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RESEARCH ARTICLE

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Dynamic business modeling for sustainability: Exploring a system dynamics perspective to develop sustainable business models

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Abstract

In the last decade, business models for sustainability have gained increasing attraction by corporate sustainability scholars with international conferences and scientific journals encouraging the development of the debate on their design, use and innovation processes. Capitalizing on the basic principles, requirements, and methodological limitations found in the literature on sustainability-oriented business model design, this paper aims to conceptualize a dynamic business modeling for sustainability approach, which combines an adapted sustainable business model canvas and system dynamics modeling. To this end, the paper also illustrates the key operating principles of the proposed approach through an exemplary application to Patagonia's business model. Findings suggest that dynamic business modeling for sustainability may contribute to sustainable business model research and practice by introducing a systemic design tool, which frames environmental, social, and economic drivers of value generation into a dynamic business model causal feedback structure, thus overcoming methodological gaps of the extant business model design tools.

KEYWORDS

business model design, business models for sustainability, dynamic business modeling, sustainability, system dynamics modeling

1 | INTRODUCTION AND RESEARCH DESIGN

1.1 | Introduction

In recent years, research on business models (BMs) has tremendously increased, becoming a hot topic to investigate on the border between strategic management and entrepreneurship. Therein, different research streams are multiplying (e.g., BM ontology, BM design, BM innovation, circular BMs, and so on) as testified by the growing number of scientific, and applied contributions recently appeared in scientific journal's special issues, dedicated conferences, and workshops, as well as international academic networks (Foss & Saebi, 2017; Massa, Tucci, & Afuah, 2016).

In this prolific research background, one of the most promising lines of inquiry relates to BMs for sustainability (or sustainability-oriented BMs, or simply sustainable BMs—these notions are abbreviated in the following as "BMfS"), that is currently experiencing a heated debate among scholars (Bocken, Short, Rana, & Evans, 2014; Boons & Lüdeke-Freund, 2013; Dentchev et al., 2018; Lüdeke-Freund, Bohnsack, Breuer, & Massa, 2019; Schaltegger, Hansen, & Lüdeke-Freund, 2016; Upward & Jones, 2016). BMfS are defined as BMs incorporating concepts, principles, or goals that aim at sustainability, or integrating sustainability into their value proposition, value creation and delivery activities, and/or value capture mechanisms (Bocken et al., 2014; Boons & Lüdeke-Freund, 2013; Geissdoerfer, Vladimirova, & Evans, 2018). Indeed, including sustainability issues into BMs enables to adopt a comprehensive perspective of the strategy design

and associated organizational dynamics driving the success (or failure) of organizations.

Recent studies highlighting the relevance of BMfS explored the state of the art in this research field, thus bringing out principles, criteria, and tools related to BMfS development, as well as design requirements, methodological gaps, and shortcomings of the extant modeling approaches (Breuer, Fichter, Lüdeke-Freund, & Tiemann, 2018; Dentchev et al., 2018; Lüdeke-Freund et al., 2019). Attempts to deal with these requirements and criticisms have resulted in valuable approaches for designing BMfS, such as the triple layer BM canvas (TLBMC; Joyce & Paquin, 2016) and the value mapping tool (Bocken, Short, Rana, & Evans, 2013). However, despite their relevance in fueling the debate on BMfS development, these design tools still fail in adopting a systemic view of the core dynamics underlying sustainable value creation processes. According to Lozano (2018), a BMfS should be "a holistic and systemic reflection of how a company operationalizes its strategy, based on resource efficiency (through operations and production, management and strategy, organizational systems, governance, assessment and reporting, and change), so the outputs have more value and contribute to sustainability more than the inputs (with regard to material and resources that are transformed into products and services, economic value, human resources, and environmental value). The business model is affected by the company's resources (tangible and intangible), the supply chain and the company's stakeholders (internal, interconnecting and external), including the environment (inside and outside the company)." Therefore, a systemic perspective to develop BMfS may provide decision makers and managers with a lean strategy design tool—to be used on a regular basis—which not only lists the key elements shaping a sustainable BM (i.e., social, environmental, and economic value forms) but also outlines the causal interdependencies among them (Casadesus-Masanell & Ricart, 2010; Demil & Lecocq, 2010). In fact, framing the causal interdependencies among BM components within a lean systemic framework enables to trace how results are affected by performance drivers and associated strategic resources, thus offering a more effective perspective to promptly undertake corrective actions and/or strategy reversals (Cosenz, 2017; Cosenz & Noto, 2018).

With the intent to overcome such critical issues affecting BMfS development, this paper aims to conceptualize and investigate a systemic perspective for designing BMfS wherein sustainable value elements (i.e., environmental, social, and economic/financial) coexist and interact, forming causal feedback structures able to frame value generation processes according to a lean design perspective. Such an approach—named dynamic business modeling for sustainability (DBMfS)—builds upon a revised BMC derived from the combination of an adapted sustainable BMC (Osterwalder & Pigneur, 2010) proposed by Bocken (2015) and Bocken, Schuit, and Kraaijenhagen (2018) and system dynamics (SD) modeling (Cosenz, 2017; Cosenz & Noto, 2016; Cosenz & Noto, 2018). The methodological support provided by SD has proven to be effective in modeling and analyzing business systems characterized by dynamic complexity and unpredictability, as well as in experimenting with the models to design and test strategies for performance management, sustainable development, and change (Bianchi, 2016; Morecroft, 2007, 2013; Sterman, 2000; Torres, Kunc, & O'Brien, 2017; Videira, Antunes, Santos, & Lopes, 2010). Following the abovementioned purpose, this paper also provides an illustrative example of a DBMfS design in a real organization (Patagonia). At the present stage, although SD modeling enables to quantify the causal interdependencies among BMfS variables and simulate possible trends of sustainable value generation results, this paper adopts a qualitative approach to develop the DBMfS approach and illustrate its application to Patagonia's BM. The emerging insights will then form the basis on which to further develop applied knowledge and investigate those practical implications associated with the quantification of causal interdependencies and corresponding simulation results.

1.2 | Research design

For the above purpose, as depicted in Figure 1, the research process begins with the review of the literature on BMfS design tools. This review is also combined with an examination of those extant approaches using a systemic design perspective to model BMfS, thus offering a wide overview on the state of the art wherefrom to draw insights for identifying basic principles, requirements, and methodological shortcomings in developing BMfS, as well as for ultimately comparing research findings. In particular, the literature review moves from the definition of sustainable value to the exploration of the main approaches to design BMfS, whose examination enables not only to detect limitations of extant BMfS design tools but also to frame the core methodological requirements and criteria underlying BMfS development.

Building on this comprehensive literature review, the paper proposes and illustrates the DBMfS approach as a lean systemic method to model and explore sustainable value creation processes. Then, following a qualitative perspective, the approach is tested on the Patagonia case study to offer an illustrative example of DBMfS design. A case

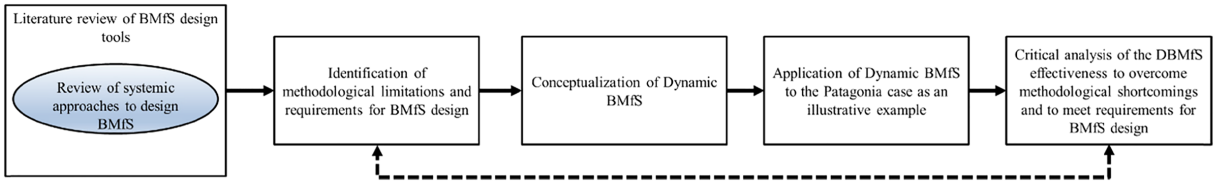

FIGURE 1 Research process design. BMfS, business modeling for sustainability; DBMfS, dynamic business modeling for sustainability [Colour figure can be viewed at wileyonlinelibrary.com]

study strategy is particularly valuable to address theory-building research and to demonstrate that the existing research does not properly address the investigated propositions (Eisenhardt & Graebner, 2007). In this context, the case study research technique is likely to limit potential bias and enrich the analysis, offering useful insights on how to frame BMfS elements within a systemic structure (Furnari, 2015).

Patagonia case study was selected among a panel of businesses with a high propensity for sustainability issues within their institutional mission (i.e., certified B Corporations), whose peculiar BM was already exhaustively explored in the recent literature on BMfS. In fact, the DBMfS application to Patagonia uses secondary data sources retrieved and re-elaborated from the works by Reinhardt, Casadesus-Masanell, and Kim (2010), Chouinard and Stanley (2012), and Khmara and Kronenberg (2018). In particular, the analysis of these contributions supported not only the identification of the key elements forming the Patagonia BM but also the causal interdependencies among them.

Subsequently, applying DBMfS approach to Patagonia enables to discuss its main advantages and limitations in comparison with the methodological gaps found in the literature and the associated requirements for developing BMfS.

Eventually, the paper concludes with future research perspectives addressing the next steps aimed at moving from a conceptual to an empirical perspective in the adoption and use of DBMfS.

2 | THEORETICAL BACKGROUND

2.1 | Sustainable value

As the concept of BMs has been strongly rooted in the rationale of how a company does business and how its structure creates, delivers, and captures value (Evans et al., 2017; Lozano, 2018; Osterwalder & Pigneur, 2010; Teece, 2010), the fundamental construct of value is of great importance (Den Ouden, 2012). Coherently, Richardson (2008) develops a BM framework consisting of three main components built upon the concept of value (i.e., value proposition, value creation and delivery system, and value capture system). More particularly, the emerging trends underpinning the development of BMfS are essentially based on the idea of sustainable value (Lüdeke-Freund, Massa, Bocken, Brent, & Musango, 2016). Hart and Milstein (2003) argue that sustainable value has to do with creating shareholder wealth that simultaneously pushes the world towards a more sustainable trajectory. In slight contrast with this view, Morioka, Bolis, Evans, and Carvalho (2017) claim that sustainable value can be understood as meeting economic, social, and/or environmental needs of current and future generations, which ultimately delivers satisfaction for corresponding stakeholders, being therefore a concept relative to stakeholders (Upward & Jones, 2016).

Despite the lack of a streamlined and agreed upon meaning, sustainable value is a multidimensional concept and generally entails the triple bottom line dimensions (Elkington, 1994, 1997; Stubbs & Cocklin, 2008). Alongside, perspectives of all relevant stakeholders in the business space and the alignment of their interests are also fundamentally considered, as opposed to favoring specific short-termed expectations of limited shareholders (Evans et al., 2017; Lüdeke-Freund et al., 2016; Stubbs & Cocklin, 2008). As such, several scholars and practitioners agree in considering the multitude of sustainability challenges—for example, climate change, waste generation, poverty, and inequality—as engines of sustainable value creation (Adams, Jeanrenaud, Bessant, Denyer, & Overy, 2016; Breuer et al., 2018; Jay & Gerard, 2015; Lüdeke-Freund & Dembek, 2017; Schaltegger & Wagner, 2011).

The triple bottom line approach emphasizes the joint creation of social and environmental benefits, alongside profit (Schaltegger & Lüdeke-Freund, 2012). Moreover, the stakeholder-centric view can be formulated as a way to extend the value creation process beyond the limits of a single firm, encompassing a complex set of stakeholder relationships with a view to long-term sustainable development, for both the firm and the society at large (Evans et al., 2017; Morioka et al., 2017; Searcy, 2016). A concise and holistic representation of sustainable value that integrates the multidimensionality of the construct, adapted from Evans et al. (2017), is provided on the schematics in Figure 2.

2.2 | BMfS design tools

Given such a multidimensional and complex concept (Laasch, 2018), designing BMs in order to adequately encapsulate sustainable value becomes a major challenge (Biloslavo, Bagnoli, & Edgar, 2018; Hart & Milstein, 2003). Furthermore, extant modeling and design methods for BMs are limited and rarely geared towards sustainable value (Evans et al., 2017; Yang, Vladimirova, Rana, & Evans, 2014; Zott & Amit, 2010).

As a fundamental point of departure, the BMC, developed by Osterwalder and Pigneur (2010), has become a very well-established standard for BM design amidst practitioners and academics (Biloslavo et al., 2018; Cosenz, 2017; França, Broman, Robèrt, Basile, & Trygg,

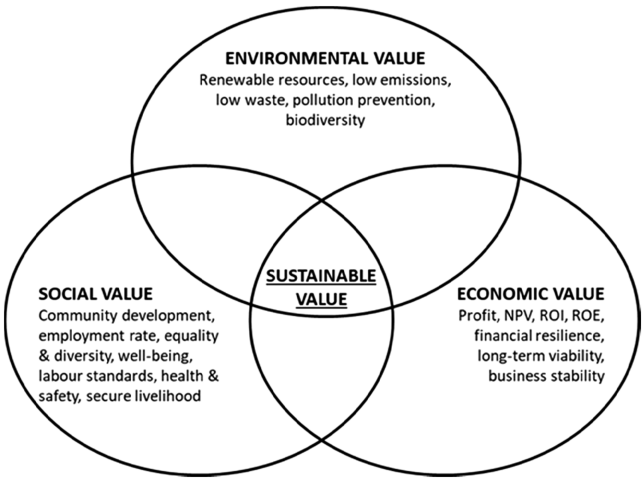

FIGURE 2 The multidimensional aspects of sustainable value (adapted from Evans et al., 2017, p. 600). NPV, net present value; ROI, return on investment; ROE, return on equity

2017). The BMC is arranged around nine building blocks that depict both internal and external forces of the business—these building blocks are key partners, key activities, key resources, value proposition, customer relationships, channels, customer segments, cost structure, and, finally, revenue engines or streams (Osterwalder & Pigneur, 2010). The internal forces are related to the business operations, whereas the external forces represent those elements that are simultaneously affecting and being affected by business activities, such as the extended supply chain network composed of customer segments and main partners. The BMC enables different stakeholders to readily comprehend the operations behind the business structure and how it captures value in terms of profitability and significance to customers' demands (Cosenz, 2017).

Complementing and expanding on the original BMC, Joyce and Paquin (2016) propose the TLBMC, which builds on top of the economically oriented perspective concept with extra layers in order to support the exploration of the environmental and social dimensions of value creation. The additional layers of the TLBMC originate (a) a horizontal view, wherein each one of the three layers presents coherence among the nine building blocks of the original BMC individually ("horizontal coherence") and (b) a vertical view that combines the perspective of value creation across the three canvas layers: environmental, social, and economic ("vertical coherence"). These views featured by the TLBMC emphasize the interconnections and relationships that are relevant for social and environmental impact assessments of a business while supporting the integrative business performance measurement from a triple bottom line perspective (Hubbard, 2009; Nikolaou & Tsalis, 2013; Sherman, 2012). With that, the TLBMC was proposed as a way to support businesses towards addressing sustainability challenges as a source of innovation for products, processes, and related BMs (Joyce & Paquin, 2016).

Still building on the highly influential BMC, França et al. (2017) propose an approach for BM design that integrates a unifying, principle-based framework for sustainability called framework for strategic sustainable development. The framework puts forth an operational definition of sustainability and set strategic guidelines with a view to guiding organization towards supporting a structured sustainability transition, without disregarding the organization's own performance (Broman et al., 2017; Broman & Robèrt, 2015; Missimer, Robèrt, & Broman, 2017; Robèrt, Daly, Hawken, & Holmberg, 1997). The joint BMC-framework for strategic sustainable development approach proposed by França et al. (2017) is based on a systematized four-step backcasting procedure that allows organizations to design, develop, or innovate on each one of the nine building blocks of the BMC, whose point of departure is an agreed-upon vision with long-term goals (França et al., 2017).

As a way to respond to the limitations of BM design tools in dealing with the natural and social aspects of organizations, the interconnections between economic and noneconomic actors, and the trade-off of BMs over time of a typical BMfS, Biloslavo et al. (2018) propose the "value triangle". The value triangle is a BM design framework that includes societal elements, with a focus on the natural environment and the future generations and distinguishes between three types of values that are co-created and co-delivered: public value, partner value, and customer value. In a reframed version of the BMC, the value triangle also proposes the co-creation and co-delivery of capital, key operational activities, and products (i.e. goods or services) while simultaneously capturing value via revenue stream and cost structure (Biloslavo et al., 2018; Richardson, 2008).

Further on, with the value proposition aspect at the center of their contribution, Bocken et al. (2013) propose the "value mapping tool" as a way to aid the design and development of sustainable BMs by means of creating value propositions. The consolidated version of the tool maps three types of values (i.e., value captured; value missed, destroyed, or wasted; and value opportunities) across four dimensions, namely, environment, society, customers, and network actors (Yang, Evans, Vladimirova, & Rana, 2017). It is mainly used to understand positive and negative aspects of a business value proposition, to identify conflicting value across the stakeholder network, and to spot opportunities for the redesign and realignment of a BM.

In a conceptual extension of the value mapping tool for designing BMfS, the overall BM is then classified into three main categories (Bocken, Rana, & Short, 2015; Osterwalder & Pigneur, 2010): (a) value proposition, which oversees the product/service structure, the customer segments, and the value for society and the environment; (b) value creation and delivery, encompassing the activities, resources, distribution channels, partners/suppliers, and technological features of products; and (c) value capture, where the cost structure, revenue stream, key actors, growth strategy, and ethical values are defined and highlighted. In particular, it is important to highlight that an organization's core ethical values might be a source of value capture (Bocken et al., 2015). This approach is intended to be used on a workshop-based setting as a part of a toolkit with the objective of supporting strategic innovation (Bocken et al., 2013; Phaal, Farrukh, & Probert, 2001; Phaal, Kerr, Oughton, & Probert, 2012).

With a view to summarizing this more detailed articulation of value proposition and building on top of the framework developed by Richardson (2008), Bocken (2015) and subsequently Bocken et al. (2018) illustrate the adapted sustainable BMC—where the value proposition component describes environmental, social, and economic forms of value (labelled as "profit, people and planet" in the framework), the value creation and delivery system depicts how internal resources, capabilities, and activities are used in partnership with a wide set of stakeholders, and the value capture system moves from selling products to more environmentally and socially sustainable ways of generating profits (e.g., selling services, paying per use, or paying for performance). The adapted sustainable BMC proposed by Bocken et al. (2018) and Bocken (2015) is shown in Figure 3.

Given that the adapted sustainable BMC builds on top of the prominent and well-established BMC, proposed by Osterwalder and Pigneur (2010), the sustainability-oriented adoption of the framework proposed by Bocken et al. (2018) becomes easier and more straightforward to use and develop further. Therefore, the adapted sustainable BMC forms the basis upon which the DBMfS approach is built, which will be detailed and explained in the next sections of the paper.

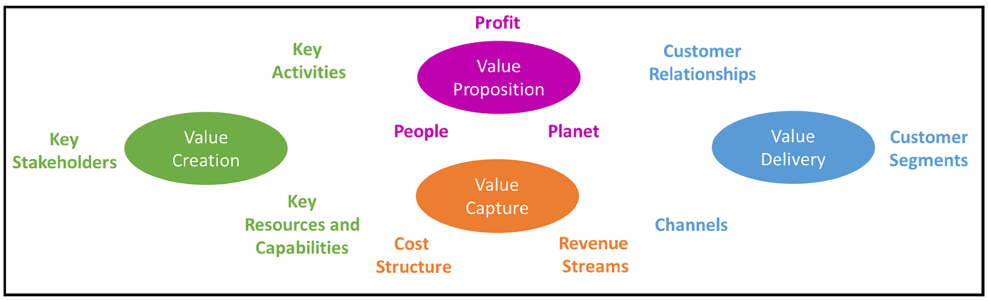

FIGURE 3 Adapted sustainable business model canvas (Bocken et al., 2018, p. 82; Bocken, 2015) [Colour figure can be viewed at wileyonlinelibrary.com]

2.3 | Requirements and limitations of BMfS design tools

With a view to categorizing and explaining BMfS, along with providing examples for action, eight archetypes were mapped out in the literature by Bocken et al. (2014). They are associated with the development of social and/or environmental benefits by means of the creation of new sustainable value or the significant reduction of negative impacts on society and environment. These archetypes are categorized in three clusters: (a) technological grouping that maximize material and energy efficiency, create value from waste, and substitute with renewables and natural processes; (b) social grouping that deliver functionality rather than ownership, adopt a stewardship role, and encourage sufficiency; (c) organizational grouping that repurpose for society/environment and develop scale-up solutions (Bocken et al., 2014). More recently, Ritala, Huotari, Bocken, Albareda, and Puumalainen (2018) propose an updated version of the sustainable BM archetypes, by adding the "inclusive value creation" archetype in the organizational group, to reflect the increasing success of inclusive, peer-to-peer and sharing BMs.

Along these lines, Lüdeke-Freund, Carroux, Joyce, Massa, and Breuer (2018) provide a BMfS pattern taxonomy developed through literature review, Delphi survey, and physical card sorting, aiming at synthesizing and consolidating knowledge about existing BMfS patterns. In their taxonomy, Ludeke-Freund et al. (2018) identified 45 BMfS patterns (e.g., "industrial symbiosis", "market-oriented social mission," "Crowdfunding," and so forth) categorized into 11 different groups (e.g., "closing-the-loop patterns", "social mission patterns," "financing patterns," and so forth) according to their ecological, social, and economic dimensions of sustainable value creation.

The fundamental requirement underlying the rationale of all these operational tools for designing BMfS relies on the idea that the ultimate innovation must be geared towards generating social and/or environmental benefits in business operations, therefore shifting the focus of value proposition to the society and the environment (Bocken et al., 2014; Porter & Kramer, 2011; Stubbs & Cocklin, 2008). In addition, Breuer et al. (2018) identify a set of theoretical prerequisites, guiding principles and process-related criteria to develop BMfS, that currently are totally or partially neglected in the extant BMfS design tools. Their research underlines the need to reframe conventional BM components by spanning the organizational boundaries of the firm according to a systemic perspective, with the intent of facilitating the integration of stakeholders and of internal and external resources (including information, knowledge, etc.). In fact, besides considering a broader view of sustainable value creation, the possibility to include stakeholder contributions and expectations enables not only to reduce risks based on actors' interaction and integrated knowledge but also to identify and resolve tensions between them by aligning their interests within a common and shared direction. To do this, collaborative modeling approaches are proved to be effective methods for an active stakeholder engagement (Rouwette, 2011; Voinov & Bousquet, 2010). Yet, in line with Dentchev et al. (2018), BMfS are called to investigate both the sustainability and viability of a business, embracing a variety of performance measures through more rigorous empirical methods, which may reflect the differences between planned and realized BMs, as well as unrealised and emergent activities.

In an extensive review of the literature, there seems to be a convergence on three main severe limitations with current design mechanisms and tools for the development of BMfS, namely, (a) the main outputs of meetings and workshops (i.e., innovation ideas) are not followed up; (b) lack of implementation of promising concepts of BMfS; and (c) most implemented BMs end up failing in the market (Geissdoerfer et al., 2018). These three main limitations are mainly caused by a set of inherent characteristics of BMfS, which are derived from their complex and dynamic nature (Abdelkafi & Täuscher, 2016; Demil & Lecocq, 2010; Evans et al., 2017). Namely, such a dynamic complexity characterizes BMfS as living structures, with a wealth of interactions and complementarities that can be framed through feedback loops (Abdelkafi & Täuscher, 2016; Hjorth & Bagheri, 2006; Sterman, 2000), thus capturing sustainability from a systemic perspective (Abdelkafi & Täuscher, 2016; Boons, Montalvo, Quist, & Wagner, 2013; Lozano, 2018).

Within this context, as BMs will ultimately moderate the relationships among actors across a complex value network in a constantly changing setting, simulation tools are necessary in order to reflect accurate decision-making processes (Evans et al., 2017; Rodrigues, Pigosso, & McAloone, 2017; Täuscher & Abdelkafi, 2017). Moreover, the integration of sustainability considerations in the design of BMfS raises its dynamic complexity considerably (Iandolo, Barile, Armenia, & Carrubbo, 2018; Rodrigues, Morioka, Pigosso, de Carvalho, & McAloone, 2016; Täuscher & Abdelkafi, 2017). In such a setting, simulation-based approaches are able to capture multilevel systems

and reduce its complexity towards a proper understanding of the fundamental characteristics and relationships between the elements of BMfS, together with an adequate account of the main performance outputs and outcomes that are generated (Bianchi, Cosenz, & Marinković, 2015; Davis, Eisenhardt, & Bingham, 2007; Schwaninger & Groesser, 2008). Finally, a systemic and simulation-oriented approach allows experimentation with BMfS (Evans et al., 2017) and the structured development of "what-if" scenarios and potential implementation strategies and trajectories (Ghosh, 2015; Nabavi, Daniell, & Najafi, 2017).

Therefore, the systemic and dynamic aspects of the DBMfS approach, proposed in this paper, directly tackles these fundamental limitations pointed by Geissdoerfer et al. (2018), shown above. With an approach that characterizes the complexity of the BMs explicitly by adequately capturing the feedback loops and the dynamic behavior of important performance measures, organizations are better equipped to follow up on their innovation ideas (e.g., workshop outputs), to more quickly implement promising sustainability concepts and, finally, to reduce the likelihood of implementing an unsuccessful BM due to its capability of testing multiple strategies and what-if scenarios (Abdelkafi & Täuscher, 2016; Cosenz, 2017; Cosenz & Noto, 2018). These aspects are further addressed in the Discussion section.

3 | CONCEPTUALIZING AND EXPLORING DYNAMIC BMS FOR SUSTAINABILITY

Building on the above theoretical background identifying the main requirements and limitations for developing BMfS, this section aims to introduce an integrated methodological approach, which blends a revised BMC structure with SD modeling. Although using the BMC arrangement offers a lean and well-known framework for describing the strategic architecture of the value creation, delivery, and capture mechanisms (Osterwalder & Pigneur, 2010; Trimi & Berbegal-Mirabent, 2012), SD provides a systemic perspective for capturing and simulating the dynamic aspect of complex business systems in action (Cosenz & Noto, 2016; Morecroft, 2007; Sterman, 2000). Thus, orienting this combined approach towards the exploration of both BM sustainability and viability enables to conceptualize the DBMfS.

3.1 | Systems dynamics modeling

Recent studies prove that SD modeling may provide a valuable methodological support to design BMs (Cosenz, 2017; Cosenz & Noto, 2018; Groesser & Jovy, 2016), including those for sustainability purposes (Abdelkafi & Täuscher, 2016; Täuscher & Abdelkafi, 2017). SD was developed in the late 1950s and early 1960s at MIT by Jay Forrester. It is an approach for modeling and simulating complex social systems and experimenting with the models to design strategies for management and change (Forrester, 1961).

SD models are tailored to specific managerial challenges/phenomena and built by mapping the relevant business system structure in order to generate and convey an understanding of behavior driving processes, as well as a quantification of its causal interactions so as to produce a set of equations that lay the groundwork for simulating possible system behaviors over time (Warren, 2008). In particular, SD models entail an endogenous and feedback view of a BM, seen as a closed boundary, that is, encompassing all the main variables associated with the business system under observation (Cosenz & Noto, 2018). More specifically, SD identifies the complex interactions among feedback loops, rejects notions of linear cause and effect, and requires the business analyst to view a complete system of relationships whereby the "cause" might also be affected by the "effect." This means that a variable—other conditions being equal—may influence another variable: (a) positively (i.e., an increase of the one corresponds to an increase of the other and vice versa), (b) negatively (i.e., an increase of the one corresponds to a decrease of the other and vice versa), or (c) according to a nonlinear relation between them. Then, if such relations originate closed circuits that endogenize the reaction of the business system under different strategic choices, these are defined as feedback loops and determine the system behavior over time (Sterman, 2000).

After identifying causal feedback loops, BM variables are converted into stock-and-flow diagrams by using SD-based simulation software. These diagrams enable decision makers to simulate the behavior of the business system over time (Sterman, 2000). An SD simulation model is calibrated by comparing model output with empirical data and, in case of discrepancies or inconsistencies, by refining the model and input parameters where adequate data do not exist. As suggested by Cosenz and Noto (2018, p. 129), "[o]nce the simulation model has been developed, calibrated, and tested whether it realistically behaves, inputs are modified to conduct *what if*" analyses of how short- and long-term outcomes would change in response to alternative strategy scenarios" (Kunc & O'Brien, 2017; Torres et al., 2017). When real BM experimentation is too costly or complex, simulation becomes a valuable tool to discover how complex business systems work and where high leverage points may lie (Cosenz & Noto, 2018; Davis et al., 2007).

SD differs from other simulation approaches (e.g., agent-based modeling) because it adopts a systemic perspective for mapping value generation processes and underlying BM variables, thereby integrating feedback loops, accumulation and depletion processes of strategic resources, time delays, and nonlinear interplays among BM elements (Sterman, 2000). As remarked by several scholars (Baden-Fuller & Mangematin, 2013; Casadesus-Masanell & Ricart, 2010; Sanchez & Ricart, 2010), BM design requires the adoption of a systemic approach so as to embody important understandings of causal links between BM elements. Furthermore, differently from other systemic methods, using SD models provides the possibility to establish active stakeholders' engagement. In fact, SD facilitates a shared BM understanding, as well as the incorporation of strategic ideas and innovations from those actors involved in the model building process. As such, engaging stakeholders can improve both model accuracy and legitimacy and foster the alignment of key-actors' mental models and group consensus about what actions to undertake (Rouwette, 2011).

3.2 | Conceptualizing dynamic business modeling for sustainability

As previously mentioned, the DBMfS approach builds upon a revised BMC originating from the combination of an adapted BMC and SD modeling. The BMC is one of the most used BM representation frameworks worldwide, offering a standardized way for designing the strategic and organizational architecture of many organizations (Osterwalder & Pigneur, 2010). Capitalizing on its widespread popularity, the revision of the BMC structure contributes to incorporating those elements related to sustainable value creation (divided into economic, social, and environmental value;Bocken, 2015 ; Bocken et al., 2018), as well as to adopting a resource-based view of the firm aimed to support decision-making and performance management processes for viability purposes (Peteraf, 1993; Wernerfelt, 1984). The emerging framework proposed in this study—named DBMfS canvas—offers a modified arrangement of value generation processes that includes seven building blocks corresponding to the core DBMfS elements outlining how an organization operates in achieving both sustainability and viability goals. They are (a) key stakeholders, (b) strategic resources, (c) value proposition, (d) key processes, (e) customer segments, (e) cost structure, and (f) revenue streams.

Unlike the original BMC (Osterwalder & Pigneur, 2010), the DBMfS canvas expands the key partners section by including other relevant stakeholders as additional interlocutors of the sustainable value offered by the firm (Bocken, 2015; Bocken et al., 2018). Customer relations, distribution channels, and key activities are gathered inside the key processes block.

The value proposition is the section that undergoes the main changes with respect to its original formulation in order to combine the multiple perspectives of value offered by the organization, thus including not only short and long-term results but also viability and profitability with sustainability. In particular, such a building block is divided into subsections addressing (a) *value drivers*, that is, those critical success factors affecting key processes thus providing a source for competitive advantages; (b) *outputs*, that is, short-term results achieved by the firm; (c) *outcomes*, that is, long-term results impacting on the broader context where the firm operates. With the intent to better frame the sustainable value dimensions and span the organizational boundaries of the firm, outcomes are further classified into (a) *social value*, (b) *economic value*, and (3) *environmental value*. Each subsection forming the value proposition embraces a set of indicators to measure the firm's performance according to the multidimensional perspective of sustainable value (Bocken, 2015; Bocken et al., 2018; Dentchev et al., 2018; Evans et al., 2017). As a result, this new structural arrangement—alongside the subdivision of the value proposition block—facilitates the adoption of resource-based view as it fosters an understanding of how strategic resources and key stakeholders affect value drivers, which, in turn, influence key processes. Therefore, it allows the firm to generate both outputs and outcomes over time (Cosenz, 2017; Cosenz & Noto, 2018; Kunc & Morecroft, 2009; Kunc & O'Brien, 2017).

In this setting, with the twofold purpose of overcoming BMfS design limitations and complying with its requirements (Bocken et al., 2014; Breuer et al., 2018; Dentchev et al., 2018), the methodological support provided by SD modeling enables the mapping and quantification of the causal connections among BMfS elements according to a systemic perspective. The attributes proving the effectiveness of this systemic approach for the design of BMfS are also associated with its theoretical rationale aimed to exploring how inputs to a complex system of interconnected causal loops generate results (Davis et al., 2007; Torres et al., 2017). On this regard, Davis et al. (2007, p. 481) argue that "simulation is particularly useful when the theoretical focus is longitudinal, nonlinear, or processual, or when empirical data are challenging to obtain." These features comply with the pragmatic approach required by BMfS design research (Bocken et al., 2014; Breuer et al., 2018; Dentchev et al., 2018). Therefore, differently from other modeling approaches, SD may offer a deeper understanding—on the basis of the systemic exploration of the causal interdependencies among the BM variables—of how specific conditions (i.e., strategies) may affect business sustainability and viability alike.

3.3 | An illustrative example of DBMfS: Patagonia

Figure 4 displays an illustrative example of DBMfS by applying the DBMfS canvas to the case of Patagonia's BM. Patagonia is a company located in Ventura, California, United States, and operating in the outdoor clothing and gear industry. The company was established in the early 70s by Yvon Chouinard, as a branch of the Chouinard Equipment Company, aiming at diversifying Chouinard's core business through a more profitable business line offering outdoor clothing for climbers (Chouinard & Stanley, 2012;Khmara & Kronenberg, 2018 ; Reinhardt et al., 2010). Patagonia has grown significantly in recent years (Khmara & Kronenberg, 2018), and it is now considered a leading innovator company in the outdoor clothing industry (Bocken & Short, 2016). Besides, Patagonia is widely renowned for its responsible conduct, its support to environmental causes, and its commitment in integrating sustainability in all aspects of business (Choi & Gray, 2008; Honeyman, 2014; Bocken & Short, 2016; Khmara & Kronenberg, 2018; Reinhardt et al., 2010;). Indeed, Patagonia's mission is to be "in business to save our home planet" (Patagonia, 2019), and it has been a certified B Corporation since December 2011 (B Lab, 2019).

In particular, Patagonia's BM has been widely discussed in the BMfS literature for its sufficiency-driven approach (Bocken & Short, 2016; Pal & Gander, 2018), its focus on maintenance, repair (Lewandowski, 2016), and online reselling (Bocken et al., 2014; Pedersen, Gwozdz, & Hvass, 2018; Pedersen & Netter, 2015); its collaborative value creation approach and the stewardship role the company are playing in its industry (Khmara & Kronenberg, 2018; Reinhardt et al., 2010).

Patagonia's BM has thus been chosen in this study as illustrative example due to its innovative characteristics spanning across environmental, social, and economic value dimensions (Bocken & Short, 2016; Khmara & Kronenberg, 2018).

Keeping the same building blocks illustrated in Section 3.2, the built-in SD model is tailored, evaluated, and remodeled according to

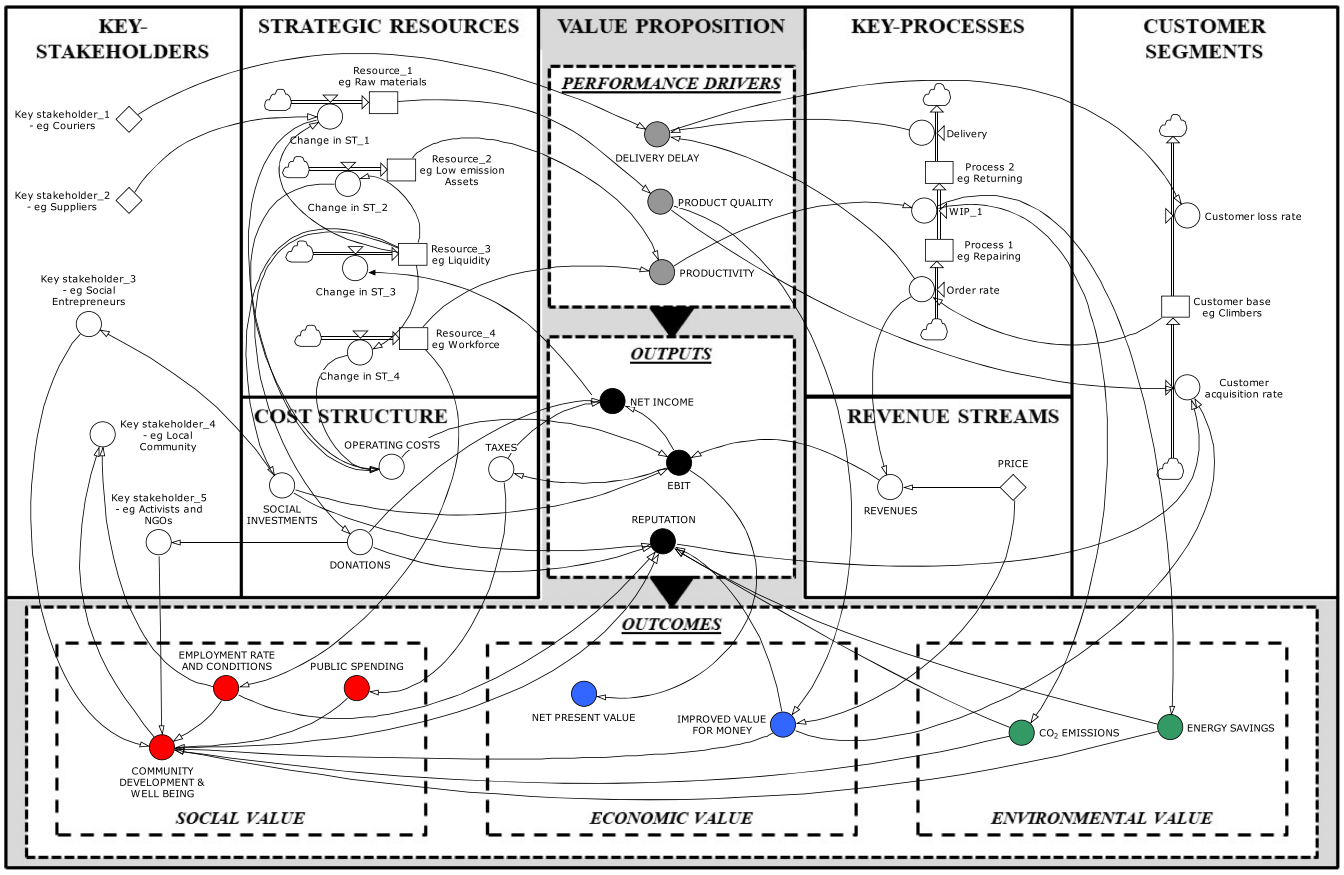

FIGURE 4 The dynamic business modeling for sustainability canvas applied to Patagonia. EBIT, earnings before interest and taxes; NGO, nongovernmental organization; WIP, work in progress [Colour figure can be viewed at wileyonlinelibrary.com]

the specific characteristics of Patagonia's business model and its economic, social, and environmental outcomes.

Namely, strategic resources and process developmental stages are identified as stocks (i.e., rectangle-shaped variables) whose value changes by virtue of inflows and outflows corresponding to the results generated by the firm over time. Strategy levers—identified by diamond-shaped variables—define the different decisions managers may make to change the business strategy (e.g., setting a different product price, establishing strategic alliances with key stakeholders, and modifying budget allocation). Value drivers, outputs, and economic, social, and environmental outcomes are modeled as colored circle-shaped variables.

Particularly in this example, both price and order rate positively influence revenues, which, alongside the costs associated with strategic resources acquisition (i.e., raw materials, assets, and workforce), determine the profit. The profit, after donations, social investments, and taxes payment, generates the net income. The net income fuels the firm's liquidity, which can be allocated to increase other resources, such as raw materials, low-emission assets, and workforce. These strategic resources affect a set of value drivers, for example, product quality, productivity, and delivery delay, which, in turn, produce an effect on both business processes (e.g., product repairing and returning) and changes in the customer base. Resources and value drivers can be further influenced by other key stakeholders, for instance, in terms of agreements with suppliers and farmers for ensuring compliance to Patagonia's standards in raw material supply, or with retailers for reducing the delivery time.

In the medium–long term, the firm produces a set of outcomes corresponding to economic, social, and environmental value. More specifically, Patagonia's initiatives for encouraging sufficiency (e.g., the "don't buy this jacket" campaign) and product exchanging, returning, and repairing have positive effects on energy savings and CO_2 emissions' reduction, which in turn have a positive impact on community development and well-being. Similarly, both product quality and price produce an effect on the improved value for money, which in turn impacts community development and well-being. Community development and well-being also depends on employment rate and conditions, which the company aims to continuously improve, as well as on the public spending fueled by the taxes the company pays and the value generated by the social entrepreneurs, activists, and nongovernmental organizations funded and sponsored by Patagonia. Eventually, both community development and well-being contribute to improving the satisfaction of the local community seen as a key stakeholder in the area where the company operates. Finally, community development and well-being together with employment rate and conditions, social investments, donations, and reduction of CO_2 emissions and energy consumption have an effect on Patagonia's reputation, which can, in turn, boost customer acquisition rate.

In this illustrative example of DBMfS, the strategy levers are price (which positively influences revenues and negatively the improved value for money) and key stakeholders, such as suppliers (resulting, for instance, in an agreement for increasing the time to pay back debts) and retailers (with whom to agree on a reduction in the product delivery time).

4 | DISCUSSION

This study aimed at exploring and proposing a dynamic approach to business modeling for sustainability with a view to overcoming methodological gaps raised by the literature. To do so, systemic approaches to business modeling for sustainability were reviewed, along with the main limitations of current BM design tools (Abdelkafi & Täuscher, 2016; Demil & Lecocq, 2010; Evans et al., 2017; Geissdoerfer et al., 2018). Furthermore, the overall requirements for designing sustainable BMs were gathered in order to understand which aspects required further development (Bocken et al., 2014; Breuer et al., 2018; Stubbs & Cocklin, 2008). The findings of such examination have led to a deeper understanding of current BM design tools, along with their main shortcomings and opportunities for improvement. In turn, these findings ultimately allowed a new BM framework to be developed and proposed.

The resulting framework proposed in this study (DBMfS canvas) prescribes a modified arrangement of the original BMC on the basis of the new conceptualization of value generation processes that considers the core elements of how the organization achieves its sustainability and viability goals, based on seven building blocks. Upon this structure, an SD modeling approach was proposed with a view to mapping and quantifying the causal connections among the BMfS elements.

The core advantages of the DBMfS canvas relies on its dynamic nature, as opposed to the purely static stance taken by the extant BM tools in the BMfS literature (Dentchev et al., 2018). The framework allows not only a deeper interpretation of the connections among the elements of a BM but also how ultimate business value accrues from the interplay among key resources, processes, and stakeholders. The proposed framework also renders an integrated view of the core concept of value proposition, fundamentally based on the relationships between value drivers, outputs, and outcomes.

The value drivers relate to the build up of a competitive edge for the business over time, whereas outputs refer to the short-term results an operation achieves and outcomes purviews the long-term impact of businesses. By breaking down the value proposition concept, decision makers are able to understand and manage the impacts of strategic choices on key results.

Furthermore, the possibility of dynamically simulating how these strategic choices lead to different scenarios better equip managers in their decision-making processes regarding crucial aspects of a BM. The DBMfS approach thus allows for the deployment of what-if analysis that enrich the understanding of potential future scenarios, as discussed by Kunc and O'Brien (2017) and Torres et al. (2017).

The endogenous and feedback view of complex systems provided by the SD modeling approach typically augments individual's understanding of potentially counterintuitive phenomena and results in business settings, as discussed by several researchers in the literature, such as Sterman (2000) and Torres et al. (2017). Within the context of business modeling, the DBMfS approach brings this perspective to the particularly challenging task of evaluating and designing sustainability-oriented models.

As a multifaceted construct, sustainability adds layers of complexity to business modeling, which can be therefore properly approached through the lens of the DBMfS approach. It is expected, within such context, that the proposed framework not only addresses the complex aspects of BMs for sustainability but also supports managers in accurately delineating social, environmental, and economic value. These different types of value are explicitly depicted as outcomes in the DBMfS framework, expanding the boundaries of the firm and considering its relationships with the broader network of stakeholders.

With that, by means of a dynamic BM, different initiatives can be evaluated in terms of performance over time. For example, the application of the DBMfS approach to Patagonia, depicts how Patagonia's sufficiency initiative, along with policies regarding product exchanging, returning, and repairing, has positively affected the organization's sustainable value (i.e., energy saving, CO_2 emissions, community development, and well-being), as portrayed in the illustrative example of DBMfS in the previous section.

Additionally, the DBMfS approach might also support enhanced communication around BMs. With the distinction between the different dimensions of sustainable value (i.e., social, environmental, and economic), as well as the division of the value proposition into three clear-cut subsections (e.g., value drivers, outputs, and outcomes), any communication on the BM may become more rigorous and transparent. Therefore, the underlying dynamic nature of the proposed DBMfS approach attempts to address major gaps found in the literature such as, for instance, the lack of proper tools for active stakeholder engagement (Rouwette, 2011; Voinov & Bousquet, 2010) and the expansion of organization boundaries with a view to incorporating the perspective of other stakeholders and different types of internal and external resources (Breuer et al., 2018).

Although this study contributes to the literature on sustainability-oriented business modeling, it also shows some limitations. First, the conceptualization of the DBMfS approach still does not allow for the operationalization of the quantitative framework. Second, although the illustrative example fosters an improved understanding of the framework, empirical studies should inform the validity of the model. Third, the peculiar types of data that need to be captured in order to model each one of the BM components are still not defined and need further refinement. In particular, the possibility to quantify and simulate a DBMfS is quite challenging due to the major complexity of obtaining reliable data on the long-term outcomes (i.e., sustainable value) generated by an organization.

Building on both the literature review addressing the methodological gaps of the extant BMfS frameworks and the findings emerging from the exploration of the DBMfS approach, Table 1 summarizes

TABLE 1 Comparing requirements for designing BMfS with advantages and limitations of DBMfS

Requirements and limitations of extant BMfS design tools	Implications for developing new BMfS design tools	Advantages of using DBMfS	Limitations of using DBMfS
Sustainability orientation (Bocken et al., 2014; Porter & Kramer, 2011; Stubbs & Cocklin, 2008; Upward & Jones, 2016).	BMfS should frame and explore the multidimensional aspects of sustainable value generated by the business (as characterized by Evans et al., 2017).	The value proposition building block of the DBMfS canvas includes a clear distinction of the social, economic, and environmental value generated by the business. According to a systemic perspective, the framework also identifies the causal connections among the business model components involved in the sustainable value creation.	The social, economic, and environmental value refers to the outcomes (i.e., long-term results) generated by the business. As such, the quantification of such a value appears quite complex due to the lack of reliable data. This can potentially hinder future research developments aimed to build simulation models.
Spanning organizational boundaries (Breuer et al., 2018; Rouwette, 2011; Upward & Jones, 2016).	The design of BMfS should facilitate the interaction between the firm and its stakeholders, thus integrating their activities.	The DBMfS canvas reframes conventional business model components by spanning the organizational boundaries of the firm according to a systemic perspective, with the intent of integrating stakeholders. Besides the customer segments, the framework also includes the "key stakeholders" building block and the causal interdependencies they establish with the other business model components.	The DBMfS adopts a selective approach to identify the key stakeholders that might neglect the effect of the activities produced by other players (e.g., the Patagonia model does not show firm's competitors). Therefore, the selection of key stakeholders represents a critical operation in DBMfS.
Integrating internal and external resources (Boons & Lüdeke-Freund, 2013; Breuer et al., 2018).	BMfS design should identify internal and external resources and their role in generating sustainable value.	The DBMfS structure identifies both internal and external resources, which are strategic for generating sustainable value. Following a RBV perspective, the framework highlights how these resources are fueled (or destroyed) by business operations and results through feedback loops.	Specific business models mainly aimed to manage external resources (e.g., multisided platforms) may require a revision of the DBMfS articulation to highlight the contribution offered by such external resources (e.g., seekers and solvers).
Resolving conflicts and aligning interests (Breuer et al., 2018).	Designing BMfS should enable to resolve tensions between actors and to align their interests.	DBMfS is a collaborative modeling approach based on an active stakeholder engagement, which reduces potential risks emerging from actors' interaction and resolves tensions between them by aligning their interests within a common and shared direction. In particular, the use of SD modeling facilitates a shared understanding and integration of strategic ideas from multiple actors into the model building process, fostering the alignment of actors' mental models and group consensus about what actions to take.	The emerging DBMfS can be affected by the subjectivity of those actors involved in making strategic assumptions.
Integrating business viability and sustainability, as well as associated performance measures (Dentchev et al., 2018).	A BMfS is called to investigate both the sustainability and viability of a business embracing a variety of performance measures.	All the subsections of the value proposition building block of the DBMfS canvas encompass a set of performance indicators measuring not only drivers and outputs (i.e., short-term results) and outcomes (i.e., long-term results) but also each dimension of sustainable	Although measuring drivers and outputs can be easily carried out, severe complexities arise in evaluating the outcomes generated by the business due to the paucity of reliable data and methods able to capture long-term results.

(Continues)

TABLE 1 (Continued)

Requirements and limitations of extant BMfS design tools	Implications for developing new BMfS design tools	Advantages of using DBMfS	Limitations of using DBMfS
		value (i.e., economic, social, and environmental) generated by the business model. Therefore, the approach allows the exploration of both business viability and sustainability.	
Supporting experimentation with BMfS simulation models (Bocken, Weissbrod, & Antikainen, 2019; Breuer et al., 2018; Upward & Jones, 2016; Voinov & Bousquet, 2010)	BMfS design tools should provide the possibility to test and experiment through simulation models, reflecting the differences between planned and realized business models, as well as exploring the value creation potential of unrealized and emergent activities.	Through the methodological support offered by SD modeling, each variable included in the DBMfS approach can be simulated in order to test the corresponding behavior over a given time interval. The possibility to simulate the behavior of the business model over time enables to experiment alternative strategic choices, that is, to assess the effectiveness of a given business strategy and to manage the potential trade-offs in terms of performance between planned and realized business models, as well as exploring the value creation potential of unrealized and emergent activities.	The prevailing literature on simulation-based techniques suggests that all models are imperfect representations of reality and because they are based on assumptions, their validity depends on the extent to which these assumptions are met (Sterman, 2000).

Abbreviations: BMfS, dynamic business modeling for sustainability; DBMfS, dynamic business modeling for sustainability; RBV, resource-based view; SD, system dynamics.

how this approach meets the requirements for designing BMfS by describing its advantages and limitations.

5 | CONCLUSIONS

The contributions of the study to research, practice, and policy are manifold. For researchers, the study provides a new stream of research for simulation-based and dynamic business modeling tools to be developed. Because many of the challenges of sustainable business modeling can be properly tackled through the lens of a systemic and dynamic approach, there is increased potential in exploring novel simulation and design tools. Furthermore, researchers might want to explore how different simulation paradigms and approaches, such as agent-based modeling, fit into an overarching framework to support the development of DBMfS.

As for practitioners, the conceptualization of the DBMfS approach adds value to how a company's BM can be properly understood, adapted, and changed over time in order to create sustainable value, with its three distinguished components. Besides, the study also enlights how decision makers can potentially use the framework to derive scenarios and more robust answers to what-if questions, stemming from different stakeholders in a multitude of contexts.

For policymakers, the proposed DBMfS approach might potentially aid the development of targeted sustainability-related policies based on the substance of value created by specific initiatives. Different industrial sectors (e.g., electronics, apparel, and consumer good) or types of companies (e.g., startups, small and medium companies, and large corporations) might respond differently to sustainability initiatives in terms of overall performance. This, in turn, could inform the development of sector-specific or type-specific policies for sustainability.

Based on the limitations of the DBMfS approach described in the previous section, several streams of future research could be explored, particularly the (a) development of a quantitative approach based on the conceptual core of DBMfS in order to quantify and simulate the different potential scenarios for the BMs; (b) design of an empirical data collection with a view to testing the efficacy and usefulness of the proposed framework, along with its validity; and finally (c) definition and structure of the types of data that are required in order to fully develop the quantification portion of the DBMfS approach. These future research perspectives provide new challenges for corporate sustainability, BM, and SD scholars and practitioners.

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