure 4: An illustration of the attendance model



2.3 Research context and data

CDP, formerly Carbon Disclosure Project, is a non-profit that collects and analyzes data about the environmental conduct of the largest Multi-National Enterprises (MNEs) around the world on behalf of their investors. CDP disseminates three annual surveys, on practices regarding climate change, water, and forestry. As of 2019 more than 6,000 of the world's largest companies responded, and the analyses and reports that CDP produced were subsequently employed by investors representing over 110 trillion dollars of assets (CDP, 2019). The organization’s assessments reach additional audiences through prominent financial data platforms. The surveys cover multiple aspects of environmental sustainability and have become a staple in the management literature (Ben-Amar & McIlkenny, 2015; Gasbarro, Rizzi, & Frey, 2016; Lee, Park, & Klassen, 2015; Weinhofer & Hoffmann, 2010).

2.3.1 CDP data limitations

CDP collects data that was provided voluntarily based on self-reporting and that does not undergo any sort of auditing. Respondents typically assign a specific official whose job role may vary to draw the necessary information from the different sections of the organization (e.g. operations, marketing, management, etc.) as well as to sign off the survey. At the end of each year’s cycle, CDP calculates the scores using their in-house methodology and publishes a letter grade scale ranging from “A” to “F”. The final scores and scoring rules are publicly available on the CDP website. The surveys come in many versions, corresponding to the varying environmental impacts of different sectors.

This process entails some inherent limitations (Chatterji, Durand, Levine, & Touboul, 2016; Delmas, Etzion, & Nairn-Birch, 2013) which are reviewed next. The first is a lack of homogeneity in how the surveys are addressed and interpreted. Some firms may assign a midlevel manager to fill them out, while others may assign a board member or even a top manager, which might entail vastly different response styles and strategies (Oliver, 1991). Many of the survey items can be interpreted differently even among individuals sharing the same job role. While I did not address this issue under the current scope, it can be addressed in the future by adding a nominal control for the job role of the official in charge.

Second, some of the survey items pertain to metrics such as water withdrawals and carbon emissions, whose valid and reliable measurement has been a subject of debate. Matisoff, Noonan, and O'Brien (2013) found that CDP reports of carbon emissions shifted in quality and transparency over the years depending on industry and location. Water performance has been systematically collected for less than a decade and is thus even more prone to reliability issues. I addressed this issue by examining several different measures of water and energy consumption (see below). Third, the surveys are subject to learning and gaming effects from one year to the next (Espeland & Sauder, 2007). Since the scores are publicly available, reporters have an inherent motive to “game” the survey to achieve higher scores over time. I controlled for survey familiarity by adding the number of CDP reports of the focal firm as a control (see below). In chapter 4 I discuss additional limitations related to the data structure. What follows is a description of this chapter’s constructs and variables as summarized in Table 2.

Table 2: Proxy table for chapter 2

Category	Construct	Variable / proxy	Source
DV	Acknowledgment	Trade-offs (T)*Linkages (L) >0 (dummy)	CDP/ W9.1
IV (H1)	Lower quantity	Lower among water and energy attendance hierarchy (dummy)	CDP/ CC1.1, W6.1
IV (H2)	Lower quality	Lower among water and energy attendance frequency (dummy)	CDP/ CC2.1a, W6.1
IV (H3a)	Quantity coherence	Balance among attentional quantities (dummy)	CDP
IV (H3b)	Quality coherence	Balance among attentional qualities (dummy)	CDP
Control variables	Sector	GICS sub-sector (dummy)	Reuters Eikon
	Country	Headquarters country (dummy)	Reuters Eikon
	Institutional ownership	Publicly traded/ private (dummy)	Reuters Eikon
	Size	log (annual total revenues)	Reuters Eikon
	Age	log (years since foundation)	Reuters Eikon
	Financial status	log (net income before taxes)	Reuters Eikon
	CDP experience	log (CDP participations)	CDP
	Year	(Dummy)	CDP

2.3.2 Paradox acknowledgment

The CDP surveys provide a fitting framework in which to explore acknowledgment. First, they prompt respondents to directly report on how they see the relationship between the two, as explained next. Second, they allow a consistent, longitudinal, and comprehensive inspection of firms' environmental conduct on both water and energy issues. Since its launch in 2010, the CDP water survey has included a section inquiring respondents regarding the identification of *trade-offs* (T) and *linkages* (L) between water and other environmental issues, including energy. CDP currently defines a linkage as "a relationship where water and another environmental issue are correlated" and a trade-off as "an inverse correlation between an environmental issue and water use" (CDP, 2019). It provides examples such as the use of water as a medium for heat transfer (for linkages), and the mitigation of water scarcity by desalination (for trade-offs).

The wording of the section stabilized in 2015 as follows: Item W9.1 asks whether the organization "has identified any linkages or trade-offs between water and other environmental issues in its value chain (Yes/No)". Respondents may fill this item once per survey. Conditional on replying "Yes" to W9.1, the next item (W9.1a) allows any given number of trade-offs and linkages to be reported for the focal year, each consisting of three identifiers: the environmental issue that was found to be tied to water usage (e.g. biodiversity, energy, etc.), the type of tie identified (i.e. linkage or trade-off), and a free form description. The majority of Ts and Ls reported pertain to various facets of the water-energy nexus. I interpreted the simultaneous recognition of both Ts and Ls in a given year as fitting the concept of paradox acknowledgment, because they represent contradictions and interdependencies between water and energy, respectively. For example, desalination is a commonly mentioned trade-off, which represents a contradiction between having more freshwater and increasing carbon emissions. In contrast, applying advanced irrigation techniques is a common linkage, which involves improvements in both the efficiency of water transfer and the emissions status.

I constructed my measure of acknowledgment as (T*L>0), i.e., a dummy that takes "1" if the firm has identified at least one trade-off and one linkage, and "0" otherwise, and then reversed the coding scheme to align with that of the independent variable as detailed below. I used a dummy for several reasons. First, since only a minority (133 firms out of 1912) acknowledged paradox at any point in time, there was little conceptual justification in differentiating more than two levels of acknowledgment. Second, the dummy allowed to minimize granularity concerns since (T*L>0) produced the same result whether a certain issue spurred a single trade-off and a single linkage or more of each. Third, a dummy is considered more reliable than a multilevel (Grassi, 2007), especially for concepts such as paradox acknowledgment for which there are no previously institutionalized measures.

2.3.3 Minimal attentional quantity

I operationalized attentional quantity using the hierarchical level of the managers attending water and energy. The level of hierarchy can be viewed as a measure of attentional quantity, i.e., a measure of attentional resources, to the extent that higher-level managers' bandwidth is relatively more scarce and valuable than that of floor and middle-managers (Ocasio & Joseph, 2008). Indeed, higher-level managers are, on average, fewer, more experienced, and paid more per working hour (Barney, 1991; Lado, Boyd, Wright, & Kroll, 2006). Alternative measures of quantity such as time and money were not available as further discussed in chapter 4. Although I could have used hierarchy to approximate attentional quality rather than quantity, I saved it for quantity as I explain over the next section.

I operationalized *minimal quantity* as the lower between the hierarchical rank of the manager attending water and the one attending energy. I pulled the hierarchical ranks using items CC1.1 (“Where is the highest level of direct responsibility for climate change within your organization?”) and W6.1 (“Who has the highest level of direct responsibility for water within your organization?”) from the climate change and water surveys, respectively. The following choices are available: “Senior manager/officer”, “Board member/subset/committee”, “Non-senior manager” & “No manager appointed”.

I created two separate “quantities”, one for water and one for energy: I coded “Senior manager/officer” and “Board member/subset/committee” as “0”, “Non-senior manager” as “1” and “No manager appointed” as “2”. The direction of the coding was chosen at random. Next, I calculated the unified minimal quantity construct. Since I coded the top rank for each topic as “0”, I calculated minimal quantity as the *maximum* between water rank and energy rank. At this point, I had a three-level construct (“0”, “1”, and “2”). Since there were relatively few observations with the value of “2”, I recoded each case of “2” as “1”. This resulted in a final range of 0/1 (dummy), where “0” corresponded to “Senior manager/ officer” and “Board member/subset/committee”, and “1” to “Non-senior manager” and “No manager”. This category merge allowed to increase construct reliability since a dummy is generally considered more reliable than a multilevel, especially when levels are unbalanced (Grassi, 2007). Based on similar considerations I constructed dummies for the rest of the attentional constructs.

2.3.4 Minimal attentional quality

I operationalized attentional quality based on the frequency of board meetings. Since attentional quantity and quality are not mutually exclusive, this measure could have potentially been employed to represent quantity as well. I reserved it for quality to conform with Weick and Sutcliffe (2006) who depicted stability (frequency) as a qualitative attribute. However, under the current data limitations I was not able to find an equivalent measure for vividness. I discuss this point further in chapter 4. I pulled both frequencies using items CC2.1a (“frequency of monitoring climate change risks and opportunities”) and W6.1 (“frequency of debriefing the highest level of responsibility on water issues”) for climate change and water, respectively.

The following choices are available: “semi-annually or more frequently”, “annually”, “bi-annually”, and “sporadically”. I coded these as “0”, “1”, “2”, and “3”, respectively for both water and energy. Next, since the highest frequency was coded as “0”, I calculated minimal quality as the maximum between the water and the energy frequency codes. Following the same considerations as with minimal quantity, since there were few observations with a maximum frequency of either “2” or “3”, I recoded each case of “2” or “3” as “1”. This resulted in a final range of 0/1, where “0” corresponded to “Six-monthly or more frequently” and “1” to all others.

2.3.5 Quantity and quality coherence

For each firm-year, I calculated “quantity coherence” as the absolute difference between the original quantity (hierarchy) code for water and the original quantity (hierarchy) code for energy. This initially produced a multilevel ranging from “0” (no difference in hierarchy) to “2” (a two-level difference). Following the same considerations as with minimal quantity, since there were relatively few “2”s I recoded each “2” as “1”. This resulted in a final range of 0/1 for, where “0” corresponded to “same hierarchy” and “1” to all other options. I repeated this procedure to calculate quality coherence, based on the original quality (frequency) codes.

2.3.6 Control variables

My list of control variables includes any constructs that are potentially correlated with both the dependent variable (acknowledgment) and the independent variables (attention), i.e., that might potentially mask the hypothesized relationship.

Sector is potentially correlated with both paradox attendance and acknowledgment through sector relevance of issues concerning water and energy. I added a dummy for each subsector based on the Global Industry Classification Standard (GICS).

Headquarters location is potentially correlated with both paradox attendance and acknowledgment through the local climate (Ortas, Burritt, & Christ, 2019). For instance, firms from the Middle East are probably more sensitized to climate change and water than firms from North America. I added a dummy for each of the countries where headquarters were located.

Institutional ownership is potentially correlated with both paradox attendance and acknowledgment through the level of stakeholder pressure (Okhmatovskiy & David, 2012). I added a dummy for ownership (Public =1).

Size is potentially correlated with both paradox attendance and acknowledgment through factors such as organizational complexity. For example longer supply chains have been shown to entail a negative effect on corporate social responsibility (Kim & Davis, 2016). I used the transformational log of total annual revenues.

Age is potentially correlated with both paradox attendance and acknowledgment because younger firms might be more capable of noticing and responding to environmental trends (Pinkse & Kolk, 2010; Tutusaus, Schwartz, & Smit, 2018). I used the transformational log of the foundation year. **Financial status** is potentially correlated with both paradox attendance and acknowledgment through resource scarcity, as mentioned in the review (Ivory & Brooks, 2018). I used the transformational log of annual net income before taxes as a proxy.

CDP experience is potentially correlated with both paradox attendance and acknowledgment since both are derived from the survey. To control for experience, I added the number of CDP participations of the focal firm. Responding to both water and energy in a given year was calculated as 1 participation. Finally, the **focal year** is potentially correlated with both paradox attendance and acknowledgment through the likes of environmental trends. I added a dummy for each year.

2.3.7 Final sample

The final sample included 2,543 unbalanced records (rows) from 739 firms between 2010-2018 (2014 was excluded since the tradeoffs and linkages section was omitted that year). These firms reported either "Yes" or "No" (at least once) to item W9.1 ("has your organization identified any trade-offs or linkages between water and energy…"). Firms that did not respond to this item were excluded. In the next section I explain how I controlled for any bias that might have occurred because of this selection. I also screened out firms from non-relevant sectors (such as finance and banking, who experience the nexus only indirectly), and firms having no International Securities Identification Number (ISIN – which was used as a key identifier). Within each firm I screened out non-energy related trade-offs and linkages (e.g., Ts and Ls between water and biodiversity).

2.4 Analytic methods

I experimented with three different analytic techniques for this chapter. The first method is a binary response panel data analysis based on the R-*pglm* command. This method involved two critically acute challenges. The first is that it assumes that time-invariant factors such as sector and country are randomly assigned. In the social sciences and economics framework this assumption is rarely justified (Davidson & MacKinnon, 1993). The second is that under most configurations there were not enough observations to estimate all the parameters, so that some had to be excluded (see below). The second method is Observed Least Squares (OLS) with dummies for time-invariant fixed effects (Greene, 2003). The issue with this method was that it generated an unusually high R-squared. This is the direct outcome of having the time-invariant fixed effects explicitly identified rather than driven out through demeaning as in *plm* and *pglm* (Croissant & Millo, 2008).

The third method is a within-firm regression model based on R-*plm* with a two-way effect for firm and year (Croissant & Millo, 2008). Since it uses demeaning, time-invariant fixed effects are driven out by definition. This is considered standard practice in social sciences and economics for panel data analyses (Davidson & MacKinnon, 1993). The main limitation of this method is that predictions can fall outside the dependent variable's range (i.e. acknowledgment should be either 0 or 1). However, since the purpose of this analysis is estimation rather than prediction, this is acceptable. Table 3 summarizes the advantages and disadvantages of the various methods that I experimented with.

Table 3: A comparison of different analytic methods for chapter 2

	Panel data (binary response)	OLS (FE dummies)	Panel data (continuous response)
Underlying assumptions	A random effects model	A fixed effects model	A fixed effects model
Predictions	Within DV range	Outside DV range	Outside DV range
R-squared	Normal range (1-10%)	~100%	Normal range (1-10%)
Other limitations	Requires a particularly large number of observations	-	-

Controlling for selection bias: The final sample excluded firms who ignored item W9.1. I controlled for any resulting self-selection using Inverse Probability Weighting (IPW) (Wooldridge, 2007). First, for each original observation (11,395 rows from 1,921 firms) I calculated the probability of being included in the final sample, using logistic regression and the R "predict" function, and taking into account all of the control variables (Table 2). For all subsequent regression analyses, each observation was assigned a weight equal to the inverse of its corresponding probability of being included in the final sample. Therefore, underrepresented observations received inflated weights, whereas overrepresented observations were deflated.

I calculated the significance of the IPW model based on the difference in explanatory power between this model and a null model, i.e., a model that includes only an intercept (Davidson & MacKinnon, 1993; Zheng, 2000). First, I calculated the difference between the null deviance and the residual deviance (ΔX=4123-3151=972) and the difference between their respective degrees of freedom (Δdf =3417-3357=60), and then I calculated the difference in their explanatory power. The result was $1-\chi^2(\Delta X,\Delta df)= 1-\chi^2(972,60)= 0$, meaning that the IPW model indeed had significant explanatory power over the null model.

Expected pattern of results: To be able to make a conclusion regarding the validity of my theoretical model given any pattern of results, I had to determine in advance which patterns of findings would lend support to the model. Since attentional quantity and quality represent two somewhat competing mechanisms, I expected to find either support for one or the other, i.e. either support for the attentional quantity hypotheses (H1 and H3a) or the attentional quality hypotheses (H2 and H3b).

Multiple comparisons correction: Since I tested several hypotheses simultaneously, upfront correction for multiple comparisons was required. I used the Benjamini-Hochberg (BH) correction procedure (Thissen, Steinberg, & Kuang, 2002): For a given α, find the largest k that holds $P_{(k)} \leq \frac{k}{m}\alpha$. The null hypotheses are rejected for all $H_{(i)}$ that holds $i \leq k$. For example, suppose that m=4, α=0.05 and the *p-values* are [0.025, 0.071, 0.019, 0.044] for H1-H3b, respectively. According to the BH procedure, the sorted *p-values* [0.019; 0.025; 0.044; 0.071] are compared against [0.05/4=0.0125; 0.05/2=0.025; 0.05*3/4=0.0375; 0.05], respectively. In this example k equals 2, so that H1 and H3a are rejected even though the *p-value* for H3b is also < α.

2.5 Descriptive statistics

Tables 4 and 5 provide descriptive statistics and correlations, respectively, and are followed by additional descriptive information. Since the data contains multiple observations for each firm, these tables are based on a one-year snapshot (2017, N=513). I chose 2017 since it corresponds to the largest number of observations: The longitudinal dataset is comprised of 125 observations from 2010, 195 from 2011, 207 from 2012, 268 from 2013, 349 from 2015, 403 from 2016, 513 from 2017 and 483 from 2018.

Table 4: Descriptive statistics for chapter 2[2]

Statistic	**N**	**Mean**	**St. Dev.**	**Min**	**Max**
Acknowledgment	513	0.113	0.317	0	1
Trade-offs	513	1.182	0.588	0	6
Linkages	513	1.407	0.836	0	5
Minimal quantity	495	0.024	0.154	0	1
Minimal quality	448	0.839	0.368	0	1
Quantity coherence	495	0.022	0.148	0	1
Quality coherence	445	0.553	0.498	0	1
Age (year founded)	443	1964	35.4	1843	2018
Ownership	467	0.953	0.212	0	1
Log(Size)	274	23.961	2.365	13.305	31.748
Income (Million$)	274	121,922	887,866	-11,200	13,400,000
CDP Participations	513	3.36	2.06	1	7

[2] 2017, N=513

Table 5: Pearson correlations[3]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.Acknowledgment	1.00	-0.06	-0.11	0.02	**0.11**	0.01	**0.14**	-0.04	-0.02	0.07	0.05	-0.16	-0.04	-0.10	-0.10	**-0.15**
2.Tradeoffs		1.00	**0.53**	-0.04	-0.09	-0.04	-0.09	**0.17**	0.07	-0.06	-0.04	0.15	**0.36**	0.01	-0.05	0.08
3.Linkages			1.00	-0.05	-0.14	-0.05	-0.08	-0.05	0.09	-0.09	-0.09	0.23	0.09	**0.21**	0.13	0.07
4.Minimal quantity				1.00	0.05	**0.96**	-0.03	-0.01	0.04	-0.03	-0.02	-0.05	-0.02	-0.06	-0.07	-0.04
5.Minimal quality					1.00	0.05	**0.49**	-0.06	0.03	0.06	0.05	-0.01	-0.08	-0.02	-0.06	-0.07
6.Quantity coherence						1.00	-0.03	-0.03	0.03	-0.03	-0.02	-0.04	-0.02	-0.06	-0.04	0.01
7.Quality coherence							1.00	-0.14	0.04	-0.06	-0.01	0.02	0.09	-0.22	-0.10	-0.07
8.Age								1.00	**-0.12**	0.03	-0.02	0.00	0.07	-0.06	-0.14	-0.20
9.Ownership									1.00	0.03	0.02	-0.04	0.01	0.05	-0.01	0.04
10.Size										1.00	**0.64**	-0.04	-0.02	**0.17**	-0.05	0.09
11.Income											1.00	-0.05	-0.02	0.07	-0.10	0.07
12.participations												1.00	0.04	0.04	0.00	**0.12**
13.Water													1.00	0.04	-0.03	0.05
14.Scope1														1.00	-0.03	0.09
15.Targets water															1.00	**0.50**
16.Targets Co2																1.00

[3] Including chapter 3, bold if p-value <0.05

Acknowledgment: 2017 saw 58 cases of paradox acknowledgment out of a total of 513 (11%), and overall there were 305 cases out 2543 firm-years (12%). The distribution of the number of tradeoffs in 2017 was as follows: Among the 154 who identified at least one (Table 4), 135 firms identified exactly one, 13 firms identified two, 5 identified three and 1 identified six tradeoffs. 359 firms did not identify any tradeoffs that year. The distribution of the number of linkages in 2017 was as follows: Among the 194 who identified at least one (Table 4), 144 firms identified exactly one, 33 firms identified two, 8 firms identified three, 6 firms identified four each and 3 firms identified five linkages each. 319 firms did not identify any linkages that year.

In terms of the number of acknowledging firms, between 2010-2018, a total of 739 out of 1912 firms (38%) responded either "Yes" or "No" when prompted to identify trade-offs and linkages between water and other challenges. Only 133 (18% of the final sample and less than 7% of the total) were found to have simultaneously identified both linkages and trade-offs, i.e. to have acknowledged paradox, at any point in time. A whopping 93% either did not respond to the entire section in the first place or explicitly responded "No". The nexus clearly remained unnoticed by the vast majority.

Attentional quantity: "Board member/subset or committee" was chosen by 76% and 87% of firms for water and energy, respectively, followed by "Senior manager/officer" (20% and 8.5% for water and energy, respectively). Overall both minimal quantity and quantity coherence were coded "0" for 97.5% of firms in 2017. Across the entire sample, 74% and 78% of entries were coded "0" for minimal quantity and quantity coherence, respectively.

Attentional quality: For water, "Annually" was chosen by 55% and "Six-monthly or more frequently" by 17.5%. For energy, "Six-monthly" was chosen by 57% and "Annually" by 37%. Overall "lower quality" (frequency) was coded "0" (semi-annual or higher) for 72 firms

(16%), compared to “1” (annual or lower) for 376 firms (84%). “Quantity coherence” was coded “0” (full balance) for 199 firms (44%), compared to “1” (some imbalance) for 246 firms (56%).

Time-variable controls: In 2017, the inter-quartile range for annual total revenues was between 7.41 billion dollars and 75.8 billion dollars for Q1/Q3, respectively. The inter-quartile range for Net Income Before Taxes was between 611 million dollars and 8,280 million dollars for Q1/Q3, respectively. The inter-quartile range for the number of CDP participations was between 2 and 5 for Q1/Q3, respectively. The rest of the control variables (below) did not change over time so that their distribution was calculated for the entire sample (N=739). As with the time-variable controls, some of the distributions do not add up to the total because of missing data.

Sector: 102 firms are from the Chemical Manufacturing sector, followed by 90 from Computer and Electronic Product Manufacturing, 48 from Utilities, 47 from Mining (not including Oil & Gas), 45 from Food Manufacturing, 42 from Machinery Manufacturing, 38 from Transportation Equipment Manufacturing, 33 from Beverage and Tobacco Product Manufacturing, 23 from Oil and Gas Extraction, 20 from Electrical Equipment, Appliance and Component Manufacturing, 19 from Paper Manufacturing, and 18 from Primary Metal Manufacturing. Other sectors include 15 firms or less each.

Country: 174 firms in the sample are from the United States, followed by 140 from Japan, 39 from the United Kingdom, 25 from Canada, 24 from South-Africa, 24 from Australia, 23 from Germany and 22 from France. Other countries with more than 10 firms include (in decreasing order) Turkey, Switzerland, South-Korea, Taiwan, India, Ireland and Brazil.

Age: 298 firms in the sample (41.8%) were founded before 1960. 231 firms (32.4%) were founded between 1960-2000. 133 firms (18.6%) were founded after 2000.

Institutional ownership: 622 firms are publicly traded compared to 42 private firms.

Correlations: Although Spearman is more suitable for dummies, I used Pearson as an approximation (de Winter, Gosling, & Potter, 2016). All the correlations mentioned below were significant ($p < 0.05$). Correlations concerning environmental performance are discussed in chapter 3. Acknowledgment was positively correlated with minimal quality (r=.106) and quality coherence (r=.142). The correlations between acknowledgment and quantity constructs were also positive but not significant, possibly because of data homogeneity. Tradeoffs and linkages were positively correlated as expected (r=0.527). Tradeoffs were also positively correlated with age (r=0.17). Minimal quantity was highly correlated with quantity coherence (r=0.956), again possibly because of data homogeneity. Lower quality was highly correlated with quality coherence (r=0.488). Age was negatively correlated with ownership (r=-0.118). Revenues were highly correlated with net income as expected (r=0.638).

2.6 Statistical analyses

Table 6 below provides the main analyses, followed by Table 7 which repeats the analyses with 1-year lagged attentional constructs and control variables. The lagged analyses were added to examine the robustness of the original findings. The main findings should not change significantly when adding a 1-year lag. Table 8 compares the results of analyzing the fully specified model using binary panel data, OLS, and continuous panel data.

Table 6: Acknowledgment regressed on attentional constructs

	Acknowledgment					
	(1)	(2)	(3)	(4)	(5)	(6)
Minimal quantity		0.73^{***}				6.63^{***}
		(0.01)				(1.15)
Minimal quality			5.93^{***}			-2.62^{***}
			(0.21)			(0.20)
Quantity coherence				0.73^{***}		-6.15^{***}
				(0.02)		(1.14)
Quality coherence					0.28^{***}	0.46^{***}
					(0.01)	(0.07)
log(Age)	40.99^{***}	2.52^{*}	39.81^{***}	2.85^{**}	31.93^{***}	-0.56
	(1.45)	(1.32)	(1.82)	(1.36)	(0.83)	(0.55)
log(Income)	1.29^{***}	0.92^{***}	5.95^{***}	0.96^{***}	2.61^{***}	0.85^{***}
	(0.02)	(0.06)	(0.15)	(0.06)	(0.14)	(0.07)
log(Revenues)	0.05	2.52^{***}	-6.56^{***}	2.53^{***}	-2.50^{***}	-0.03
	(0.05)	(0.25)	(0.98)	(0.26)	(0.61)	(0.15)
log(Participations)	0.19^{***}	-1.07^{***}	-4.22^{***}	-1.16^{***}	0.13	0.57^{***}
	(0.02)	(0.04)	(0.03)	(0.04)	(0.08)	(0.22)
Public	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes
Sector	Yes	Yes	Yes	Yes	Yes	Yes
Observations	900	788	471	788	470	401
R^2	0.0000	0.0002	0.0001	0.0002	0.0000	0.04

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 7: Acknowledgment regressed on 1-year lagged attentional constructs

	Acknowledgment					
	(7)	(8)	(9)	(10)	(11)	(12)
Lagged minimal quantity		2.31***				1.08**
		(0.13)				(0.47)
Lagged minimal quality			-5.86***			-4.99***
			(0.17)			(0.29)
Lagged quantity coherence				2.34***		
				(0.13)		
Lagged quality coherence					0.25*	-1.56***
					(0.14)	(0.16)
Lagged log(Income)	0.63***	-0.10	0.43***	0.01	1.84***	1.20***
	(0.05)	(0.09)	(0.06)	(0.09)	(0.11)	(0.14)
Lagged log(Revenues)	-2.79***	9.96***	-3.59***	9.58***	-1.55	-12.87***
	(0.23)	(0.81)	(0.20)	(0.77)	(1.25)	(0.35)
Lagged log(Participations)	0.01	-1.93***	1.33***	-2.04***	0.44***	-1.88**
	(0.06)	(0.13)	(0.04)	(0.13)	(0.16)	(0.84)
Age	Yes	Yes	Yes	Yes	Yes	Yes
Public	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes
Sector	Yes	Yes	Yes	Yes	Yes	Yes
Observations	601	535	357	535	357	312
R^2	0.001	0.001	0.0000	0.001	0.0000	0.01

Note: *p<0.1; **p<0.05; ***p<0.01

Summary: Table 6 shows the results of regressing acknowledgment on the four attentional constructs. All four hypotheses were supported. In model 2, the effect of minimal quantity is positive and significant (β=0.73, p <0.01), meaning that a one-unit increase in minimal quantity (e.g. from middle manager to top-manager) had increased acknowledgment by 0.73 units on average. The corresponding *p-value* is lower than the multiple comparisons correction threshold (0.0125) so that H1 remains supported after controlling for multiple comparisons. In model 3, the effect of minimal quality is also positive and significant. One unit increase in minimal quality (e.g. from annual to biannual board meetings) had an effect of more than 1 unit increase in acknowledgment on average. The fact that this coefficient is higher than 1 is a by-product of using the plm model as explained in the analytic methods section. The corresponding *p-value* is lower than 0.025, lending support to H2. In model 4, the effect of quantity coherence on acknowledgment is similar to the effect of minimal quantity (β=0.73), and the corresponding *p-value* is lower than 0.0375, lending support to . This is expected since the correlation between minimal quantity and quantity coherence was high (Table 5). Finally, in model 5, the effect of quantity coherence is positive and significant (β=0.28), with a *p-value* lower than the corresponding correction threshold (0.05), so that H3b is also supported.

Since both the quantity hypotheses (H1 and H3a) and the quality hypotheses (H2 and H3b) were supported, this pattern complies with both of the conditions that were predefined as lending support to the theoretical model. Model 6 includes all four attentional constructs. Minimal quantity and quality coherence remained positive and significant but minimal quality and quantity coherence switched signs. These changes are most likely due to interaction and spillover effects between the constructs which merit further investigation. For example, minimal quantity possibly absorbed a lot of the variance previously explained by quantity coherence, since the two are highly correlated.

Models 7-12 in Table 7 repeat the analyses using 1-year lagging. Minimal quantity and quantity coherence remained positive and strongly significant. Minimal quality switched signs, and quality coherence became much less significant. The changes in significance are most likely due to the decrease in the number of observations between the original models and the 1-year lagged models. Overall, since the quantity hypotheses (H1 and H3a) were supported, the attendance model can be declared to have remained robust to lagging. In terms of the control variables, income was positively and significantly correlated with a one-unit shift from acknowledgment to non-acknowledgment across the board in Table 6 and under most models in Table 7. This implies that rather than thriving under surplus conditions, paradox acknowledgment is actually more likely under resource scarcity. All findings are further discussed in chapter 4.

Table 8: Comparison of full model across methods

	Panel data (Binary)	OLS (FE dummies)	Panel data (Continuous)
Minimal quantity	31.7	1.73***	6.63***
	(1261.1)	(0.60)	(1.15)
Minimal quality	1.69	-0.55***	-2.62***
	(1.71)	(0.18)	(0.20)
Quantity coherence	-27.84	-0.94	-6.15***
	(1261)	(0.60)	(1.14)
Quality coherence	0.295	0.30***	0.46***
	(0.9)	(0.08)	(0.07)
log(Age)	-33.7	-0.76	-0.56
	(22.6)	(22.18)	(0.55)
log(Income)	-	0.21***	0.85***
		(0.05)	(0.07)
log(Revenues)	-	-0.04	-0.03
		(0.07)	(0.15)
log(Participations)	-2.75*	0.46***	0.57***
	(1.16)	(0.13)	(0.22)
Public	No	Yes	Yes
Country	No	Yes	Yes
Sector	No	Yes	Yes
Year	No	Yes	Yes
Observations	401	401	401
Log-likelihood / R^2	-150	1.00	0.04
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table 8 compares the analysis of the full model between the three methods that I experimented with – panel data with a binary response (pglm), OLS with fixed effect dummies and panel data with a continuous response (plm). Since the first method is based on Maximum Likelihood Estimation (MLE), log-likelihood is reported under the left column instead of R-squared. As further shown in the left column, calculating the full model under the first method required the exclusion of all of the time-invariant factors as well as the exclusion of control variables such as Revenues and Income, rendering this method invalid.

While OLS (middle column) produced different coefficients than continuous panel data (right column), none of the coefficient signs had changed. This strengthens my confidence in the results of the plm analysis reported in Table 6 and Table 7. In line with the theory (Greene, 2003), it seems that explicit identification of the fixed effect dummies (as done in OLS) had artificially inflated the R-squared but did not generate a meaningful effect on coefficient estimates.

Chapter 3: The consequences of paradox acknowledgment

In line with the second research question, in this chapter I examine the effects of paradox acknowledgment on organizational outcomes, and specifically on environmental performance. I begin with a literature review which leads up to the formation of H4. The rest of the chapter is comprised of the context, data, final sample, analytical methods, findings, and summary.

3.1 Current knowledge on paradox outcomes

Since paradox acknowledgment has not been explicitly addressed in the literature, there is of course no direct evidence tying it to business outcomes. My review is focused instead on the effects of paradox *management* on such outcomes (Figure 2), and I go back to discussing acknowledgment later on. According to Schad et al. (2016), defensive responses to paradox such as pulling towards one extreme or avoiding it altogether have been associated with negative outcomes such as ambivalence, chaos, and organizational decline. For example, Drummond (1998) showed how management insistence on seeking solutions that adhered to rigid criteria led to the collapse of an IT enterprise.

In contrast, experimenting with paradox management approaches such as acceptance, separation, and resolution (Figure 2) which tend to involve dynamic and purposeful iteration between goals and targets, led to positive outcomes such as ambidexterity, creativity, innovation, operational effectiveness, learning, legitimacy, and even long-term performance improvements (Miron-Spektor et al., 2018). For example, Schmitt and Raisch (2013) found that firms that balanced retrenchment and recovery activities in the face of an ensuing environmental crisis scored higher on financial measures related to turnaround performance. Andriopoulos and Lewis (2009) looked at ambidextrous firms, as evidenced by their simultaneous top ranking in profitability and design rankings and found that such virtuous cycles were nurtured by managers' careful iteration between differentiation and integration activities.

The instrumental benefits of applying a paradox perspective have been conjectured to hold also for environmental sustainability (Hahn, Pinkse, Preuss, & Figge, 2016; Scherer, Palazzo, & Seidl, 2013). Hahn et al. (2018) defined a paradox perspective in this context as accommodating "interrelated yet conflicting economic, environmental, and social concerns with the objective of achieving superior business contributions to sustainable development" (p. 237). However, empirical work includes only several case studies to date. For example, Iivonen (2018) showed how framing obesity in a paradoxical manner allowed the Coca-Cola Company to defend its core business.

I propose that paradox acknowledgment (and subsequently management) will entail an overall positive effect on environmental performance similar to its proven effect in standard contexts. Actors who understand the paradoxical relationship between water and energy are expected to have tighter control over the implications of physical disruptions and other nexus-related developments that might otherwise affect environmental performance negatively. Purposeful iteration between water and energy targets over time is thus expected to increase their chances of keeping both carbon emissions and water withdrawals in check.

Hypothesis 4: *Paradox acknowledgment will generate a positive effect on environmental performance over time.*

3.2 Research context and data

Since paradox acknowledgment is employed as a dependent variable in chapter 2 and as an independent variable in chapter 3, the database described in chapter 2 provided the basis for the analyses in chapter 3 as well. The dependent variable this time is environmental performance as measured by the difference in respondents' total water withdrawals and carbon emissions over two consecutive years. Both measures were collected by Reuters Eikon, one of the world's leading purveyors of financial information (Reuters-Eikon, 2018), which means they underwent at least some scrutiny and quality assurance. Table 9 summarizes.

Table 9: Proxy table for chapter 3

Category	**Construct**	**Variable**	**Source**
DV	Environmental performance	log (water(t)/ water(t-1)) and log (scope1(t)/ scope1(t-1))	Reuters Eikon
IV	Acknowledgment	T*L >0 (dummy)	CDP
Control variables	Sector	GICS subsector (dummy)	Reuters Eikon
	Country	Headquarters country (dummy)	Reuters Eikon
	Institutional ownership	Private/ publicly traded (dummy)	Reuters Eikon
	Size	log (annual total revenues)	Reuters Eikon
	Age	log (years since foundations)	Reuters Eikon
	Financial status	log (net income before taxes)	Reuters Eikon
	CDP experience	log (CDP participations)	CDP
	Environmental targets	Water targets (dummy)	Reuters Eikon
		Energy targets (dummy)	Reuters Eikon
	Year	(Dummy)	CDP

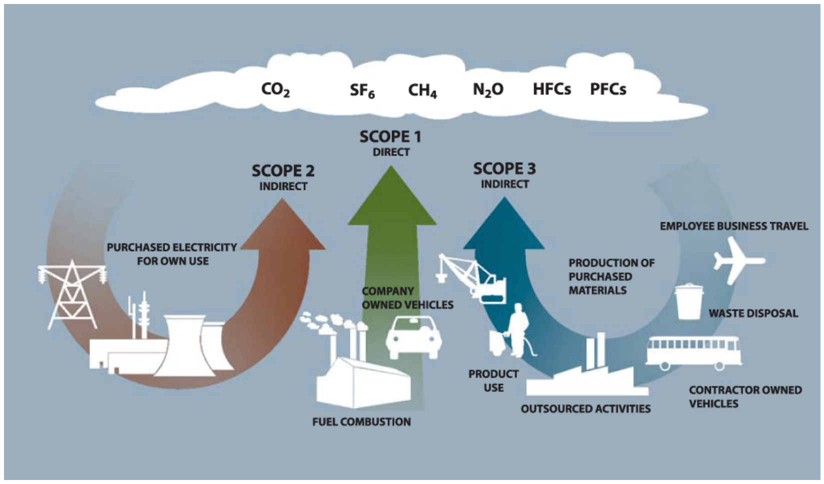
3.2.1 Dependent and independent variables

To measure water and energy consumption I chose two metrics commonly used in the management literature – water withdrawals and carbon emissions, respectively (Ardito & Dangelico, 2018; Lewandowski, 2017). The independent variable is *paradox acknowledgment*.

Water withdrawals: Reuters Eikon collects data on water withdrawals (A), water consumption (B), water discharge (C), and (D) recycled water. Their relationship is defined as A=B+C, where D is a subset of C. There is still little empirical work to rely on in terms of choosing one proxy over the other (Money, 2014). I chose water withdrawals and performed supplementary analyses using discharged water and recycled water. Reuters employs the GRI definition of water withdrawals (G.R.I, 2018) as the sum of all water drawn into the boundaries of the organization from all sources (including cooling, surface, ground, rainwater, and municipal supply) for any use during the reporting year.

Carbon emissions: Reuters Eikon also collects data on carbon emissions, divided into scope 1, 2, 3, and total – see Figure 5 below (George, Schillebeeckx, & Liak, 2015). Scope 1 represents direct emissions from owned or controlled sources. Scope 2 represents indirect emissions from the generation of purchased energy. Scope 3 represents solely indirect sources such as the supply chain. I chose scope 1 whose reliability is considered the highest (Downie & Stubbs, 2012) and performed supplementary analyses using scope 2, scope 3 and total emissions.

Figure 5: An illustration of carbon emission scopes[4]



Environmental performance: My first difference measure of environmental performance is defined as

$$\log[Y(t)] - \log[Y(t-1)] = \log[Y(t)/Y(t-1)]$$

where Y(t) represents either water withdrawals or carbon emissions at (t). This form is in line with the notion that environmental performance has improved to the extent that footprint has been *reduced* over time. The higher the footprint reduction (the better the performance), the more negative this term is. Therefore, I expected to find a *positive* relationship between a shift from non-acknowledgment to acknowledgment and footprint reduction. An alternative measure of environmental performance involves *intensity measures*, e.g., net emissions per dollar revenue or per employee (Martin & Rice, 2010). While these allow a standardized comparison between otherwise different actors, as ratio-based variables they are nevertheless subject to various methodological difficulties (Wiseman, 2009).

[4] Figure 5 includes some GHGs which are non-carbon such as hexafluoride and nitric oxide.

3.2.2 Control variables and final sample

Previously mentioned factors such as sector, country, institutional ownership, size, age, financial status, and CDP experience are all potentially correlated with both paradox acknowledgment and environmental performance, and therefore still had to be controlled for. I also controlled for active environmental management using two indicators, one for having quantitative water withdrawal targets and one for having quantitative carbon emission targets, both of which I extracted from Reuters Eikon (Table 9). In this study I made use of the same sample as in chapter 2, i.e., 2543 unbalanced firm-years between 2010-2018 except that this time I added two target indicators as controls.

3.3 Analytic methods

As in chapter 2, I used a within-firm regression model based on R's *plm* command with a two-way effect for firm and year. Again, the main shortcoming of this model is that its predictions might lie outside the range of the dependent variable (i.e. negative predictions in this case), but since the overall purpose is estimation rather than prediction this is acceptable.

The Inverse Probability Weighting (IPW) procedure (Wooldridge, 2007) that was described in the previous chapter was executed as part of the regression analyses of this chapter as well, including the additional target indicators. The IPW model still generated significant explanatory power over the null ($1\text{-}\chi^2(899, 63) = 0$, see the previous chapter). Since I used two different performance measures, to support H4 I expected to find an effect for one or the other. i.e. either for water withdrawals or for carbon emissions. Since I used two performance measures, applying the BH procedure entailed comparing the lower *p-value* to α=0.025 and the other one to 0.05.

3.4 Descriptive statistics

Table 10: Descriptive statistics for chapter 3[5]

Statistic	**N**	**Mean**	**St. Dev.**	**Min**	**Max**
Acknowledgment	513	0.113	0.317	0	1
Trade-offs	513	1.182	0.588	0	6
Linkages	513	1.407	0.836	0	5
Age (Year)	443	1964	35.4	1843	2018
Ownership	467	0.953	0.212	0	1
Log(Size)	274	23.961	2.365	13.305	31.748
Income (Million$)	274	121,922	887,866	-11,200	13,400,000
CDP Participations	513	3.36	2.06	1	7
Log(Water)	210	16.839	2.471	10.447	25.348
Log(Scope1)	195	13.508	2.234	8.642	18.474
Targets (Water)	237	0.620	0.486	0	1
Targets (Energy)	237	0.814	0.390	0	1

[5] 2017, N=513, see chapter 2 for correlation table

Summary of descriptive data (see also chapter 2): The interquartile range for annual water withdrawals (million gallons) was between 5,095,055 and 130,372,500 for Q1 and Q3, respectively. The interquartile range for annual scope 1 Co2 emissions (tons Co2) was between 274,967 and 5,830,000 for Q1 and Q3, respectively. 62% and 81% of firms with available data had active water targets and scope 1 emissions targets in 2017, respectively. 2017 water withdrawals were significantly correlated with trade-offs (r=0.36), and scope 1 emissions were significantly correlated with linkages (r=0.21). However, this pattern recurred only twice more for water (2016 and 2015) and once more for emissions (2018). Scope 1 emissions were also correlated with revenues (r=0.17) as expected due to the firm's size. Emission targets were significantly correlated with acknowledgment (r=0.15) and water targets (r=0.5).

3.5 Statistical analyses

Table 11 provides the main analyses and is followed by 1-year lagged analyses to examine the robustness of the findings (Table 12). To account for potential issues with the measurement of water withdrawals and scope 1 emissions, I examined discharged and recycled water (Table 13) as well as scope 2 and scope 3 emissions (Table 14). I also examined the effect of acknowledgment on financial performance, using revenues and net income before taxes as proxies (Table 15). Finally, since water withdrawals and carbon emissions are based on raw data, I used a processed measure as an alternative proxy (Table 16). Environment-Society-Governance (ESG) scores are provided by Reuters Eikon based on publicly available data, thus independent from CDP. The ESG scores range between 0-100 and are comprised of three sub-scores, one for each domain. I examined both the total ESG scores and the environmental (E) pillar score.

Table 11: Environmental performance regressed on acknowledgment

	Environmental performance (first difference)			
	Water withdrawals	Water withdrawals	Scope 1 emissions	Scope 1 emissions
	(1)	(2)	(3)	(4)
Acknowledgment		-0.82***		-0.94***
		(0.08)		(0.03)
log(Income)	0.50***	1.14***	-0.44***	0.004
	(0.07)	(0.09)	(0.09)	(0.04)
log(Size)	5.30***	0.25	5.05***	0.32*
	(0.23)	(0.51)	(0.24)	(0.18)
log(CDP participations)	-5.88***	-5.63***	-4.11***	-3.82***
	(0.11)	(0.10)	(0.12)	(0.06)
Targets (Water)	-2.04***	-2.32***		
	(0.23)	(0.20)		
Targets (Energy)			-1.20***	0.04
			(0.23)	(0.11)
Age	Yes	Yes	Yes	Yes
Public	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Sector	Yes	Yes	Yes	Yes
Observations	535	535	518	518
R^2	0.001	0.001	0.07	0.18
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 12: Environmental performance regressed on 1-year lagged acknowledgment

	Environmental performance (first difference)			
	Water withdrawals	Water withdrawals	Scope 1 emissions	Scope 1 emissions
	(5)	(6)	(7)	(8)
Lagged acknowledgment		-3.02^{***}		-2.07^{***}
		(0.03)		(0.01)
Lagged log(Income)	-0.44^{***}	-0.65^{***}	18.07^{***}	0.92^{***}
	(0.01)	(0.003)	(0.52)	(0.08)
Lagged log(Size)	0.33^{***}	-2.43^{***}	-91.96^{***}	-7.89^{***}
	(0.05)	(0.03)	(2.64)	(0.40)
Lagged log(CDP participations)	-1.16^{***}	-1.16^{***}	23.78^{***}	0.01
	(0.05)	(0.01)	(0.70)	(0.11)
Targets (Water)	-3.36^{***}	16.94^{***}		
	(0.21)	(0.20)		
Targets (Energy)			-114.02^{***}	4.08^{***}
			(3.21)	(0.55)
Age	Yes	Yes	Yes	Yes
Public	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Sector	Yes	Yes	Yes	Yes
Observations	507	507	489	489
R^2	0.002	0.005	0.002	0.0001
Note:				$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 13: Alternative water measures regressed on acknowledgment

	Environmental performance (first difference)			
	Discharged water	Discharged water	Recycled water	Recycled water
	(9)	(10)	(11)	(12)
Acknowledgment		-1.15^{***}		1.24^{**}
		(0.06)		(0.56)
log(Income)	1.11^{***}	1.07^{***}	0.16	0.16
	(0.17)	(0.09)	(0.22)	(0.21)
log(Size)	4.96^{***}	-2.99^{***}	3.29^{**}	3.48^{***}
	(0.46)	(0.49)	(1.32)	(1.29)
log(CDP participations)	-7.94^{***}	-5.37^{***}	-3.67^{**}	-3.80^{**}
	(0.33)	(0.22)	(1.51)	(1.47)
Targets (Water)	-6.99^{***}	-1.86^{***}	0.66	0.71
	(0.69)	(0.45)	(1.19)	(1.16)
Age	Yes	Yes	Yes	Yes
Public	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Sector	Yes	Yes	Yes	Yes
Observations	221	221	156	156
R^2	0.01	0.004	0.04	0.07
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 14: Alternative energy measures regressed on acknowledgment

	Environmental performance (first difference)			
	Scope 2 emissions	Scope 2 emissions	Scope 3 emissions	Scope 3 emissions
	(13)	(14)	(15)	(16)
Acknowledgment		-2.79***		-4.95***
		(0.09)		(0.11)
log(Income)	-3.32***	-0.15	-4.41***	0.05
	(0.34)	(0.18)	(1.18)	(0.33)
log(Size)	15.72***	0.59	41.10***	3.04**
	(0.79)	(0.60)	(2.93)	(1.17)
log(CDP participations)	-10.44***	-12.20***	7.57***	-2.76***
	(0.35)	(0.17)	(1.44)	(0.45)
Targets (Energy)	0.29	0.49	1.36	1.32*
	(0.84)	(0.37)	(2.80)	(0.75)
Age	Yes	Yes	Yes	Yes
Public	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Sector	Yes	Yes	Yes	Yes
Observations	400	400	273	273
R^2	0.002	0.02	0.001	0.01
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 15: Financial performance regressed on acknowledgment

	Financial performance (first difference)			
	Revenues	Revenues	Income	Income
	(17)	(18)	(19)	(20)
Acknowledgment		0.04*		4.23***
		(0.02)		(0.06)
log(CDP participations)	-2.01***	-1.89***	-0.24	13.26***
	(0.13)	(0.14)	(0.32)	(0.20)
Targets (Water)	2.33***	1.87***	-5.46***	-126.55***
	(0.50)	(0.55)	(1.55)	(1.72)
Targets (Energy)	-4.91***	-4.39***	0.38	152.35***
	(0.50)	(0.57)	(1.80)	(2.16)
Age	Yes	Yes	Yes	Yes
Public	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Sector	Yes	Yes	Yes	Yes
Observations	622	622	568	568
R^2	0.0000	0.0000	0.004	0.0001
Note:		*p<0.1; **p<0.05; ***p<0.01		

Table 16: ESG scores regressed on acknowledgment

	ESG performance			
	ESG Scores	ESG Scores	Environment	Environment
	(21)	(22)	(23)	(24)
Acknowledgment		2.20***		32.17***
		(0.24)		(0.79)
log(Age)	42.51***	18.07***	471.79***	115.16***
	(3.66)	(4.29)	(22.53)	(14.34)
log(Income)	0.28*	-0.88***	13.30***	-3.71***
	(0.17)	(0.20)	(1.03)	(0.66)
log(Size)	6.96***	13.03***	3.21**	91.93***
	(0.25)	(0.69)	(1.57)	(2.31)
log(CDP participations)	13.56***	14.22***	4.97***	14.72***
	(0.17)	(0.18)	(1.08)	(0.59)
Targets (water)	11.08***	8.06***	81.80***	37.77***
	(0.63)	(0.67)	(3.88)	(2.24)
Targets (Energy)	-0.72***	-0.55***	2.21***	4.81***
	(0.08)	(0.08)	(0.50)	(0.26)
Public	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Sector	Yes	Yes	Yes	Yes
Observations	857	857	857	857
R^2	0.05	0.06	0.02	0.02
Note:				*p<0.1; **p<0.05; ***p<0.01

Summary: As shown in Table 11, a shift from acknowledgment to non-acknowledgment was associated with a reduction rather than with an increase in footprint for both water withdrawals (β=-0.82, p<0.01) and scope 1 emissions (β=-0.94, p<0.01). H4 is therefore not supported. Either the null hypothesis is true, or a type II error was made, e.g., because of various methodological limitations that are discussed in chapter 4.

As shown in Table 12, this pattern was robust to lagging the control variables by 1-year. As shown in Tables 13 and 14, this pattern was also robust to changing the footprint measures in three out of four cases: Discharged water (β=-1.15, p<0.01), scope 2 emissions (β=-2.79, p<0.01) and scope 3 emissions (β=-4.95, p<0.01). The pattern switched only when testing recycled water (β=1.24, p<0.05). As shown in Table 15, a shift from acknowledgment to non-acknowledgment was also associated with an increase in both revenues (β=0.04, p<0.1) and income (β=4.23, p<0.01). Finally, as shown in Table 16, a shift from acknowledgment to non-acknowledgment was also associated with an increase rather than a decrease in total ESG scores (β=2.2, p<0.01) and in the environmental pillar score (β=32.17, p<0.01). Overall, these findings stand in contrast to H4. The effects of the various control variables were inconclusive.

Chapter 4: Discussion

This research sets the stage for the long due discussion on the organizational implications of nexus-like phenomena. As mentioned in the preamble, every large-scale sustainability challenge is inevitably entangled. For example, biodiversity loss which is exacerbated due to corporate activity (Whiteman et al., 2013), is inextricably related to both water shortages and climate change. Under this scope I focused solely on the water-energy nexus and proposed a theoretical model linking attentional structures, nexus acknowledgment, and subsequent environmental performance, and examined its predictions while employing a paradox perspective. The analyses, especially from chapter 2, revealed promising findings that merit further exploration. In this chapter I discuss the theoretical, methodological, and practical implications as well as limitations and pathways for further development.

Complementing the current emphasis in the literature on paradox management, in chapter 2 I offered attentional mechanisms to explain how and why organizations may come to *acknowledge* the nexus in the first place. First and foremost, the fact that only 7% of respondents acknowledged it at any point in time over almost a decade (2010-2018) speaks to itself. The majority still do not conceive of water and energy as related, at least within their jurisdictions. I constructed an attendance model comprised of minimal quantity (H1), minimal quality (H2), quantity coherence (H3a) and quality coherence (H3b). All four had a positive and significant effect on acknowledgment, and in three out of four cases the effect was found robust to 1-year lagging. Both of the quantity hypotheses (H1 and H3a) were supported with and without lagging, in line with the conditions that were predefined as lending support to the theoretical attendance model.

Next, heeding the calls to examine the benefits of paradox in a sustainability context (Hahn et al., 2018), in chapter 3 I hypothesized that acknowledgment would improve environmental performance (H4). This hypothesis was not supported neither when examining raw environmental performance (water withdrawals and scope 1 emissions) nor when examining ranked performance (ESG scores).

4.1 Theoretical contributions

This study sheds necessary light on the implications of the water-energy nexus for organizations, while also addressing the emerging discussion on sustainability paradox. I begin this section by discussing contributions that are directly related to the focal phenomenon and follow with potential contributions to wider bodies of literature, including paradox, ABV and Corporate Social Responsibility (CSR).

Attending the water-energy nexus: The current body of knowledge points to the contribution of environmental turbulence and managerial frameworks to organizational paradox becoming salient (Schad et al., 2016). I found firm statistical evidence that organizational attention matters too. In particular, I found that the level of attention to each topic (whether it was defined as the minimal hierarchy attending either water or energy or the minimal frequency of board meetings) had a positive effect on the likelihood of paradox acknowledgment. Quantity and quality coherence also contributed to acknowledgment.

These findings suggest that acknowledgment is not a clear-cut byproduct of neither external conditions nor agency. Rather than relying on an outside shock or an inside champion, organizations should foster readiness by looking repeatedly and rigorously into 1) the amount of resources they assign to attending water and energy i.e. to their levels of attentional quantity, 2) the discipline and creativity with which they attend water and energy i.e. their levels of attentional quality, and 3) the balance between these features i.e. to their levels of coherence. Continuous nurturing and synchronizing of these scanning, communication and interpretation channels (Ocasio, 1997) may facilitate the level of familiarity with other challenges, as discussed in the future research section.

The outcomes of nexus attendance: Further exploration of the association between acknowledgment and environmental performance using additional ESG measures is required to verify the findings of this study. In the future research section below, I offer specific measures of doing so. Nevertheless, to the extent that my null findings from this chapter are true, they stand in contrast to previous findings pointing to superior long-term financial performance as firms became increasingly adept at meeting persistent competing yet complementary demands over time (Chung & Beamish, 2010; Schmitt & Raisch, 2013; Smith, Lewis, & Tushman, 2011). This implies that the dynamics surrounding paradox in the context of environmental performance are fundamentally unique (Etzion, 2018).

Paradox theory: Paradox scholars have been heavily skewed towards examining the outcomes of organizational paradox rather than its antecedents (Schad et al., 2016). To the best of my knowledge, only Zimmermann et al. (2015) have considered organizational dynamics as an antecedent, but they did not presume to generalize their findings beyond exploration/ exploitation. My study suggests that continued dwelling on the instrumental benefits of any paradox management technique is misguided as long as there is little guarantee that paradox has been acknowledged in the first place. Scholars and practitioners are therefore advised to deepen their understanding of the organizational conditions and practices surrounding acknowledgment. My attendance model can serve as a preliminary basis for such exploration.

Furthermore, my research can potentially expand the current paradox typologies. The sustainability conversation on paradox has traditionally revolved around tensions between social and economic goals, yet the nexus raises dilemmas that occur solely within the environmental sphere. This is important because it implies that local and operational levels face unique forms of paradox that typically go under the radar of top echelons (Hahn et al., 2014).

Attention-Based View: ABV scholars have traditionally assumed that decision-makers are forced to be selective in the choice of the issues they attend (March & Simon, 1958). The ability to address multiple goals simultaneously was therefore generally contested (Greve, 2008). To the extent that nexus acknowledgment can be interpreted at least as quasi-simultaneous (Ocasio, 2011) addressing of multiple goals, my findings imply that such view is questionable. This is in line with the accumulation of new empirical evidence in support of the feasibility of simultaneous attention in individual settings (Miron-Spektor & Beenen, 2015) as well as in organizational contexts (Birkinshaw et al., 2016). Future work along these lines will have to provide a more detailed account of the meaning of "simultaneity" in organizational processes.

Furthermore, from an ABV perspective it should not matter whether the focal actor has identified tradeoffs, linkages, or both, as long as either form contributed to noticing of the nexus. Testing either (T>0), (L>0) or (T OR L > 0) instead of (T*L >0) should be indicative of this conjecture. Finally, some firms have consistently reported unusual numbers of either linkages or trade-offs, but not both (Van der Byl & Slawinski, 2015). Future research could examine the unique characteristics of these actors and the likelihood of transitioning from one inclination to another.

Corporate Social Responsibility (CSR) and environmental sustainability: My findings imply that the configuration of organizational attention has a profound effect on the corporate's sustainability agenda (Crane, McWilliams, Matten, Moon, & Siegel, 2008). In particular, I found that the likelihood of nexus acknowledgment was positively correlated with the level of coherence between water and energy attendance. This finding implies that collective efforts to design and implement CSR in organizations (Maon, Lindgreen, & Swaen, 2009) may be more successful to the extent that information, power, and other resources have been equally rather than centrally distributed. Indeed, Maon et al. (2009) found that "because many functions must work in unison to execute a CSR program successfully, managers need to invest in…marketing programs and … CSR-relevant activities." (p. 86). Notwithstanding the importance of individual openness to paradox, my findings imply that nurturing of CSR champions is less likely to lead to successful diffusion as long as critical stakeholders remain disengaged (Donaldson & Preston, 1995).

Grand challenges: Beyond the organizational context, my study points to the importance of generating theoretical frameworks that explicitly address the relationship between supposedly disparate sustainability goals. Weitz et al. (2014) showed that while many SDGs are inextricably linked or at least reinforce each other, others cancel each other out, calling for higher-level prioritization and clustering. Le Blanc (2015) similarly proposed to look at the SDGs as a network rather than a list, with meta-issues such as inequality, poverty, and hunger inhibiting central nodes (Etzion, 2018). My study is hopefully another harbinger of the development of a systemic and holistic approach to environmental sustainability.

4.2 Research limitations

In this section I present the main data-related shortcomings of my research followed by a discussion on the boundaries of my theoretical premises.

4.2.1 Data-related limitations

Construct validity and reliability. In chapter 2 I examined five concepts that are brand new from a theoretical standpoint: paradox acknowledgment, minimal quantity & quality, quantity coherence and quality coherence. Furthermore, I devised operationalization and estimations methods for each of these concepts that have not been experimented with yet. More research is warranted to determine the extent to which these innovative constructs and methods are meaningful and reliable across different contexts and datasets.

In particular, while constructing paradox acknowledgment (as well as the attentional constructs) as a dummy probably contributed to its robustness, it may have entailed other difficulties. Some firms that marked both (T>0) and (L>0) might have done so as a deliberate act of greenwashing (Lyon & Montgomery, 2015) or simply because they misunderstood the question. Some reports of (T*L>0) may have pertained to local trade-offs and linkages that do not merit corporate level acknowledgment. Other reliability concerns related to my acknowledgment construct were mentioned in the research context section above. The attentional constructs are discussed in the theoretical limitations section below.

Common methods variance: Both the independent variables and the dependent variable in chapter 2 originate in the CDP database, which raises concerns regarding potential common methods variance (Fuller, Simmering, Atinc, Atinc, & Babin, 2016). However, the fact that the two groups originate in different sections of the survey alleviates such concerns to a large extent. The attentional constructs were drawn from the risk management section, whereas paradox acknowledgment originated in the trade-offs and linkages section. There does not seem to be any aspect in the CDP data collection process that would have biased items from these two different sections in the same direction.

4.2.2 Theory-related limitations

Level of analysis: Although previous work has already established that individual dynamics can affect organizational recognition of paradox (Crilly & Sloan, 2014; Hahn et al., 2014; Shepherd et al., 2017; Zimmermann et al., 2015), under the current scope I focused solely on organizational-level dynamics, which might have spurred some incongruencies. For example, attentional quality is often attributed to psychological constructs such as mindfulness (Dane, 2011), rather than to organizational-level analysis. Theorizing about the relationship between individual and organizational levels of attendance and acknowledgment across the organization would have probably resulted in a richer and more viable model, as further discussed in the future research section.

Incompleteness of the theoretical model: Even under the assumption that individual-level factors can be excluded from the current analysis, a richer account of the organizational-level dynamics surrounding paradox acknowledgment might have improved the validity and reliability of the results. For example, attentional quantity can be broken down into several components and attentional quality was similarly conceptualized as bidimensional (Weick & Sutcliffe, 2006). I elaborate on this point in the future research section below. Furthermore, the link between acknowledgment and performance can be re-examined. Acknowledgment may have improved actors' ability to respond to specific disruptions or cost-saving opportunities only once they occurred, which would not necessarily entail any consistent effects on performance.

4.3 Future research

This section is comprised of three subsections: further verification of the current findings, research extensions that stem from the current theoretical model, and model extensions.

4.3.1. Further testing the current model

Additional examinations under chapter 2 would involve adding two-way interaction terms between attentional constructs and allowing for longer time lags between attentional constructs and paradox acknowledgment. In terms of chapter 3, while I did cover many proxies related to raw performance, additional measures of ranked performance such as TRUCOST and ASSET4 (Chatterji et al., 2016) could further illuminate the relationship between acknowledgment and performance.

4.3.2. Extensions of the current model

In order to pinpoint the contribution of attention to acknowledgment, environmental turbulence and managerial frameworks should be explicitly added to the model. Moreover, as mentioned in the limitations section, the attentional constructs that I used for chapter 2 might have under-reflected the richness of the theoretical concepts that they purport to measure. Attentional quantity could be broken down along components such as time and money invested in water and energy, which were not available under the current scope. Attentional quality could take into account creativity, depth and other elements related to the vividness with which actors discuss water and energy (Weick & Sutcliffe, 2006). For example, in 2018 CDP added an item pertaining to the time horizon that guides environmental risk management. While some firms plan for several years, others foresee decades into the future. The time horizon can be interpreted as a signal of attentional quality to the extent that longer horizons are associated with deeper levels of engagement. However, since this item was added only recently there is still not enough data to go by. The attendance model could also be further branched by adding moderators such as resource constraints. At the same time, the construction of paradox acknowledgment as binary apparently fits the preliminary stage of nexus familiarity.

In terms of chapter 3, external shocks such as technological and operational installations or physical and political disruptions could be added to moderate the relationship between paradox acknowledgment and environmental performance. Constructs that pertain to paradox management could be added as mediators.

4.3.3. Other extensions

My findings could be further broken down along industries, locations, periods, and other contingencies to provide a richer account of the data, and to better pinpoint the characteristics of actors who have consistently acknowledged paradox. It should be particularly telling to track the accumulation of trade-offs and linkages over time (Kim, Bansal, & Haugh, 2019), and to note how and when new acknowledgments have emerged. The effects of acknowledgment could also be examined under a "treatment" framework, e.g. using matching or Difference-In-Differences (DID) techniques. In terms of adding a qualitative aspect, interviewing and/ or surveying managers could lend support to my theoretical model. Future research could also employ text analyses to the descriptive responses under the trade-offs and linkages section.

Finally, the CDP surveys are a source of additional items of interest, concerning risk and opportunity management, the prevalence of physical, regulatory and reputational disruptions and the overall importance that actors assigned to each topic. Future variations of the model could also attempt to accommodate the notion of a virtuous cycle (Smith & Lewis, 2011) where paradox acknowledgment reinforces the attentional structures that pre-empted it.

Conclusion

Only a small portion of CDP respondents have acknowledged the reciprocating relationship between water and energy at any point in time between 2010-2018. The large majority still perceive and manage these challenges as silos. In light of the imminence of an all-encompassing environmental crisis (IPCC, 2018), these findings should serve as an urgent wake-up call to the business sector. My research can assist actors to move ahead by understanding what the water-energy nexus entails, how to handle it, and what outcomes to expect.

Throughout this essay I advocated a paradox approach as an overarching strategy with which to face environmental challenges. Looking beyond the organizational level, there is potential in harnessing paradox to the context of grand challenges (Etzion et al., 2017; Ferraro, Etzion, & Gehman, 2015). Instead of the continued framing of such challenges as disparate, an explicit acknowledgment of their overlaps may allow stakeholders to perceive otherwise subtle interrelations and synergies, thus scaling the benefits of paradox acknowledgment to the global and societal level.

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