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Bringing the biophysical to the fore: Re-envisioning organizational adaptation in the era of planetary shifts

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Jennifer Howard-Grenville
Cambridge Judge Business School, University of Cambridge, UK

Brooke Lahneman
Montana State University, USA

Abstract

The nature and scope of changes in organizations' external environments is without precedent due to planetary shifts, or major changes in earth's biophysical systems. Our theories of organizational adaptation lack the capacity to explain what will be needed on behalf of business organizations, and their strategists and managers, to adjust to these shifts. In this essay, we review organizational adaptation theory and explain why it falls short of offering adequate explanations in an era of planetary shifts. We then draw on ecological theories of adaptation, with their focus on social-ecological systems and panarchy, to suggest ways to advance organizational adaptation theory for our times.

Keywords

climate change, contingency perspectives, organizational change, sustainability, time horizon/pacing/temporality, topics and perspectives

The nature and scope of shifts in our planetary systems is without precedent. Climate change, biodiversity loss, and changes in water quality and availability are among the pressing shifts to which businesses must respond. There is no doubt that companies will do business on a warmer, more volatile planet in coming decades (Steffen et al., 2015). Significant changes in weather patterns are already in store given the current composition of the atmosphere and climate feedback processes (Howard-Grenville et al., 2014). Relatedly, impoverished ecosystems will have decreasing capacity to provide services that have so far been taken for granted by businesses in support of their operations—such as clean air, water, and pollination of agricultural crops (Whiteman et al., 2013).

Businesses will need to adapt to changes that are slow moving and accumulative, and to sudden jolts. As 2020 so amply illustrated, a sudden event like a pandemic (long associated with habitat

Corresponding author:
Jennifer Howard-Grenville, Cambridge Judge Business School, Trumpington Street, Cambridge CB2 1AG, UK.
Email: j.howard-grenville@jbs.cam.ac.uk

loss; IPBES, 2019) commands attention, as do extreme events like devastating forest fires in Australia and the American West. However, long-term adaptations demanded by decarbonization of energy systems and changes in global supply chains are no less critical for organizational survival. Furthermore, businesses must increasingly adapt their operations to better support social foundations, like healthcare, education, and equity, which are highly unevenly distributed and in net deficit on a global scale (Raworth, 2017).

One might expect that organization theory, having attended to how businesses adapt to changes in their external environments, might have something to contribute. But core tenets of our theories of organizational adaptation were largely developed in the 1960s and 1970s and have persisted long past the conditions in which they were generated. As businesses navigate changes in their environments—not limited to, but notably, the biophysical environment—of a scope and scale never previously imagined, how must we update our theories of adaptation to keep pace and to enable relevant and useful further research? Work examining how organizations build resilience in the face of planetary shifts provides a foundation (e.g. Linnenluecke and Griffiths, 2010; Rivera and Clement, 2019; Williams et al., 2019). Resilience and adaptation are distinct, though related, however, in that resilience is the *outcome* of effective adaptation. The need remains for theory development focused on adaptation itself to better understand the processes underpinning organizational capacities to adapt to changes in the biophysical environment, and other shifts these trigger. Importantly, we also need to better understand how organizations adapt over the short and long term to slow-moving changes as well as disruptive events, which, in turn, will strengthen our understanding of organizational resilience in the face of disruptive shocks.

In this essay, we turn to ecology theory (Folke et al., 2002; Holling, 2001) to demonstrate its potential for informing theory on organizational adaptation to planetary shifts. Ecological theories of adaptation provide conceptual handholds through which we can reconceive of organizational adaptation as (1) rooted in the biophysical environment and not simply refracting this through the proxies of regulatory, technological, or market aspects of an organization's environment; (2) playing out simultaneously on multiple spatial and temporal scales, and recognizing interdependencies between these; and (3) encompassing interdependencies between organizations themselves, as well as their environments, which shape the unfolding conditions for individual and collective organizational action. These perspectives help us expose and revise core assumptions of organizational adaptation theory to enable further theory development fit for our times.

In the remainder of the essay, we first review the literature on organizational adaptation and elaborate on its limitations. We then make the case for drawing on theory of adaptation from an ecological perspective. Finally, we suggest several ways forward for theory development on organizational adaptation. These include situating organizational adaptation within a multifaceted social-ecological system (Holling, 2001), tuning to learning processes in such settings, and exploring how actors coordinate across temporal and spatial scales.

What we know about organizational adaptation

Organizational scholars have long been concerned with how organizations adapt their practices, structures, and strategies to match the demands of their external environments. While there is no single theory of organizational adaptation, several decades of study explore core how organizations configure themselves internally to face their external environments, and how they respond, through shifts in practices, structures, and strategies, to changes in these environments (Van de Ven et al., 2013).

Empirically, scholars have explored diverse *triggers* of organizational adaptation. These include discrete, episodic shifts, stemming from technological (Tushman and Anderson, 1986), economic

(Moore and Kraatz, 2011), labor (Meyer, 1982), and regulatory shocks (Fox-Wolfgramm et al., 1998), or more gradual shifts arising from changing social norms (Hoffman, 1999). Put differently, the external environment considered of relevance to organizational adaptation has historically been composed of technological, economic, market, social, and regulatory facets, and the nature of shifts in these arise as either episodic jolts or gradual evolutions. Despite some early calls to consider the biophysical environment as an important component of organizations' external enviroment (Gladwin et al., 1995; Hart, 1995), this literature has developed largely outside that on organizational adaptation.

Scholars interested in organizational adaptation have attended to equally diverse *foci*—that is, *what* is being adapted—including organizations' structures and governance arrangements (Boeker and Goodstein, 1991; Moore and Kraatz, 2011), strategies (Fox-Wolfgramm et al., 1998), and decision processes and actions (Siggelkow, 2001).

Finally, the *mechanisms* of adaptation are also diverse, and fall into two broad camps: (1) those that rely on managerial choice and agency as guiding organization's adaptations, and (2) those that posit adaptation is the result of pressures in the external environment selecting for certain organizational attributes. In the first camp, managerial agency may be guided by either strategy or ideology (Hrebiniak and Joyce, 1985; Meyer, 1982), but it nonetheless gives managers an active role in detecting shifts in and navigating their environments. In the second camp, organizations are subject to population-level selection processes driven largely by the external environment (Levinthal and Posen, 2007), downplaying any real role for managerial agency. The degree to which managers are active agents, versus environments deterministic, has been subject to considerable debate, but these two perspectives anchor opposite ends of a continuum of possibility on the mechanisms of organizational adaptation.

A third, perhaps less vocal, perspective highlights that the mechanisms driving adaptation need not reside with managerial agency *nor* environmental determinism, but instead can arise from lower level employees and their day-to-day actions, which may respond to emergent conditions in a way that eventually produces significant adaptation. In such cases, individual employees' tendencies to conform with identities or practices can lead progressively to revised, yet unforeseeable, courses of action (Bundy et al., 2013; Burgelman, 1994; Dutton and Dukerich, 1991). For example, Burgelman (1994) demonstrated that Intel's middle managers began allocating resources in a way that matched external competitive conditions, but *before* official strategy was changed, showing how adaptation can set in prior to higher level managerial commitment to it.

Despite this variety, the core logic of early theories of organizational adaptation—one of *fit* between an organization's internal arrangements and the demands posed by its external environment (Van de Ven et al., 2013)—has proven tenacious. Attention to fit between organizations' structures and practices in relation to their environments began in earnest in the 1960s, with Lawrence and Lorsch (1967) showing that internal differentiation alongside interdepartmental coordination enabled superior performance in the face of technological and market uncertainty. As the environments facing organizations changed, so did the conceptualization of fit. Achieving static fit became increasingly inapplicable to organizations facing rapidly changing, ambiguous environments (Brown and Eisenhardt, 1997), leading scholars to articulate fit as a more dynamic process, achieved through more complex interrelationships between structure, strategy, and action.

Finally, the literature on organizational adaptation and the logic of fit at its heart has long recognized that external environments, themselves, vary considerably in the degree to which they are deterministic (Hrebiniak and Joyce, 1985). Managers exercise choice in how they respond to (Bundy et al., 2013)—and even attend to (Cho and Hambrick, 2006; Fox-Wolfgramm et al., 1998)—the content of their external environments. Some external events are regarded as consequential, while similar others are not attended to at all (Hoffman and Ocasio, 2001).

Beyond recognizing attentional myopia that influences what aspects of environments "show up" to managers, scholars also increasingly acknowledge that environmental shifts can be generated at least in part by organizations' own actions. For example, companies can reshape the technological and normative standards to which they and their competitors are held (Hoffman, 1999).

Coevolutionary explanations for organizational adaptation take this observation on board and attempt to collapse the debate betweeen managerial agency and environmental selection, accepting that both operate simultaneously. Coevolutionary accounts foreground an ongoing reciprocity between organizations' actions and their environments (Porter, 2006); they posit "change is not the outcome of managerial adaptation or environmental selection, but rather the joint outcome of [both]" (Volderba and Lewin, 2003: 2132). An empirical challenge of such approaches is that it becomes even harder to trace the factors at play given their scope and variety. Some have turned to complexity modeling as a solution (Levinthal and Warglien, 1999; Siggelkow and Rivkin, 2005), which, while elegant, has limited empirical tractability and simplifies the conflicting "expectations and assessments" that managers juggle while making choices (Anderson, 1999: 224). Furthermore, such models do not explore the *processes* by which organizations experience and work through such interdependencies to adapt effectively to them (Volderba and Lewin, 2003).

In sum, the vast and varied literature on organizational adaptation has itself evolved over time away from reductionist approaches, which "treat[ed] the anatomy of an organization as decomposable into independent elements that can be examined separately" (Van de Ven et al., 2013: 403), to those that now conceptualize organizations as embedded within dynamic external environments and in many ways actively shaping—and being shaped by—these. However, this body of theory falls short of conceptualizing organizational adaptation in a way that makes it useful to understanding adaptation in the face of planetary shifts.

Shortcomings of current theory for organizational adaptation to planetary shifts

Planetary shifts are changes in major earth systems, also called the biophysical environment, from the seemingly more stable states (Seddon et al., 2016; Willis et al., 2018) in which humans have built their social and organizational structures, to more volatile states that invite destabilized conditions (Steffen et al., 2015). We see this clearly in how changes in our global climate system affect changes in localized weather, such as increased hurricane activity in the Gulf of Mexico. However, the adaptations business organizations will make in coming decades stem not only from the shocks that accompany extreme weather or other disruptive events (Linnenluecke and Griffiths, 2010). Adaptations will also involve significant and ongoing changes to business models, supply chains, and product and service provision in a world where many interrelated factors are in flux, due not only to the direct effects of climate change but to alterations in habitats, social conditions, human health, energy provision, and technological change (Howard-Grenville et al., 2014).

According to theories in ecology, change in planetary systems is a constant, with the biophysical world relying on a dynamic set of properties to foster adaptation, renewal, transformability, and thus resilience in ecosystems over time (Holling, 2001; Walker et al., 2004). However, societies and organizations that rely on the biophysical environment for health, prosperity, and life itself, and thus theories of their adaptation have been constructed assuming stable conditions in planetary systems (Folke et al., 2011; Steffen et al., 2015). We turn to ecology theory to inform theorizing about organizational adaptation that will better match the contemporary conditions where planetary system stability can no longer be assumed.

Before elaborating these opportunities, we identify three main ways in which existing theory on organizational adaptation falls short of accommodating planetary shifts.

Refracting the biophysical environment through other lenses

Existing theory on organizational adapation has—with few exceptions (Gladwin et al., 1995; Hart, 1995; King, 1995; Linnenluecke et al., 2012; Linnenluecke and Griffiths, 2010; Rivera and Clement, 2019; Williams et al., 2019)—not explicitly considered the biophysical environment as an aspect of the external environment to which organizations must adapt. This same critique has been launched more generally: Whiteman et al. (2013) argue that organizational scholarship to date is decoupled from "the on-the-ground, in-the-air, and through-the-water material impacts of collective corporate and consumer activity" (p. 308).

Indeed, much work positions businesses as if their primary interactions with the biophysical environment come through shareholder, regulatory, supply chain, or market pressures (Bansal and Hoffman, 2012; Rivera and Clement, 2019). Notwithstanding the importance of these pressures, they obscure the biophysical systems in which businesses and their supply and value chains operate, and how these provide, with varying degrees of predictability and reliability, the materials, energy, and water that underpin all economic activity. As such, the assertion that "most management theorizing and research continues to proceed as if organizations lack biophysical foundations" (Gladwin et al., 1995: 874) is almost as true now as it was 25 years ago when it was first made.

To be sure, there has been a considerable literature on business and the natural environment (for a good overview, see Bansal and Hoffman, 2012), and increasing attention to organizational responsiveness to climate change (Schüssler et al., 2014; Wright and Nyberg, 2017), chemicals, pollution, and material scarcity (Barberá-Tomás et al., 2019; Howard-Grenville et al., 2017; Maguire and Hardy, 2009), and biodiversity and natural habitat conservation (Baudoin and Arenas, 2020; Lahneman, 2015). However, organizational scholars, trained as we are to conceive of the world as constructed and hence as least partially governed through social orders—cultural, normative, regulative and legitimating meaning systems[1]—have tended to represent biophysical systems as they most proximately show up to organizational stakeholders—that is, as cultural expectations, industry norms, regulatory requirements, or actions expected as part of a "social license to operate."

Even if this approach works for some discrete issues, it is increasingly inadequate as businesses are already feeling the direct effects of planetary shifts. For example, changes in land use, water availability, and climate are showing up to businesses through shifts in the capacities of smallholder farmers in their supply chains (Reinecke and Ansari, 2016).

Some recent organizational scholarship has directly theorized how climate change—a critically important but not the only planetary shift of interest—shapes the adaptation and resilience of business organizations. Much of this work, like the organizational adaptation literature, centers on a focal organization and asks how it can adapt in the face of extreme disruption, say due to weather events associated with climate change (Linnenluecke et al., 2012; Linnenluecke and Griffiths, 2010). Less explored is how firms adapt to slower changing variables associated with climate change, like changes in temperatures that affect the season length for ski resorts (Rivera and Clement, 2019). These studies tend to focus on resilience, which is "capacity to adapt" (Walker et al., 2006), rather than adaptation processes per se. In other words, these studies orient to the outcome and its importance; less examined is the adaptation process itself, nor the implications for how we revise our long-standing theories of organizational adaptation.

Impoverished treatment of spatial and temporal scale

A second shortcoming of existing literature on organizational adaptation is it does not take explicit account of events and disturbances that arise and play out at diverse spatial and temporal scales. Interconnected changes across diverse scales are critical to conceiving the complexity of the biophysical environment (Williams et al., 2019). Increasingly, all businesses, regardless of their sector, activities, or the long- or short-lived nature of their assets, will need to adapt to foreseeable or unexpected shifts that arise throughout as supply partners, service providers, or consumers experience extreme weather events, cyclical or seasonal water shortages, forest fires, or simply express different preferences (away from single-use plastics, for example).

Inclusion of spatial and temporal scale is important for theorizing about organizational adaptation to such conditions, because a precursor to adaptation is attention to the triggers for it (Bansal et al., 2018). Organizations struggle to sustain attention to phenomena that lie outside their dominant attentional structures, which are tuned to specific spatial and temporal scales (Bansal et al., 2018; Gibson et al., 2000; Gifford, 2011). Furthermore, most businesses orient to near-term and proximate issues (Bowen et al., 2018) and these tendencies are reinforced by the industry, institutional, financial, and social settings in which they operate that emphasize short-term results (Bansal et al., 2018; Piezunka and Dahlander, 2015; Reinecke and Ansari, 2016).

Changes in planetary systems unfold over vastly broader and longer spatial and temporal scales, which in turn shape disturbances in the biophysical environment at narrower scales. Though such changes can impact businesses in immediate, local (and often surprising) ways, organizational attentional structures are not well tuned to the longer term, broader scale shifts in the biophysical environment (Williams et al., 2019). Put differently, there is a broadly recognized but infrequently accounted for mismatch between the spatial and temporal scales on which biophysical environments change, and those at which businesses and markets act and interact (Bowen et al., 2018; Gibson et al., 2000; Schad and Bansal, 2018; Williams et al., 2019). Organizational adaptation theory needs to better account for how organizations attend to both near-term signals and shocks that arise from the biophysical environment as well as longer term and less proximate developments that will give rise to future disruptions.

Over-emphasis on the focal organizational actor

Finally, given the complexities of the biophysical environment and any given organization's attentional myopia, we need to rethink our focus on adaptation as a characteristic of individual organizations. Organizational adaptation theory as first conceived was strongly oriented to how a single focal organization navigated "its" external environment. Recent work suggests it is an oversimplification to treat an organization as if its actions alone could determine fit and performance in a complex environment (Marino et al., 2015; Schad and Bansal, 2018; Tsoukas, 2017).

Indeed, even the limited research on how organizations adapt to climate change is biased toward understanding the resilience of a focal organization (Linnenluecke et al., 2012; Linnenluecke and Griffiths, 2010; Rivera and Clement, 2019), neglecting the interdependence of organizational resilience with the resilience of biophysical systems (Williams et al., 2019) and indeed other organizational, technological, economic, and social arrangements.

These points raise the critical question of whether a single focal organization is even an appropriate unit of analysis for exploring organizational adaptation, especially if it distracts from needed attention to the broader system. Van de Ven et al. (2013) assert that "In an increasingly global and knowledge-intensive economy, the design of work and economic life is no longer contained within a single organization," (p. 397) and argue for expanding the boundaries for theorizing about

adaptation. Thus, our theories need to consider how interconnections between organizations themselves, as embedded within biophysical and other environments, shape *collective* adaptation.

Insights from ecological adaptation theory

We now revisit the question of how we must update our theories of adaptation to keep pace with contemporary organizational environments and to enable relevant and useful further research. To do so, we address the three considerations above by integrating key tenets from ecological theory on adaptation. Ecological adaptation theory takes planetary systems and biophysical constraints as core to understanding how such systems develop and maintain resilience (Folke et al., 2011; Walker et al., 2006). However, ecological adaptation theory has long included attention to the social systems that interact with the biophysical.

Social-ecological systems (SESs)

The concept of a "social-ecological system" (SES) (Holling, 2001) brings together biophysical and social systems. An SES lens asserts that few biophysical ecosystems can be understood without reference to the social systems with which they interact, and calls attention to how human intervention shapes the adaptability and resilience of such ecosystems, and vice versa (Allen et al., 2014; Folke et al., 2011). Operating within the constraints of the biophysical environment, an SES is conceptualized as inherently multilevel, characterized by structures and processes that interact across spatial and temporal scales (Walker et al., 2004). Within this framework, organizations are promulgated as key players in the functioning of an ecosystem as they rely on natural resources for the production and consumption of products and services, and deposit waste from these processes back into the biophysical environment (Folke et al., 2011; McGinnis and Ostrom, 2014; Olsson et al., 2004). As such, how organizations adapt—or do not adapt—to the biophysical environment, including both localized and planetary shifts, has a powerful influence on the adaptability of the societies and ecosystems in which they are embedded.

Scale and "panarchy"

An SES lens on organizational adaptation also offers a set of concepts to account for spatial and temporal scales and their interdependence. Within an SES,'spatial scale' refers to geographic dimensions of an issue, process, or set of actions, generally with "narrow" referring to more localized and "broad" referring to more global dimensions; "temporal scale" refers to the scope of time encompassed by the issue, process, or set of actions, with "narrow" referring to more proximate time periods and "broad" to more distal (Bowen et al., 2018; Holling, 2001). Ecology theory commonly refers to these scales in two-dimensions, or the "spatial-temporal scale" of an issue, process, or set of actions, recognizing that local effects often occurring in more proximate time periods, and global ones often unfold over longer time periods (Folke et al., 2002; Holling, 2001). Ecologists see diverse spatial-temporal scales as inherently interconnected, meaning changes at any scale can influence changes at *any* other, a relationship they term "panarchy" (Garmestani et al., 2009; Gunderson and Holling, 2002).

Panarchy is characteristic of an SES and refers to "a conceptual model that describes the ways in which complex systems of people and nature are dynamically organized and structured across scales of space and time" (Allen et al., 2014: 578). "Panarchical" systems, such as an SES, operate differently from those that are hierarchically ordered in that any scale can interact with structures and processes at other scales below and above it, in any direction, whereas in a hierarchy

"lower-level patterns and processes are dominated by higher levels" (Garmestani et al., 2009: 1037). In a panarchical system, therefore, processes can trigger changes that ripple unpredictably across scales, manifesting as as nonlinear shifts, or "surprises" (Gibson et al., 2000).

Example of "panarchy" in an SES

A classic illustration of the panarchical characteristics of an SES is found in the account of the eradication of wolves in the greater Yellowstone National Park (YNP) region in the early 1900s, and their subsequent re-introduction in the 1990s. When Western settlers arrived at the now Montana-Wyoming area of the United States in the 1800s, farming and ranching took hold in a once wild ecosystem, which supported settlers' livelihoods and the growth of a market economy (National Park Service (NPS), 2020). At a broader scale, farming and ranching reduced regional biodiversity through the planting of monocultures and overgrazing of grasslands, which in turn reduced the number of prey animals lower on the food chain, such as rabbits, deer, and elk, for larger "alpha" predators at the top of the food chain, namely wolves and bears (Carter et al., 2019). Food sources for these alpha predators were further depleted by the settlers' hunting of elk and deer among others. Consequently, wolves faced stronger pressure to find food, and so turned to farmers' livestock (NPS, 2020).

Perceiving a threat to settlers' livelihoods, in the 1880s the government encouraged a "predator control" policy aimed at reducing the numbers of alpha predators, which resulted in the elimination of wolves from the greater YNP ecosystem by the 1940s (NPS, 2020; Riley et al., 2004). With this threat reduced, farms and ranches increased in size and improved the stability of their livestock populations, but the effects of these changes were felt throughout the system at various spatial and temporal scales, degrading the overall social and ecological resilience of the region (NPS, 2020). Without wolves, narrow scale shifts were seen in an expontential increase of the elk population, which helped settlers in the short term. However, effects of these narrow scale shifts emerged at other scales, as more elk led to an overconsumption of grasses and trees, and, over a longer timescale, elk once again started dying out, destabilizing that food source for settlers (Carter et al., 2019). Other "surprising" narrow scale shifts, like the dying of grasses and trees, induced increased erosion that polluted and disrupted aquatic ecosystems and loosened riverbank sediment, which had other far-reaching ripple effects at much larger scales, including shifting the river topography (NPS, 2020). A once robust and vibrant ecosystem went to the verge of collapse, threatening both the existence of many wildlife species and settlers' livelihoods (Carter et al., 2019).

By the 1990s, YNP biologists had realized that these broad and narrow scale changes were interconnected in panarchical relationships, and that particular ecosystem variables could set off ripple effects that appeared as "surprising" disturbances (Carter et al., 2019), but were understandable when the dynamics within the SES were comprehended. By taking a panarchical lens, these biologists realized that by re-introducing alpha predators such as wolves, the regional SES could rebuild resilience. Within three decades, the re-introduction of wolves into the YNP region restored the ecosystem's ability to self-regulate and thus also better supports human livelihoods in the region (Carter et al., 2019).

In this illustration, we realize not only the intricate connections between humans and the biophysical environment, but also the interconnections between processes unfolding at diverse spatial and temporal scales. Although the YNP example may seem "closer" to the biophysical environment than many contemporary business interactions might, these same multi-scalar interconnections with the biophysical environment exist for all organizations—small and large, and across all industries—though perhaps are more obscured by physical infrastructure and growing urban areas, social structures, and long time horizons (Gifford, 2011; Williams et al., 2019). By integrating the

panarchical characteristics of the SES context into our theorizing, organizational scholars can better develop adaptation theory that accounts for both localized disturbances that once would have been perceived as "surprises," or disruptive jolts (Meyer, 1982), and interrelated shifts occurring over broader scales.

Collective level

Furthermore, the SES concept and its associated attention to panarchical relationships between scales hold significant promise for also reconceptualizing *what* is adapting. As the YNP example makes clear, adaptation is an ongoing process within an SES and specific changes influence not only processes and dynamics at vastly different scales (the course of river banks eventually changes in response to death of grasses, for example), but also the fate of one entity, population, or species is intimately tied to that of others. This implies that one focal actor within a system cannot thrive indefinitely without others sustaining viable conditions for thriving as well. Our existing theories of organizational adaptation do not adopt such a systems perspective; even those that emphasize co-evolution between organizations and their environments attend to mutual adjustments over time as each accommodates the other, but the emphasis remains on optimizing outcomes for an organization, rather than the system as a whole. To advance understanding of adaptation in the face of planetary shifts we must move away from the assumption that the adaptive acts of a single focal organization in relation to "its" environment serve as the right level and focus of analysis. Instead, we must begin to theorize about the conditions and processes that beget effective adaptations of organizations and other aspects of the SESs in which they operate.

Implications for future research in organizational adaptation theory

Given these shortcomings and building on prior work that has adopted an ecological perspective on adaptation and resilience, we outline three ways in which organizational adaptation theory can itself adapt to reflect the realities of the biophysical environment, and more broadly to meet the conditions organizations face in an era of planetary shifts.

Integrating the biophysical environment through an SES lens

As noted, management scholars have long considered diverse triggers for adaptation, often from discrete aspects of the environment, such as regulatory, technical, or social aspects. To add the biophysical as yet another aspect that can trigger organizational adaptation would miss the point of regarding organizations as a part of a larger system of entities and processes, as captured by the concept of an SES (Folke et al., 2011; Holling, 2001). Triggers and mechanisms for adaptation within an SES are fundamentally different (Linnenluecke et al., 2012; Linnenluecke and Griffiths, 2010; Rivera and Clement, 2019; Williams et al., 2019) from those emphasized in earlier organizational adaptation theory. Triggers for adaptation can no longer be considered as discrete as they emanate, with differing degrees of salience, scale, and pacing, from multiple interrelated sources. For example, the use of scarce minerals in manufacturing may raise concerns about biophysical limitations on their long-term availability or accessibility, yet this issue can also present as a more immediate social or regulatory concern if human rights abuses are found in the supply chains for these materials. Conversely, a flooding event that destroys critical infrastructure can also be associated with longer term shifts in insurance provision.

In other words, the "environment" presents itself as multifaceted—biophysical, economic, regulatory, technical, *and* social—and the panarchical nature of relationships within an SES mean that broad and narrow scale changes among these aspects are linked in different and often unpredictable ways. The dominant logic of fit—even dynamic fit in a complex, coevolutionary setting—is complicated when we can no longer presume mechanisms of progressive adjustment over time between an organization and its environment, and instead must accept that nonlinearity and surprise resulting from processes rippling across scales and between aspects of an SES better capture the adaptation challenge.

Scholars taking an SES lens on organizational adaptation can build theory that considers specifically how trajectories unfold when environmental conditions are panarchical. Despite being characterized by unpredictability, such environments may nonetheless be amenable to building systematic theory on, for example, the mechansims of adaptation that are triggered by narrow scale phenomenon versus those triggered by broader scale phenomenon. Scholars could also consider how the people, roles, and structures of an organization are exposed differently to signals and triggers from an SES and explore how these—and the capacity to attend to and integrate these signals—influence adaptation processes and their trajectories. Within an organization itself, do adaptive responses ripple in a panarchical fashion and with what consequences? As in Burgelman's study where lower level managers adjusted their production allocations in relation to signals from customers, prior to the senior management team seeing the need for a shift in strategy, scholars might study in what ways employees or others in the value chain propagate or dampen emergent responses to biophysical (or other) constraints and opportunities. How do these then trigger or block further attention, sensemaking, or action that might reveal or conceal interconnections within an SES?

Tuning to learning across scales

By viewing organizational adaptation through an SES lens, scholars will inherently attend to diverse spatial and temporal scales, and their interconnection (McGinnis and Ostrom, 2014). An ongoing challenge in organizational adaptation is the role of managerial attention in detecting the conditions that demand adaptation, which of course prefigures effective adaptation (Bowen et al., 2018). In panarchical systems, this challenge becomes less about seeking to optimize organizational attention to—and hence action within—the "right" scale(s), and more about enabling organizations to experience multiple scales and begin to develop "a deeper understanding of the relationship between spatial and temporal attributes of underlying processes" (Bansal et al., 2018: 232). We have limited insight into how organizational members develop such understandings, but it is clear that there is a considerable role for learning, and in particular for learning through exposure to phenomena at diverse scales.

Organizational scholars can explore the individual and collective capabilities that enable organizations to detect and identify patterns and interconnections that emanate from diverse sources and scales. Such capabilities would have to overcome knowledge boundaries and organizational and occupational role and power differences, topics that have been extensively studied but not explicitly through the lens of organizational adaptation (Bechky, 2003; DiBenigno and Kellogg, 2014; Howard-Grenville et al., 2017). Beyond acknowledging well-established cognitive limitations and organizational practices, incentives, and routines that favor attention to narrow scale phenonmenon (Bowen et al., 2018; Gifford, 2011; Piezunka and Dahlander, 2015), we might learn from organizations that are tuned to broad scale phenomenon, like conservation organizations, large-scale technology development programs (e.g. gravitational wave detection, space exploration), or even the oil and gas sector, where investments, activities, and their consequences play out over decades (and, in some of these settings, are less entrained to quarterly results). Scholars might explore what learning practices, processes, and structures support the collation and integration of inputs from

diverse scales, which can in turn inform organizational learning about biophysical and related processes that demand adaptation.

At a broader level, these considerations and questions importantly point to a need for theories and frameworks that explain *how* organizations identify and continuously navigate the panarchical relationships within their SESs, attending to salient issues at focal scales and their connections with other scales. Further research could also investigate similarities and differences in how panarchical relationships manifest for organizations embedded in similar SES contexts, such as those that are geographically co-located or in the same industry. What about panarchical properties of organizational systems themselves, such as cultures, routines, supply chains, and strategies? Developing theory on these topics could greatly deepen our scholarly understanding of operating within an SES and overturn assumptions about adaptation as occuring within or through hierarchical or nested relationships.

Examining mechanisms that promote coordination between distributed actors

As patterns and interdependencies in panarchical systems are only discernible to an organization when processes at a focal scale are seen in light of processes at other scales, the coordinated experience of multiple actors distributed throughout an SES could help overcome many of the obstacles that hinder single actors in "seeing" this complexity (Bowen et al., 2018; Gifford, 2011; McGinnis and Ostrom, 2014).

The idea that adaptation is best conceptualized at a system level is most in line with complexity theory perspectives on organizational adaptation which model dynamics of systems (Levinthal and Warglien, 1999; Siggelkow and Rivkin, 2005). However, such approaches tend to single out a focal organization within a complex landscape, and demand that variables are clearly specified in advance to be meaningfully modeled. An SES lens on organizational adaptation would complement complexity modeling by revealing the processes through which actors throughout the system gain awareness of dynamics and interdependencies and can individually and collectively act to sustain system functioning.

Opportunities for building adaptation theory through tuning to these dynamics abound. In particular, our understanding of how organizations engage in "adaptive co-management" (Cash et al., 2006; Folke et al., 2002) of SES needs development. Primarily developed in the field of ecology, adaptive co-management involves the coordinated, collective action of a diverse set of actors, including for-profit companies, nonprofit organizations, and governments, operating at different scales to better understand and act within a panarchical system (Cash et al., 2006; Folke et al., 2002). Ecology scholars recognize the attainment of such cooperative solutions is challenging, in part because more work is needed to "identify modes of engagement between scientists and decision makers working at different scales of governance . . . and analyses (e.g., global, watershed, patch)" (DeFries et al., 2012: 604). Organizational scholars can build on this body of work to extend and deepen our understanding of how such collective work occurs. For example, under what conditions is adaptive co-management possible and effective? King (1995) argued from the historical record of four communities that community property management in combination with practices to enable rapid feedback from the environment, diverse participation, and access to a diverse resource base helped these communities avoid surprise from their biophysical environments. However, he also rightly pointed out that small-scale communities differ fundamentally from modern corporations, and questioned the extent to which norms operating within communities could operate in settings where individual control and interest are paramount.

Beyond these fundamental questions, scholars could look for particular types or configurations of actors and organizations that may be able to combine knowledge to enable adaptive co-management, such as a combination of organizational leaders and ecologists with local ecological

knowledge. Furthermore, can the biophysical environment inform organizational adaptation on its own terms (i.e. can science more explicitly guide adaptation)? Is adaptive co-management best suited for organizations within the same industry, such as how industry sustainability working groups are often organized, or for organizations across different industries, such as how the B Corp certification is structured? Is there a role for certified management systems (CMS) in enabling learning and coordination across members (Lahneman, 2015) or do these systems largely preclude or supplement regulation (Barnett and King, 2008), or elicit symbolic adoption (Howard et al., 2000)? Do organizations need to be geographically proximate for adaptive co-management, or do technological or other affordances allow for other configurations? Many more questions may bubble up as we think through the lens of SES and its attention to panarchy about organizational adaptation.

Concluding thoughts

We are running out of time for business organizations to make the changes needed to adapt to major planetary shifts now underway—climate change, biodiversity and habitat loss, and their attendant influences on human health and livelihoods. The adaptations businesses will need to make in the coming decades are hard to predict in the nearer term but crystal clear in the longer term. By 2050, energy infrastructure, transportation, products reliant on agriculture or natural capital, and many more aspects so central to our economy will look fundamentally different. The theories we use and advance about organizational adaptation need to face these new realities, rather than blindly perpetuate assumptions about organizations and their environments that held true a century earlier. Our review of organizational adaptation theory and its evolution over time to become more dynamic led us to conclude that it nonetheless falls short of capturing the complex and panarchical nature of organization-environment relationships that characterize organizational activity in an era of planetary shifts. We offer some ways forward, drawing on ecological theories of adaptation, and encourage future organizational scholarship to build new organizational adaptation theory that situates organizations as part of a multifaceted, panarchically governed SES, explores processes of learning that unfold within such settings, and develops new insights into how coordination among actors and across scales is enabled. With such theoretical developments, we hope organizational adaptation theory will be fit for the conditions our children will inherit, unburdened by assumptions about how organizations operated in relation to their environments in their predecessors' days.

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ORCID iD


Jennifer Howard-Grenville https://orcid.org/0000-0002-3737-0465

Note

1. For a good discussion of organizational sustainability in the Anthropocene through an institutional and cultural lens, see Hoffman and Jennings (2018).

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Author biographies

Jennifer Howard-Grenville is the Diageo Professor in Organization Studies at the Cambridge Judge Business School, University of Cambridge. Her research focuses on how people generate and navigate change related to sustainability. She conducts qualitative research to contribute to theory on organizational culture, organizational routines, identity, identification, and sensemaking. She serves as Deputy Editor at *Academy of Management Journal* and is a Fellow of Trinity Hall college, Cambridge. Address: Cambridge University, Trumpington Street, Cambridge CB2 1AG, UK. [email: j.howard-grenville@jbs.cam.ac.uk]

Brooke Lahneman is a visiting assistant professor of management at Montana State University. Her research contributes to our greater understanding of how organizations can successfully navigate complexities inherent in pursuing sustainable business models and practices, individually and collectively, and how organizational culture and identity shape sustainable organizational practices that work within the constraints of biophysical systems. Address: Montana State University, PO Box 173040, Bozeman, MT 59717-3040, USA. [email: brooke.lahneman@montana.edu]