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DANCING THE SUPPLY CHAIN: TOWARD TRANSFORMATIVE SUPPLY CHAIN MANAGEMENT

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Most of the theories that have dominated supply chain management (SCM) take a reductionist and static view on the supply chain and its management, promoting a global hunt for cheap labor and resources. As a result, supply chains tend to be operated without much concern for their broader contextual environment. This perspective overlooks that supply chains have become both vulnerable and harmful systems. Recent and ongoing crises have emphasized that the structures and processes of supply chains are fluid and interwoven with political-economic and planetary phenomena. Building on panarchy theory, this article reinterprets the supply chain as a social–ecological system and leaves behind a modernist view of SCM, replacing it with a more contemporary vision of "dancing the supply chain." A panarchy is a structure of adaptive cycles that are linked across different levels on scales of time, space, and meaning. It represents the world's complexities more effectively than reductionist and static theories ever could, providing the basis for transformative SCM.

Keywords: *panarchy; adaptive cycle; dancing; social–ecological system; social–ecological resilience; transformative management*

INTRODUCTION

The COVID-19 pandemic has led to the closure of numerous factories, and stay-at-home orders affected countless supply chains across industries (Ketchen & Craighead, 2020). Disruptions sparked by this pandemic have resulted in the loss of key suppliers and the unavailability of critical parts. By exposing the vulnerability of contemporary supply chains, the pandemic has led many companies to fundamentally question the dominant supply chain narrative of cost reduction and responsiveness. The pandemic has succeeded in getting people to ask the questions they have failed to ask about other serious issues, including the much more existential climate and biodiversity crises (see Pagell & Shevchenko, 2014; Vinke et al., 2020).

Science shows that our planet's carbon budget will be completely exhausted in just a few years (Rogelj et al., 2019) and that we are amid an exceptionally rapid and human-induced loss of biodiversity, thereby entering the sixth mass extinction (Ceballos et al., 2015). Yet food supply chains still rely on soy and meat products from Brazil, despite the resulting destruction of the Amazon. Electronic supply chains are still routinely built on linear, fossil, and resource-intensive business models. Asian fishers harvest the by-products of the current supply chain model in the form of plastic waste, and children breathe them in the form of toxic fumes in the recycling yards of Western Africa. The unanswered question is how supply chain management (SCM) in the post-COVID-19 era can "build back better" to deal with the large crises we are facing—and ignoring—right now.

The deterministic approaches that have largely characterized SCM are no longer sufficient to address

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contemporary challenges (see Biggs et al., 2010; Holling & Meffe, 1996). The SCM discipline has been focused on controllability, rationality, optimality, and objectivity, but this paradigm makes it difficult to handle the multifaceted challenges and rapid change of our world. As such, the discipline fails to question the definition of "successful" SCM (Darby et al., 2019; Nilsson, 2019). Its mode of science "focuses on parts of the system and deals with experiments that narrow uncertainty to the point of acceptance by peers; it is conservative and unambiguous by being incomplete and fragmentary" (Gunderson, 2003, pp. 39–40).

Researchers in this discipline have certainly not been so naive as to believe that the outside world has nothing to do with supply chains and the decisions of supply chain managers. This implies it is insufficient to take the perfectly connected rectangles in the figures of our textbooks literally. It feels morally troubling to me to teach and research isolated "best" practices in SCM when the planet is breaking down because, in part, these practices are at the heart of "wicked problems" (Touboulic et al., 2020). This article will argue SCM deserves to be reshuffled, slipping off the fetters of theoretical interpretations that are predominantly reductionist and static.

More adaptive and integrated approaches can improve the ability to manage processes and structures that are embedded in our complex world (Biggs et al., 2010; Davoudi et al., 2013). One of these approaches, rooted in ecology, is panarchy theory (Gunderson & Holling, 2002). A panarchy provides a structure for understanding how a system follows the movements of adaptive cycles on scales of time, space, and meaning (see Holling, 2001; Westley et al., 2002). This theory has proven to be extremely powerful in other fields, helping researchers overcome static and reductionist assumptions (Davoudi, 2012).

Based on panarchy theory, a new research paradigm that allows SCM researchers to understand the world's empirical complexity in a nontraditional way is proposed. It allows the discipline to analyze how the structures and functions of a supply chain change as a result of both internal dynamics and external interactions (see Walker et al., 2006). It is time to replace the modernist tropes of designing, planning, and optimizing the supply chain with a new metaphor that accounts for the transformative power of management: that of *dancing the supply chain* (see Evans, 2011; Gunderson, 2003).

This article proceeds as follows: First, the conventional assumptions of the supply chain are challenged by reinterpreting it as a social–ecological system. Second, the adaptive cycle from panarchy theory is used to describe the supply chain's behavior. An adaptive cycle sequentially accounts for growth and stability, as well as change and variety. Third, a panarchy is then presented as a structure of adaptive cycles that are linked across different levels on scales of space, time, and meaning: (1) the supply chain level, (2) the political-economic level, and (3) the planetary level. Fourth, cross-level linkages are analyzed within the panarchy, revealing that these adaptive cycles interact. Finally, a new research agenda that will allow understanding the world's empirical complexity differently and challenging the effectiveness and relevance of SCM research in a turbulent and uncertain environment is presented.

REINTERPRETING THE SUPPLY CHAIN

The supply chain has traditionally been interpreted as a static system, as a *being* that is clearly delimitable from its surroundings (Nilsson & Gammelgaard, 2012)—for example, as a "network of connected and interdependent organisations mutually and co-operatively working together" (Christopher, 2016, p. 3) or a system that "consists of all parties involved, directly or indirectly, in fulfilling a customer request" (Chopra, 2019, p. 15). Supply chains have often been treated deterministically by managers, just like an engineer would treat a machine they were designing or controlling. SCM has been described as "the value-creation engine of the modern organization" (Fawcett & Waller, 2013, p. 183) and has been dominated by the notion that the supply chain should behave like clockwork. This suggests that once its functioning is sufficiently understood, strategies could then be designed to control it and maintain it in an optimal state (see Biggs et al., 2010; Cortner & Moote, 1999). This perspective has led to remarkable new insights about how the supply chain works as a system and how it can be controlled. Yet this article argues that two assumptions, often implicit, have led to the discipline's failure to deal with the dynamics of processes and structures over space and time and in terms of changing meaning, as well as with the interrelations between a supply chain and the rest of the world.

First, contemporary theories in SCM usually consider a certain set of conditions as stable. These conditions include wide support in business, society, and politics for global sourcing strategies; the long-term availability of sufficient natural resources needed in manufacturing; and the willingness of humans to consecutively consume new product generations. What unites the discipline's empiricist and modeling camps is their pursuit of commanding target variables—for example, "competitive advantage" or "efficiency." Ecological studies have revealed, however, that optimizing a system to a specific set of ostensibly stable conditions should be avoided because this will reduce the system's ability to adapt when these conditions change (Evans, 2011; Gunderson et al., 1995). This

"command and control" approach can result in unforeseen consequences and has led to the notion of management "pathology"—in which the system loses its resilience, resulting in crises and surprises (Holling, 1996; Holling & Meffe, 1996). For example, although several countries have already announced a future ban of combustion engines, many traditional carmakers continue to promote slightly optimized versions of such engines as a futureproof solution. Meanwhile, Tesla has gained an early-mover advantage by presenting an automotive supply chain based on the new postfossil reality.

The second assumption is that a supply chain can be isolated from the rest of the world, that SCM research can be reductionist by assuming away its systemic environment. In SCM thinking, the supply chain's environment is sometimes perceived as monolithic (Borgatti & Li, 2009) and proxied by static moderating variables or stylized as some set of manageable stakeholders (Pagell & Shevchenko, 2014). Even worse, what goes on beyond the supply chain is often not considered at all. In fact, it is neither possible nor desirable to interpret the supply chain as an isolated system that can be separated from its environment. The supply chain and its environment are in no way independent of each other, which calls the reductionist assumption of traditional SCM theory into question. Our complex world can be interpreted as a *system of systems*, the supply chain being one of these. The COVID-19 pandemic provides an account of the entanglement of the supply chain with other systems that operate at different levels of the world: at the political-economic level, politicians imposed the closure of factories to curb the spread of the virus; at the sociocultural level, the pandemic resulted in novel consumption patterns; and at the supply chain level, managers began to question the overreliance on single sourcing from China and realized their supply chains were lacking resilience.

There are good arguments for leaving behind the traditional assumptions and questioning the resulting behavior and boundaries of the supply chain (Darby et al., 2019). Yet the impact of such arguments has been limited, even though practitioners are constantly reporting how important it is to deal with an ever-changing, unpredictable business reality. By acknowledging that our world is complex, striving for constancy, predictability, and efficiency, as the engineer's view assumes, has to be replaced with a focus on change, unpredictability, persistence, and transformability.

A supply chain could instead be interpreted as an organic system, as a *becoming* (Nilsson & Gammelgaard, 2012). This view shifts the focus away from attempting to maintain the supply chain in some fixed optimal state to guiding change along desirable trajectories (see Biggs et al., 2010). This perspective interprets the supply chain as dynamic in the sense that changing any one part would have considerable effects on the other parts (Westley et al., 2002). Moreover, instead of describing the supply chain as a closed system that is disconnected from its environment, it could be, building on panarchy theory, reinterpreted as a social–ecological system, thereby acknowledging the dynamics between nature and people. Table 1 summarizes how panarchical thinking adds to traditional SCM.

As our discipline becomes aware that traditional assumptions about the supply chain are not always useful, this discipline should also discuss whether traditional assumptions about the *management* of the supply chain require reformation. Holling (2003) wrote, "The bewildering, entrancing, unpredictable nature of nature and people, the richness, diversity and changeability of life come from that evolutionary dance generated by cycles of growth, collapse, reorganization, renewal and re-establishment" (p. xv). Although similar, the dancing metaphor applied in this article to the management of the supply chain as a social–ecological system goes beyond its evolutionary interpretation often applied to the management of ecological systems. Davoudi and her coauthors (2013) argued there is little that can be done to steer transformation in ecological systems, whereas intentionality and human ingenuity mean something can be done in social–ecological systems. While evolutionary processes allow ecological systems to adapt to new circumstances, dancing allows social–ecological systems to not only adapt but also transform. Dancing represents the human ability to foresee the next steps while acknowledging that "[a]ctor bonds and resource ties are contexts which may both shape the dancing and be shaped by the dancing" (Wilkinson et al., 1998, p. 494) and, therefore, require the dancer to improvise, experiment, and innovate. Dancing considers disturbance as a "window of opportunity" for transforming to a more desirable and radically different trajectory (see Davoudi et al., 2013). The metaphor has also been employed during the COVID-19 pandemic to propose "a dance of measures between getting our lives back on track and spreading the disease, one of economy vs. healthcare" (Pueyo, 2020).

ADAPTIVE CYCLE

One aspect of panarchy theory is the notion that a system follows the movements of adaptive cycles (Holling, 1986, 2001). Adaptive cycles rest on dynamic theoretical interpretations—for example, how a forest changes over time and responds to a wildfire. Approaches that acknowledge the need for adaptation are not entirely new to the SCM literature (e.g.,

TABLE 1

Characteristics of Traditional and Panarchical Supply Chain Management

	Traditional supply chain management	Panarchical supply chain management
Assumptions	Static; reductionist	Dynamic; holistic
Discourses	Modernism; positivism	Holism; interpretivism
Supply chain	Closed, engineered system ("being")	Open, social–ecological system ("becoming")
Management	Command and control; optimization; scientific	Dancing; navigation; experimental
Integration	Cross-functional; cross-organizational	Cross-level
Goals of management	Growth; stability	Transformation; variety
Decision-making	Objective	Subjective

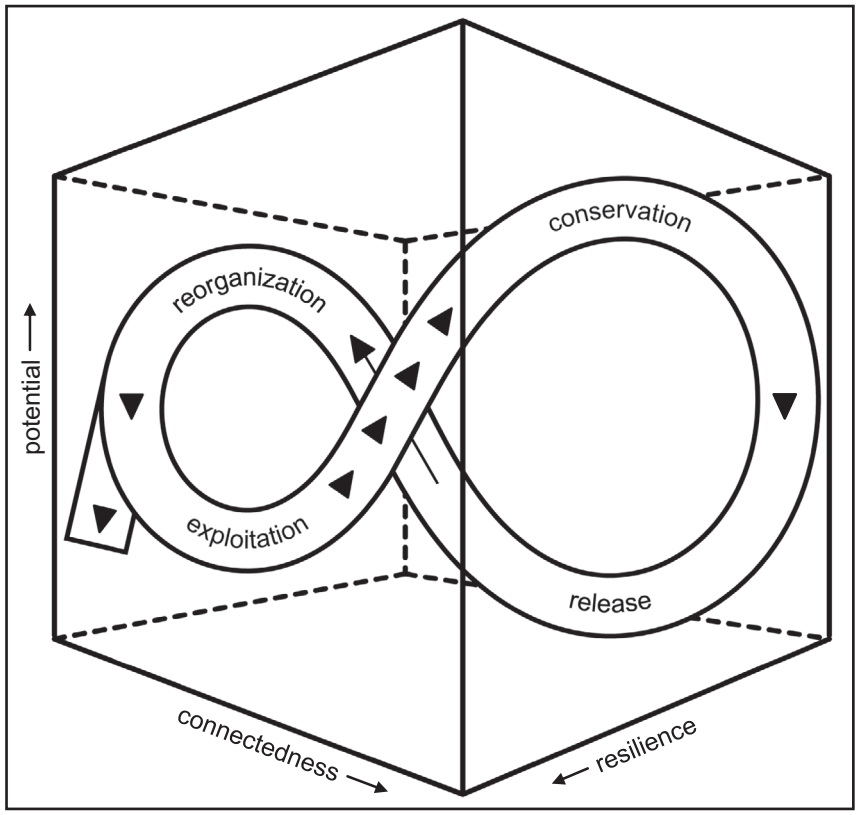
Kauffman et al., 2018). In brief, an adaptive cycle consists of four consecutive phases: exploitation, conservation, release, and reorganization (Gunderson & Holling, 2002). The trajectory from exploitation, when resources are used as opportunities, to conservation, when capital is accumulated, is thought to take place slowly (Holling, 2001), which is symbolized by the four arrows in the front loop of Figure 1. The system accumulates resources by increasing both its *connectedness*, which relates to the degree to which it can control its own destiny, and its *potential*, which determines the range of future options and includes capital that is amassed over time (for example, biomass, nutrients, and physical structure; Holling, 2001).

Transferring this idea from a forest to the supply chain, resources include suppliers, assets, workers, capabilities, materials, and technologies. Over time, as the supply chain's connectedness increases, it eventually becomes overconnected and thus increasingly rigid in its control—it becomes "an accident waiting to happen" (Holling, 2001, p. 394). The actors in a supply chain might then be culturally or contractually locked into a situation that conserves a certain business model even if consumer preferences have already changed, requiring a novel business model instead. This vulnerability leads to the release of resources, for example, if a new technology makes an existing supply chain obsolete, forcing its connections to dissolve (Christensen, 1997). The trajectory from release to reorganization proceeds quickly, as symbolized by the single arrow in the back loop in Figure 1. This is the period in which "novel recombinations can unexpectedly seed experiments that lead to innovations in the next cycle" (Holling, 2001, p. 395)—which has been linked to what Schumpeter (1942) called "creative destruction" in economics, leading to a new phase of exploitation. However, there may sometimes be an exit from the cycle after the reorganization phase, in which the potential "leaks away" and the system becomes less organized and productive (Berkes et al., 2003). Holling (2001) described the ambidexterity inherent in the front and back loops of the adaptive cycle as follows:

> It is as if two separate objectives are functioning, but in sequence. The first maximizes production and accumulation; the second maximizes invention and reassortment. The two objectives cannot be maximized simultaneously but only occur sequentially. And the success in achieving one inexorably sets the stage for its opposite. The adaptive cycle therefore embraces two opposites: growth and stability on the one hand, change and variety on the other. (p. 395)

The adaptive cycle leads to the concept of *resilience*—which, in addition to potential and connectedness, is a third dimension of the adaptive cycle (Figure 1). It is worth investigating this concept in a bit more detail because the definition of resilience inevitably changes through a reinterpretation of a system as a "becoming" rather than a "being." Resilience in SCM is traditionally defined as *engineering* resilience (see Holling, 1996). This notion is, indeed, directly borrowed from mechanical engineering, thereby being in the tradition of scientific management approaches (Sheffi, 2005; Taylor, 1911). Just as an engineer wants a material to recover its original shape after deformation (Sheffi, 2005), a supply chain manager wants the supply chain to be able to do the same. As a consequence, supply chain resilience is viewed as the ability to, and speed at which companies can, return to normal performance outcomes—production, services, and fill rate—after a high-impact, low-probability disruption (Sheffi, 2005) and "the ability to bounce back from a disruption" (Sheffi & Rice, 2005, p. 41). What construes resilience as engineering resilience is a

FIGURE 1
The Adaptive Cycle (Based on Holling, 1986, 2001)



concentration on stability near an equilibrium steady state, with the speed of return to the equilibrium and the resistance to disturbance being used to measure the property (see Holling, 1996). Therefore, time to recover and time to survive have been introduced as metrics of supply chain resilience (Simchi-Levi et al., 2018). Characterizing the supply chain as an engineerable system and placing supply chain managers in the position of engineers is just one way of interpreting it. This has been beneficial in controlling the supply chain, but panarchy theory and recent events both reveal that this control is illusory and that we need a new understanding of resilience.

Other fields have already completed the transformation of their respective management paradigms to better match the object under study. Perhaps most prominently, the understanding of resilience in ecology had long been dominated by engineering resilience as well, but the field's paradigm has shifted to *ecological* resilience: "the amount of disturbance that a system can withstand before it shifts into an alternative stability domain" (Allen et al., 2016, p. 625)—that is, before it flips into "another regime of behavior" (Holling, 1996, p. 33). It was Holling (1996) who exposed the difference between engineering resilience (being focused on constancy, predictability, and efficiency) and ecological resilience (being focused on change, unpredictability, and persistence). This transition shifted the notion of resilience from engineers' desire for *fail-safe* designs to ecologists' desire for *safe-fail* designs (Holling, 1996). To say it differently, instead of measuring resilience as "resistance to disturbance" or "speed of return" to the equilibrium, as engineers would do, ecologists measure resilience as the "magnitude of disturbance" the system can absorb before it changes its structure by changing the processes and variables that control behavior (Holling, 1996).

Holling's observations in ecology inspired researchers in other fields whose objects are even closer to that of SCM due to the role of social actors. For example, in urban planning, the city, as an important unit of analysis, is increasingly understood as a social–ecological system, abandoning the "modernist dream" of total control and "acknowledging the inherently unpredictable and unplannable nature of cities" (Evans, 2011, p. 224). It is transformability that distinguishes social–ecological resilience from engineering resilience, which relies on stability, and ecological resilience, which relies on evolution (Davoudi et al.,

2013). Social–ecological resilience means "disturbance has the potential to create opportunit[ies] for doing new things, for innovation, and for development" (Folke, 2006, p. 253). Because supply chains can also be understood as social–ecological systems, SCM can reformulate resilience "not as a fixed asset but as a continually changing process; also here, not as a being but as a becoming" (Davoudi, 2012, p. 304). For the adaptive cycle, this means resilience is no longer understood as a fixed quantity; rather, it contracts (conservation and release) and expands (reorganization and exploitation) throughout the cycle (Holling & Gunderson, 2002; Ullah et al., 2015).

PANARCHY

Various disciplines, including SCM, acknowledge that systems operate at different levels and that a hierarchy exists between these levels—for example, between the supply chain level, the political-economic level, and the planetary level (Carter et al., 2015a; Starik & Rands, 1995; Steffen et al., 2018). Hierarchy traditionally refers to processes operating at higher levels controlling and constraining lower-level phenomena (Adger et al., 2009). However, the notion of top-down authority ignores the dynamic nature of the interconnected structures of complex systems (Holling et al., 2002). To abandon the rigid idea of hierarchy, pioneering authors introduced the term "panarchy"—which is inspired by Pan (Holling et al., 2002), a Greek nature god (later interpreted as the god of everything), who is known for dancing with the nymphs.

A panarchy differs from a traditional hierarchy in that it "provides a framework that characterizes complex systems of people and nature as dynamically organized and structured" (Allen et al., 2014, p. 578) within and across different levels. In ecology, a level is understood as the unit of analysis located at a certain position on a scale of time and space (Berkes & Ross, 2016; Cash et al., 2006).[1] For example, Allen et al. (2014) described a terrestrial ecosystem dominated by needle-leaved evergreens as having discrete processes and structures at a number of levels: a needle or leaf level (months in time and centimeters in space), a tree level (decades and meters), and a forest level (centuries and kilometers). The adaptive cycles operating at these levels interfere with one another. The interdependencies between the levels of a panarchy are notably distinct from the "is constrained by" relationships between the levels of a top-down hierarchy.

[1]Some of the earlier panarchy literature used the term "scale" to denote both "level" and "scale." The more recent literature defines scales as the dimensions that are used to study and measure any phenomenon (Berkes & Ross, 2016; Cash et al., 2006).

Panarchy theory, therefore, acknowledges the need to analyze and manage at different levels simultaneously (Berkes et al., 2003). Holling (2001) described the panarchical interactions as follows:

> Each level is allowed to operate at its own pace, protected from above by slower, larger levels but invigorated from below by faster, smaller cycles of innovation. The whole panarchy is therefore both creative and conserving. The interactions between cycles in a panarchy combine learning with continuity. (pp. 398–399)

The adaptive cycle and the understanding that a system is organized panarchically have numerous applications across varied fields of study, not just ecology (Berkes et al., 2003) but also agriculture (Grundmann et al., 2012), tourism (Tsao & Ni, 2016), human behavior (Randle et al., 2015), and urban planning (Davoudi, 2012). Thus far, applications of panarchy theory in the management literature have been very rare. For example, Berkes et al. (2003) described a business cycle as following this pattern: "A business cycle may consist of a company starting up and growing. The company will eventually decline and go out of business, while its parts and the accumulated experience may combine with other sources and reorganize into a new business" (p. 16). Another example comes from Williams and her coauthors (2019), who suggested "insights from natural science may help organizational scholars to examine cross-scale resilience and conceptualize organizational actions within and across temporal and spatial dynamics" (p. 1).

It is, however, not a trivial task to transfer this logic from a system of nature, as in ecology, to a system of nature *and people*; such a transfer is required in a social science such as SCM because social–ecological, unlike ecological, systems require an additional scale beyond time and space: a symbolic construction or meaning (Westley et al., 2002). It allows an interpretivist reading of phenomena (see Darby et al., 2019) and acknowledges that human beings are constantly making sense of the events they perceive (Weick, 1995), thereby creating a "virtual reality" around them (Westley et al., 2002). Adding a qualitative meaning scale to the typically quantitative notion inherent in scales of space and time allows us to see how different narratives are embedded in each other across a panarchy (see Granovetter, 1985). A smaller narrative (e.g., "a green business model") at one level of meaning can then interact with a larger narrative (e.g., "the climate crisis") at another level.

Based on this understanding, a panarchy will now be developed. This panarchy can, for example, be observed at the supply chain level (e.g., about one year for each product generation; a relatively

simple narrative of cost efficiency and responsiveness),[2] the more abstract political-economic level (decades; a larger narrative of growth and globalization), and the planetary level (tens of thousands of years; an even more complex narrative of the meaning of life). A supply chain—which typically includes brand companies, their suppliers, their buyers, and so on—relates to discrete processes and structures not only at its own level but, notably, also beyond. As in the analogy with the leaf, tree, and forest in ecology, each of these levels relates to a characteristic structural pattern, and each of these patterns is driven by characteristic processes. In terms of meaning, each level has its own narrative—for example, the narrative of growth via consumption and globalization being told at the political-economic level. The supply chain is thus understood as being embedded in a multilevel structure that shapes a panarchy.

Supply Chain Level

The exploration of this stylized panarchy begins with the supply chain level. The dynamics of the supply chain follows an adaptive cycle, and the timeframe for each cycle is relatively short. For example, the launch of a new smartphone generation has, in the past, usually been an annual event. In fast fashion, new products are usually launched even more frequently. The cycle time might coincide with the lifespan of a product generation or might be longer if connectedness prevails across generations. The trajectory of the front loop of the adaptive cycle at the supply chain level clearly follows the pattern that would be expected based on panarchy theory (see Figure 1).

It starts with the exploitation phase, in which the connectedness of the supply chain is rather low because relationships between the brand company and other actors (e.g., suppliers of components, contract manufacturers) are still being built. Also, the potential inherent in the supply chain remains low. This potential could derive from skills, mutual trust, and networks of relationships (see Holling, 2001). The resilience, in contrast, is high because no investments have yet been made that could be lost in the case of failure.

While building the supply chain for a new product generation, resources are slowly accumulated over time, which leads to the conservation phase. In this phase, both connectedness and potential have reached their high points. Conversely, due to the rigidity of the established supply chain, resilience has now become low. Various supply chain actors are now closely linked via joint R&D teams between suppliers and buyers and via dependencies on component suppliers.

The trajectory of the back loop, which consists of the release and reorganization phases, also follows the expected pattern: The release phase occurs when the current supply chain setup will no longer lead to success. This occurs when customers downstream in the supply chain demand product innovation and are not willing to buy a product from the old line any longer. Second, release can also be induced by shocks that are located outside of the supply chain level. For instance, the supply chain of a Danish juice producer, which sells its beverages to hotels, temporarily lost its meaning during the COVID-19 pandemic when hotels had to lock down, and this producer adapted its supply chain by bottling hand sanitizers instead. Third, because forward-looking behavior is a definitive feature of human systems (Westley et al., 2002), supply chains are often transformed in anticipation of larger developments. Tesla's supply chain disrupted the automotive industry's narrative of the combustion engine by turning the larger narrative of climate crisis into an early-mover advantage for electric cars. In most of these cases, the close cohesion of the old supply chain is no longer needed, and the resources that were previously accumulated and sequestered are now set free, for instance, by terminating contracts with suppliers. Some relationships dissolve, some meanings change, and some truths become untruths.

The release of accumulated resources opens a short window of opportunity to innovate the next product generation's supply chain, which leads to the reorganization phase. A new narrative of a better product takes its course from this phase. The resilience of this phase is high because the released resources allow the supply chain to absorb a high magnitude of disturbance. This implies costs of failure are low, which allows for tests of novel combinations and results in conditions needed for creative experimentation (Holling, 2001). During this phase, the supply chain may shift to something new—which is characterized by a new set of processes, structures, norms, and routines, for example, by establishing relationships with new partners (see Allen et al., 2014). As an example, General Motors, Ventec Life Systems, CEVA Logistics, and other companies teamed up during the COVID-19 pandemic to establish a supply chain of critical care ventilators.

In more stable times, the marginal innovative leaps perceived by customers decrease from one product generation to the next; that is, it becomes increasingly difficult for customers to see a difference between the two latest product generations and for R&D teams to generate this difference. One way to cope with this

[2]This analysis is focused on scales of time and meaning. The spatial scale still plays a role for the supply chain. For example, at a small level, R&D teams often collaborate locally, while supply chains may span the globe. Because spatially small levels are not discussed here, and all three selected levels have a global reach, the spatial scale is not explicitly analyzed.

challenge, of course, could be to speed up innovation processes, but the cycle will come to a halt once the innovative leaps become too small to convince a customer to buy a new product, as evidenced by disk drive supply chains (Christensen, 1997).

The supply chain of each annually launched product generation thus far has followed the political-economic narrative of growth and globalization. However, this narrative may not be taken for granted as the only possible way of organizing business. We, therefore, turn from the adaptive cycle of the individual product's supply chain to the much slower adaptive cycle of the political economy.

Political-Economic Level

In an exploitation phase, during the 1980s and 1990s, the narrative of growth and globalization emerged via free trade agreements. This narrative resulted in a high degree of specialization and labor division and, thus, vertical disintegration (Mudambi, 2008). Companies in many industries soon took this narrative for granted. Meanwhile, many companies that attempted to conserve local production and vertical integration were doomed to disappear from the market. Globalization has since dominated most manufacturing industries, as indicated by the continuous rise of the share of foreign value-added in total exports from 1990 to 2010 (UNCTAD, 2018).

The maturation of this narrative can be described as the shift from the exploitation phase to the conservation phase of the adaptive cycle. Therefore, the front loop—from exploitation to conservation—is characterized by incremental innovation (e.g., amendments to trade deals) that strengthens the current trajectory of change (see Biggs et al., 2010).

SCM as a discipline has taken the political-economic narrative of growth and globalization for granted at least in many industries, almost like an engineer does with the construction plan of a machine. It is as if the supply chain, whenever it loses stability, simply requires sufficient command and control to bring it back to the track predetermined by this larger narrative. Management, in this sense, is mainly about getting back to normal in the case of a disruption. The first generations of supply chain managers were eyewitnesses to the exploitation and conservation phases of the political economy as we know it today. The absence of the release and reorganization phases thus far has created an illusion of stability not only in business but also in academia. For many, growth and globalization simply seem to be a timeless and indestructible way of organizing business stabilized by strong structures of signification (see Giddens, 1984).

Stabilized by rigidity and inertia (Otto et al., 2020), the connectedness at the political-economic level might persist. However, it may also increase too much, becoming too rigid in its control (i.e., an "accident waiting to happen") and triggering the back loop of the adaptive cycle. The COVID-19 pandemic might be interpreted as such an accident. The number of actors who are involved in and convinced by the dominant political-economic narrative—including academics, practitioners, consumers, politicians, voters, and those who negotiate trade deals—may simply have become too large. Their attempt to "control" a single target variable—for example, export surplus and GDP growth—independent of larger interactions can result in the "pathology" of management (see Holling, 1996; Holling & Meffe, 1996).

Viewed through a panarchical lens, the narrative of growth and globalization has become rather vulnerable over time, and the adaptive cycle should have already moved to the release phase. This weakness reflects the fragility of our social structures and creates a new window of opportunity for more radical innovation, ultimately leading to the fundamental reorganization at the political-economic level (see Biggs et al., 2010). Encouragingly, small social interventions can sometimes be sufficient to activate contagious processes of rapidly spreading behaviors, social norms, technologies, and structural reorganization and thus have a large tipping effect (Otto et al., 2020).

The reorganization phase, in which rapid changes occur, can arise, and experiments can be seeded via novel combinations, leading to innovations in the next cycle (Holling, 2001). These innovations can be manifested in various ways—for example, in new types of theories, political movements, trade agreements, or customer behaviors. One potential result of reorganization is a shift that entirely abandons the globalized interpretation of the economy in a move toward regionalization. Perhaps we are already seeing this shift: the share of foreign value-added declined globally to 30% in 2017—its growth has come to a halt for the first time in 30 years (UNCTAD, 2018). Time will show whether the discussions surrounding the dependence on medical supply from Asia during the COVID-19 pandemic (e.g., face masks), nationalist policies (e.g., "America First"), or environmental imperatives (e.g., climate tariffs) will result in a further reduction of this share.

Note that whenever a supply chain is defined as a closed system, this inevitably neglects the back loop of the political economy's adaptive cycle. By acknowledging the political economy's fluid nature, the back loop generates new opportunities that might even result in a radical departure from SCM as we know it.

Planetary Level

Although an extensive body of research exists on sustainability, few SCM authors have explicitly placed

research on sustainability in the larger context of the planetary boundaries (e.g., Beske-Janssen et al., 2015). The SCM literature has typically treated the planetary level as part of the environment, as "monolithic," and as a "thing" outside of the supply chain (Borgatti & Li, 2009). This may be the reason our discipline has not yet made the move "from the question of how [firms can] merely diminish environmental or social problems to how supply chains can become truly sustainable" (Montabon et al., 2016, p. 11). To do so, the discipline must explicitly acknowledge that planet Earth does not merely serve as the stable and uninfluenceable scenery for supply chain decision-making but also follows the logic of the adaptive cycle. It must also be acknowledged that the way businesses and supply chains are organized influences how fast and in what way the natural environment will change. Thus, such change should be guided along desirable trajectories.

It is beyond the scope of this article to repeat or even contribute to the comprehensive Earth science literature. Instead, the relevance of the adaptive cycle at the planetary level is briefly highlighted. Ice core data reveal that for the last 10,000 years, planet Earth has remained in a relatively stable climate, an era labeled the Holocene (Folke et al., 2010). One could argue that this stability was reached during a transition from an exploitation phase to a conservation phase that has lasted over tens of thousands of years.

However, it has also been argued that we have now entered a new era: the Anthropocene, an era defined as "the beginning of a very rapid human-driven trajectory of the Earth System away from the glacial-interglacial limit cycle toward new, hotter climatic conditions and a profoundly different biosphere" (Steffen et al., 2018, p. 8253). The planet is at risk in that self-reinforcing feedback could push it toward a threshold that, once crossed, could cause continued warming along a "Hothouse Earth" pathway (Steffen et al., 2018). This will rapidly lead to the release of resources and reorganize our planet into one that is potentially uninhabitable for humans: "Crossing the threshold would lead to a much higher global average temperature than any interglacial in the past 1.2 million years and to sea levels significantly higher than at any time in the Holocene" (Steffen et al., 2018, p. 8252).

Although many researchers in the domain of sustainable SCM can agree that the ecological capacity of our planet has been exceeded and that we are faced with substantial social challenges as a result, there is far less agreement about how these challenges should be addressed (Matthews et al., 2016), and most of the studies from that domain subordinate sustainability, a goal that operates at the planetary level, to profitability, a goal that operates at the supply chain level (Hardy et al., 2020). In the following, the link between the planetary level and the supply chain level will be unfolded.

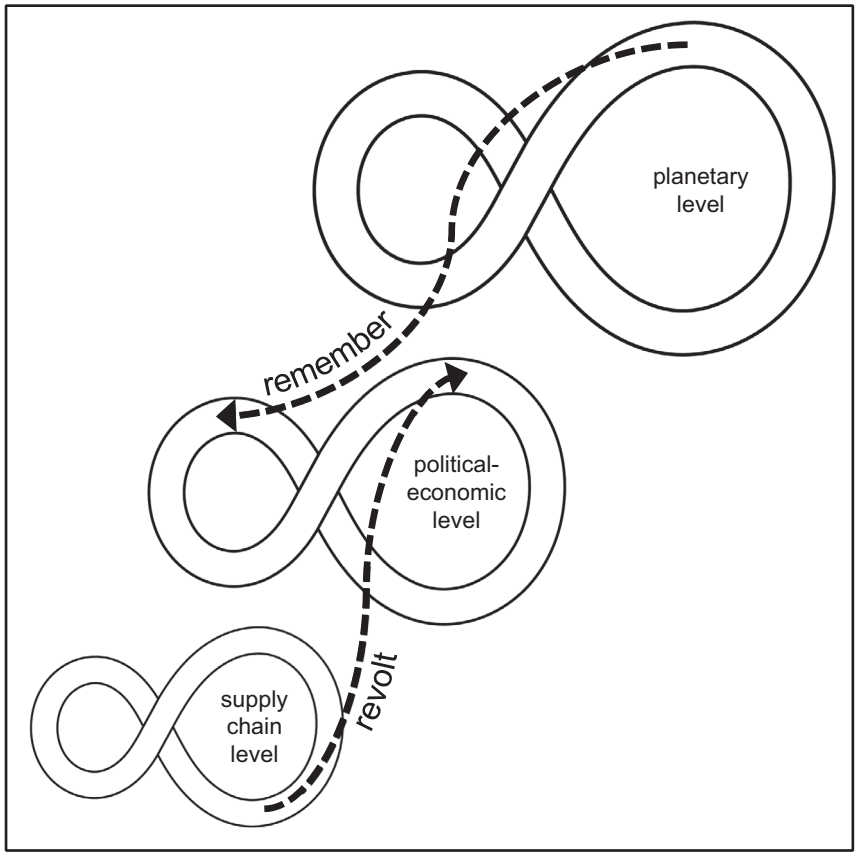
CROSS-LEVEL LINKAGES

Thus far, three adaptive cycles have been presented in isolation. These represent the processes that can be observed at the supply chain, political-economic, and planetary levels of this panarchy. Additional levels, excluded here for brevity, exist. What this reveals more explicitly, as compared to traditional supply chain analysis, is the existence of the back loops of the cycles, replacing the illusory assumption of stability with the assumption of constant change.

Let us turn to a feature of panarchy theory that will allow us to reinterpret the supply chain even more radically: cross-level linkages. They describe the mutual impact of adaptive cycles on one another, which influences overall dynamics (Allen et al., 2014; Folke et al., 2011). Without this feature, companies would assume that the processes of their supply chain do not interact with the processes that operate at other levels. This is obviously not the case. For example, electric-vehicle supply chains have tremendous effects on the health of workers at the level of miner communities, influence the agenda at the political-economic level, and create largely unresolved recycling challenges at the planetary level (Ciez & Whitacre, 2019). Cross-level linkages allow us to move away from the reductionist logic and move on to a holistic approach that treats the supply chain as more than a closed system. In principle, many potential ties between two levels, from any of the four phases of one adaptive cycle to any of the four of another, can be envisioned. For this reason, the following two highlighted cross-level linkages represent only certain instances, though probably the most relevant ones, of a larger set of possible connections.

One of the ties from the supply chain level to the political-economic level is the "revolt" linkage (see Figure 2). It describes a link that has the potential to allow a critical change in the smaller cycle to cascade up to the larger cycle if the latter is currently in a vulnerable situation (Berkes et al., 2003). The term "revolt" is used because it allows the description of, for example, how a community (represented at its own level) revolts against vulnerability at the political-economic level (e.g., when the Berlin Wall fell in 1989). By replacing *community* with the supply chain, this metaphor can also be applied to our context. As noted above, companies tend to launch new product generations on a regular basis—for example, Apple and Samsung have been presenting their newest smartphones once a year. Let us assume that this has just happened, and the adaptive cycle at the supply chain level has just moved to the release phase. It can now be

FIGURE 2
Panarchy with Two Cross-Level Linkages (Based on Gunderson & Holling, 2002)



expected that this supply chain will soon move on to the reorganization phase. However, this relies heavily on the functioning of the structures and processes at the political-economic level. As noted above, they are increasingly challenged; that is, the coarser adaptive cycle at the political-economic level is currently in a rather vulnerable conservation phase, which is a phase with low resilience. The time may arrive when a larger number of decision-makers will realize that for their respective supply chains, operating on the grounds of the contemporary legal framework no longer makes economic sense, thereby challenging its stabilizing coalition, forcing it to collapse, and turning it into something new. For example, an alliance of 68 large companies that are involved in supply chains across industries has recently called upon global governments to initiate a climate stimulus program that could increase political-economic resilience (Foundation 2°, 2020).

A second potential link extends from the planetary level to the political-economic level, and it is labeled as a "remember" linkage (see Figure 2). The term can be understood as follows: when the adaptive cycle moves to the reorganization phase at a finer level, it is reminded that the adaptive cycle at a coarser level is currently placed in the conservation phase, which influences the manner of reorganization. This linkage is triggered by the fundamental contradiction inherent in the relationship between the exponential growth agenda at the political-economic level and the limited resources at the planetary level (see Matthews et al., 2016). The behavioral patterns (i.e., social norms) at the political-economic level have been notoriously conservative (see Folke et al., 2010). When moving to the reorganization phase, several paths could contribute to reinvention at the political-economic level, but the "remember" linkage restricts the space of opportunities. This could be by reminding us that we have only one planet and that the political-economic future should be "green." This influences the constraints on and opportunities for the renewal of the adaptive cycle at the political-economic level (see Berkes et al., 2003). In our example, this could enable the social actors who will shape the globalization model's successor to remember the processes and structures that act at the planetary level and remember that the predominant political-economic objective of "mass production and mass consumption is testing

the physical limits of the globe" (Esposito et al., 2018, p. 5). Systems that also involve humans, unlike ecological systems, possess a certain foresight potential (Westley et al., 2002), which allows us to consider what an alternative to the current political-economic narrative could look like. To increase the likelihood of a resulting transformation, the social learning process should focus on both detecting potential opportunities and appreciating potential vulnerabilities (Davoudi et al., 2013). As an example, influenced by the state of the planet, the European Commission (2019) has presented the European Green Deal, which outlines how to make Europe the first climate-neutral continent.

There can, of course, also be direct remember linkages from the planetary level to the supply chain level. An example is the shift from a linear supply chain to a circular supply chain (Korhonen et al., 2018; Murray et al., 2017). The consumer and product foci inherent to the linear supply chain would then be replaced by user and service foci. Instead of launching a new product once a month/year, providers could then offer the service of using a product via a rental contract, for example. They could partner with companies that can help maintain, redistribute, or refurbish products, which creates new potential in the adaptive cycle. The meaning of ownership would then change from "a product owned by a consumer" to "parts and modules owned by a provider," an approach that could incentivize companies to invest in durability, reparability, and resource efficiency instead of fast cycles.

MOVING FORWARD

Supply chains may appear and disappear over time, as do the narratives that keep them alive. This has fundamental implications for the role of the supply chain manager. We have too often imagined the supply chain as a rigid system, similar to a machine. We have imagined that this system has a fail-safe design and that the manager acts like an engineer by "pushing the right button" and "setting the right course." The COVID-19 pandemic has created major doubts that this picture sufficiently describes reality. In this article, the transition from considering the supply chain as a static fragment to embedding it in a dynamic world was therefore investigated as one potential way forward. What does this mean for SCM theorizing?

The transition from an exclusively static and reductionist view to one that is also dynamic and holistic can be seen as a natural development for SCM. First, several adjacent disciplines, including accounting (e.g., Boland & Pondy, 1983) and organization (e.g., Bansal et al., 2018), have already begun a similar transition. In these disciplines, both approaches coexist and continue to stimulate each other (see Farjoun, 2010). This transition should also prove viable and fruitful for SCM by activating more critical, relational, interdisciplinary, and engaged scholarship (Ergene et al., 2020). Second, we should not forget that pioneering work in SCM research has already used dynamic approaches. This is true of Forrester's (1958) industrial dynamics research, for example, which laid the foundations for our understanding of the bullwhip effect. Complementing the current static models with more dynamic ones would, thus, not be a departure from the principles of SCM research but rather an overdue return. The signs are good that SCM research could once again experience a fruitful expansion. The following research agenda is organized around three themes that SCM should embrace to most effectively benefit from the strengths of panarchy theory in the post-COVID-19 era. This will allow our discipline to understand the world's empirical complexity differently and eventually influence business practice for the better.

Theme 1: Extending the Unit of Analysis

Several authors have challenged the premises of the structure and boundary of the supply chain and demonstrated that it can be better understood by interpreting it as a complex adaptive supply network instead of a simple chain (Carter et al., 2015b; Choi et al., 2001). A panarchical interpretation extends the unit of analysis even further to simultaneously capture concerns at other levels. Identifying the levels of structure present in a panarchy is by no means trivial and has major implications for construing the nature of the object under study (Allen et al., 2014). For example, in terrestrial systems, Westley and her coauthors (2002) identified "six to ten orders of magnitude in space—from leaves to plants to crowns to patches to landscapes to watersheds to biomes" (p. 106). For the study of many SCM phenomena, the three levels discussed in this article will not be sufficient.

To identify a suitable set of levels, the group, functional, organizational, supply chain, political-economic, sociocultural, and planetary levels suggested in various disciplines (Carter et al., 2015a; Starik & Rands, 1995; Steffen et al., 2018) can serve as starting points, as they place the supply chain in the center and represent sufficient interaction. However, every research setting requires a reconsideration of this set. For example, the levels investigated in a study about socially responsible supply chains likely also need to reflect individual workers, farmers, buyers, families, plants, and local communities.

Researchers could ask the following questions to test whether a set of levels is salient in a certain context:

Are the selected levels essential to explain the research phenomena? Do the smallest and largest levels sufficiently delimit the research context? Will adding additional levels help to explain the phenomena better? Are any relevant levels missing between the selected levels?

Theme 2: Managing In, Through, Out, Up, and Beyond

SCM has often been viewed as the management *of* the supply chain, focusing on business functions and businesses "within the supply chain" (e.g., Mentzer et al., 2001, p. 18) and treating the supply chain "as a whole" (Christopher, 2016, p. 3). Following a panarchical approach, Westley (2002) presented the case of one manager who attempts to apply adaptive management approaches to a series of challenges. This case could serve as a blueprint for similar studies in SCM, as it takes into account the changing reality of the manager and larger institutional forces affecting this individual (i.e., it covers different levels, adaptive cycles at these levels, and cross-level linkages). This allows the interpretation of SCM as what Westley (2002) called managing *in*, *through*, *out*, and *up*, which comes close to the panarchical view on resilience.

Managing *in*, which is about the need to manage influence and position within the supply chain, is most familiar to our discipline, which has made outstanding achievements in understanding the management of cross-functional and cross-organizational relationships. Managing *through* is a scientific management approach that treats SCM interventions as experiments to learn from (not solutions to be implemented). Managing *out* involves stakeholders and external groups in supply chain decisions. This means to "go local," an approach pursued by Symrise —a producer of flavors and fragrances who partners with local communities of smallholder farmers in Madagascar, thereby avoiding the prevailing intermediate trade approach of that industry. Managing *up* takes into account the larger political context. This expands the role of the supply chain manager to the one of a governor, lobbyist, and politician (see Krause & Miller, 2020). To bring us to a truly transformative interpretation of adaptive management (see Folke et al., 2010), managing *beyond* could be added as a more radical approach, which is about fundamentally challenging the structures and processes beyond the supply chain.

This extension of management requires scholars to seek out new collaborations with unlikely partners, in order to engage with theories that cover phenomena at other levels of the panarchy. As an example, future research projects could integrate theoretical explanations from social, economic, political, and environmental sciences and build on system dynamics approaches to model how a manager's decisions affect the properties of linked adaptive cycles and vice versa.

Theme 3: Discovering New Relationships

The literature on multitier supply chains often defines the indirect relationship between two actors (e.g., between a buyer and its second-tier supplier) in terms of mediation by another actor (e.g., first-tier supplier; Mena, Humphries, & Choi, 2013). Panarchy theory offers an alternative way of defining the relationship between seemingly unrelated and geographically distant supply chain actors in terms of their "teleconnection" via larger levels (Adger et al., 2009). This allows researchers to investigate the impact behaviors in one part of the supply chain have on the behaviors of companies and workers at the other end. Thus, to truly understand supply chain relationships requires tracking how phenomena level up and down, necessitating researchers to zoom in and out of the supply chain. This can be done by investigating how different adaptive cycles influence one another, not directly but via larger cycles.

Taking this lens to study global supply chain relationships offers new opportunities for research. Adger et al. (2009) showed for the coffee supply chain how the fate of farmers in Vietnam and Mexico are mutually connected: the concurrent gains in the livelihood security of farmers in Vietnam when expanding their production cascaded up through the commodity chain and exerted downward pressure on global prices, thereby decreasing the livelihood security of farmers in Mexico. SCM scholars could follow this approach and, for example, uncover the vulnerabilities and desires of communities of cobalt *creuseurs*, often children, digging for battery ingredients in the Democratic Republic of the Congo and determine the consumption patterns of the buyers of electric cars containing these batteries in the global North by studying how structures and processes are "teleconnected" via household, community, company, supply chain, political-economic, and planetary levels.

The dynamic and holistic nature of panarchical thinking allows SCM researchers to strike new or neglected epistemological and methodological paths when investigating cross-level relationships. Spanning a broad spectrum of quantitative and qualitative approaches, these paths could include interpretative/multilevel case studies, network analysis, scenario planning, and historical studies (Fischer et al., 2015; Vaara & Lamberg, 2016).

CONCLUSIONS

Taking *dancing* in its literal sense, most people would intuitively agree that observing a couple dancing in the banquet room of the *Titanic* does not

deserve the highest priority when the ship has started to sink. The observers seem to assume that the dance will continue forever, which is a static assumption. Instead of focusing on the bigger narrative of the approaching cataclysm, it is the narrative of the dancing couple that receives their full attention, which is a reductionist approach. Sometimes, one has the impression that the behaviors of academics and practitioners in SCM are not much different. They assume the supply chain to be a static system and are reductionist in their analysis of it. "Why do the dancers suddenly stumble?" they ask, not seeing the sinister movements of the ship. Just as the attention belongs with the sinking ship rather than the couple's dance steps, our discipline must shift attention from the traditional interpretation of SCM to the transformative dance across the adaptive cycles in the panarchy—before it is too late.

This work has attempted to advance SCM through the lens of panarchy theory. In the same way as bullwhip theory, via the larger narrative of the supply chain, allowed us to explain demand variations that previously appeared to be random phenomena, panarchy theory, via cross-level linkages, will now allow us to explain changes in the supply chain that had appeared to be spontaneous phenomena and how the supply chain contributes to changes in the wider contextual environment. It has been demonstrated here that simultaneous developments are currently occurring both at the larger planetary level and at the smaller supply chain level, requiring the political-economic narrative to be transformed into something new.

We have learned from the COVID-19 pandemic that it is possible to challenge obsolete truths at different levels. This could open a new window of opportunity to experiment, allowing us to generate "new normal" narratives that do not ignore the far more existential climate and biodiversity crises any longer. A model that has been based on linearity, carbon, consumerism, and material growth and dominated the conservation phase of most supply chains might then shift. The cross-level linkages, both from the planetary level and from the supply chain level, may guide transformation toward something that builds on a circular, postfossil, servitized, and degrowth model. This could incentivize companies to keep existing resources in the loop; design, produce, and market regenerative products; allow them to slow down their innovation processes; and still enable them to be profitable via the services sold. What we are currently observing is the interaction of revolt, remember, and release phenomena co-occurring at different levels. The resulting reorganizations may be more radical than one would assume. Those seeking to conserve the 20th-century models may be doomed to disappear. This attempt to transplant a theory to SCM from a field as alien as ecology must inevitably fail to cover all the richness of panarchical theorizing that has already been elucidated there. Therefore, this article cannot be more than the beginning of a debate. It will now be up to SCM scholars to decide how to advance a research agenda built on this encompassing way of thinking. An exciting journey lies ahead!

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