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The Catalytic Role of Sustainability Transitions for Business Models

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Introduction

This chapter examines the co-evolution of sustainability transitions and business models, highlighting how each can both promote and hinder change processes. It underscores the call for further research into the nexus of sustainability transitions and business models by various scholars (e.g. Bidmon & Knab, 2018; Boons et al., 2013; Köhler et al., 2019; Markard et al., 2020).

Socio-technical transitions is the analysis of the permeation and use of technologies in society, nowadays often stimulated by sustainability challenges, such as climate change, in a process whereby radical innovations

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emerge and conflict with existing paradigms and system characteristics (Markard et al., 2020). The subsequent discourse on sustainability transitions emphasizes a holistic, multifaceted, and system-wide approach to integrating environmental, social, and economic considerations, thereby challenging businesses to rethink their operations, business models, and stakeholder engagement strategies as well as their role in society. Thus, authors such as Schaltegger and colleagues (2016a) or Pinkse and colleagues (2023) argue that business models for sustainability require a paradigm shift in how businesses conceptualise and implement innovation processes, prioritising long-term resilience and adaptability over short-term gains. Consequently, sustainability transitions necessitate a continuous reconfiguration of business strategies, business models, and business operations. Embracing concepts and principles such as corporate social responsibility, resource efficiency, circular economy, regenerative business, or stakeholder capitalism may help put businesses on the right pathway or trajectory, but this is a journey that must be achieved at pace and ultimately may require alignment with an organisation of society and economy without economic and material growth as it is currently understood (e.g. Wells, 2016).

Bidmon and Knap (2018) highlight the multifaceted impact of business models on transition dynamics, illustrating their role as both facilitators and barriers to change within the socio-technical landscape. Firstly, they can reinforce the existing socio-technical regime, hindering transitions by bolstering current stability. Secondly, by acting as intermediaries, business models expedite transitions by aiding in the stabilisation and breakthrough of technological innovations. Lastly, as non-technological niche innovations, new business models contribute significantly to the emergence of new regimes, independent of technological advances.

Recently, there has been a growing interest in merging these two strands of research to explore how business models can serve as a catalyst for holistic, system-wide sustainability transitions (e.g. Bolton & Hannon, 2016; Foxon et al., 2015; Hannon, 2012; Hannon et al., 2013; Hernández-Chea et al, 2021; Loorbach et al., 2009; Wells, 2013). Traditionally rooted in distinct and diverse traditions, these realms of research and policy now find an opportunity to cross-pollinate and enrich each other (Aagaard et al., 2021). The goal is to foster a positive and mutually

beneficial convergence of ideas, contributing in an exploratory manner to both the acceleration of sustainable transitions and the co-evolution of robust business models for sustainability. In practical terms, numerous companies actively explore strategies to effectively learn from and manage sustainability transitions by investigating the capabilities of emerging technologies, new business models, and new forms of collaboration. The goal is to secure and influence their competitive standing for the future (Berggren et al., 2015).

The significance of regenerative and circular business models, which extend product life cycles, optimise resource use, and minimise waste, aligns closely with business models designed for sustainability transitions (Konietzko et al., 2023). This congruence is critical for promoting practices that surpass mere sustainability in terms of doing less harm or maintaining the status quo, aiming instead for the restoration and rejuvenation of ecological and social systems (Hahn & Tampe, 2021). Moreover, the needed transition towards more ambitious goals in terms of regenerative or strong sustainability is accelerating the shift from linear value chains to value networks and multi-sided platforms, wherein collaboration among diverse stakeholders, including suppliers, customers, communities, NGOs, and even competitors, becomes a cornerstone for future viability (e.g. Blackburn et al., 2023). This perspective encourages businesses to leverage the collective capabilities and insights of their stakeholders to develop solutions that are not only economically viable but also socially equitable and environmentally benign (Pedersen et al., 2021).

In summary, this chapter aims to provide a comprehensive understanding of the mechanisms through which sustainability transitions are driving business model evolution and vice versa, offering insights into the strategies that pioneers in this field are employing to navigate the complexities of sustainable development. In this chapter we are guided by the overarching question of whether sustainability transitions at a societal level can spur the emergence of fundamentally different benign and adaptable business models (Aagaard et al., 2021; Geels & Ayoub, 2023), when the need to accelerate processes of change is paramount (Roberts & Geels, 2019). Conversely, this chapter also recognises that business models may, at times, contribute to transition failure, and influences

from societal and systemic levels may hinder the development of more sustainable business models (Bidmon & Knab, 2018; Markard et al., 2023). While acknowledging the critical roles of customers, citizens, and users in collaborative value co-creation for sustainable business models (Pedersen et al., 2021), the chapter maintains a focus on sustainability transitions within a market and business context.

The chapter proceeds to explore sustainability transitions and business models as follows. First, the wider socio-technical transitions framework is explored, as it provides the overarching context within which sustainable transitions have emerged, utilising key concepts such as the Multi-Level Perspective and transition pathways. This is followed by a bridging section that has a focus on the significance of business for so-called deep transitions (Schot & Kanger, 2018) and multi-system confluence (Wells, 2023). Next, an account of business model innovation is presented where the "fit" to socio-technical transitions is considered. Here, it is argued that the key challenge in the analysis and design of business models is to determine whether they contribute to the acceleration of change, and to a significant extent of change, as implied in deep transitions. Three illustrations of business models "catalysed" by sustainability transitions are presented, which is followed by eight tentative principles to guide our thinking about how to approach business models in the context of sustainability from the perspective of business model design. A brief outlook on future research topics rounds up the chapter.

Socio-Technical Transitions: Multi-level Perspective and Transition Pathways

Sustainability transitions are a subset of socio-technical transitions research which acknowledges the profound, systemic, and enduring nature of more systemic changes of economy and society. This body of work traditionally focuses on the emergence and functionality of socio-technical systems, which may be considered as systems of provision for society, as evidenced, for example, by Bergek et al. (2008).

Building on this work, Markard et al. (2012) delineated four key frameworks for examining or guiding sustainability transitions: Multi-Level Perspective (MLP), Transition Management (TM), Strategic Niche Management (SNM), and Technological Innovation Systems (TIS). Specifically, the MLP is utilised to understand the dynamics of socio-technical transitions through the interplay among three levels: niches, regimes, and landscapes (Geels, 2002). The regime level is the core of the socio-technical system, comprised of inter-locking and co-evolutionary system elements including technologies, firms, markets, and institutionalised behaviours and practices. Below this regime level, niches may emerge in which non-mainstream innovations are initiated, for example in technologies, behaviours, or firms. Such niches may or may not eventually come to displace existing regime structures. At the level above the regime is the landscape which acts as a structuring force on multiple regimes. Landscape-level pressures may accumulate slowly over time or be experienced as sudden shocks. The MLP frames transitions as the result of synergies among developments across various strata, offering a comprehensive lens through which to analyse and categorise the complex dynamics of sustainability transitions (Geels, 2002, 2019). Thus, the MLP seeks to elucidate and theorise the mechanisms through which diverse constellations of stakeholders, resources, institutional frameworks, and regulatory norms concurrently engage across various strata to catalyse systemic transformations.

In the Multi-Level Perspective on transitions, four condensed pathways or trajectories can be summarised based on Geels and Schot (2007) and Geels (2019):

- *Dynamic equilibrium* where regime change is minimal, despite niche innovations. Established regime actors resist restructuring efforts from niche innovations, often reflecting a high degree of lock-in or path dependency.
- *Convergence* where niche experiments unify around a leading design, prompting systemic and regulatory shifts as this design gains acceptance among actors.

- *Disruption* where a significant innovation challenges the status quo, driven by external pressures and internal regime tensions, opening avenues for substantial change.
- *Transformation* where a new regime emerges, gradually phasing out the old system and establishing a fresh equilibrium, underpinned by the gradual buildup of pressures and the active involvement of regime members in adapting to or fostering competitive and socio-technical changes.

While these are regarded as the four main pathways of change, the transitions literature has little to say about the end point of change within any one system. Moreover, previously distinct socio-technical systems may converge, thereby creating the conditions for experimentation and innovation across the boundaries of these systems.

Sustainability Transitions, Deep Transitions, and Multi-system Confluence

Sustainability Transitions

Socio-technical transitions are not necessarily concerned with sustainability. Much of the early research in this area looked at historical cases where the transition has often been underpinned by fossil fuels and thus been profoundly unsustainable. However, the persistent challenges faced by contemporary societies highlight the need for an equally profound shift towards sustainability. More recently, research on transitions has predominantly focused on the prolonged transformation of socio-technical systems towards sustainability, aiming to meet fundamental human needs such as food, heating, and access to water (Markard et al., 2012; Smith et al., 2010). Accordingly, we define sustainability transitions, as "… fundamental changes in socio-technical systems … to address grand challenges in a way that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Markard et al., 2020, p. 1). Köhler et al. (2019)

underscore three key aspects of sustainability transitions. First, they highlight that transitions are multi-dimensional and co-evolutionary, citing complex interactions across technology, culture, policy, and markets that render these processes non-linear and interdependent. Second, they contend that the involvement of diverse social groups, including business, adds to this complexity, with each contributing unique resources and perspectives. Finally, research focuses on the balance between innovative practices like renewable energy provision and the persistence of established practices like fossil fuel use, illustrating the ongoing dynamics between change and stability.

Deep Transitions

An emergent thread of transitions research has been to delineate very enduring landscape features that act like meta-system rules of accepted behaviour and practice (Schot & Kanger, 2018). In the policy sphere, such landscape practices may emerge as institutional framings, such as the post-1945 funding of R&D by governments to stimulate economic growth, or the post-2000s emergence of sustainability as a legitimate goal for governments to pursue (Schot & Steinmueller, 2018). In this perspective, sustainability is comprised of multiple and not necessarily coherent elements acting to enable the societal embedding of new technologies and practices around themes such as zero carbon and circular economy. However, the ultimate deep transition would be the transformation of capitalism itself via something like degrowth principles. It follows that the ways in which economies are organised, businesses behave, and technologies are used contribute to and are shaped by deep transitions for sustainability.

Multi-system Confluence

Two key technology themes underpin the responses of business to sustainability pressures: electrification and digitisation (Björkdahl, 2020). In turn, these themes are also blurring previously distinct sector boundaries that used to form the core of socio-technical regimes via

transformational business models (Ohlendorf et al., 2023). That is, there is a process of socio-technical system confluence (Wells, 2023), with businesses developing new ways of working within complex ecosystems of stakeholders (Andersen & Geels, 2023). In this respect, transformational business models, whether by new entrants or by incumbents—or indeed in combination—act to disrupt existing markets and create new ones (Chirumalla et al., 2024).

Just as these changes in the ways companies do business may be enacted to resolve existing sustainability challenges, as for example done by sustainability entrepreneurs (Sheldon & Lüdeke-Freund, 2023), they may also result in new contradictions that must be addressed in the future. The processes of sustainability transitions and business model evolution enabling such transitions are never complete, even where there is continuous improvement in an operational efficiency sense (Geels et al., 2023). Hence, there is a requirement for multiple phases of business model evolution both in response to competitors and to meet (new) sustainability challenges. Dynamic capability is therefore a central organisational competence arising out of the need to cope with sustainability transitions, which is then realised in concrete form as (sequential) business model evolution (Teece, 2007; van Loon et al., 2022).

Business Models in Socio-Technical Transitions

Recent scholarship, such as that by Köhler et al. (2019), has begun to recognise the significance of business models within the context of sustainability transitions. However, the critical question regarding how firms can derive benefit from engaging with and learning from business model evolution remains largely unanswered, as highlighted by Sengers et al. (2019).

The urgency of addressing global sustainability challenges, such as climate change, resource depletion, and social inequality, has catalysed the need for business models for sustainability transitions (BMfST) as a critical area of research and practice (Aagaard et al., 2021). However, the deep transitions perspective suggests that the measures of eco-efficiency widely adopted by business, while beneficial in the short term and from

a single business perspective, may not achieve the required acceleration of the pace of change or be sufficiently radical. Multi-system confluence is similar to the sustainability deep transition in that it provides new opportunities for business, and business is potentially key in achieving confluence, but may fall short of radical or fundamental change. The key question is therefore *how do we know that the business models we observe today are on a pathway to radical and rapid socio-technical system change, i.e. that they are transformational?*

Business Models for Sustainability Transitions

In recent decades, considerable attention from both scholars and practitioners has been devoted to researching business models. Taking a business model perspective provides comprehensive insights into how organisations create, propose, deliver, and capture value, i.e. in the context of commercial organisations, they shed light on the business logic or the logic of value creation applied by companies (Massa et al., 2017; Wirtz et al., 2016; Zott et al., 2011). The subset of so-called sustainable business models (SBM), respectively business models for sustainability (BMfS), is distinctly different in concept and scope (e.g. Lüdeke-Freund & Dembek, 2017; Lüdeke-Freund et al., 2018; Schaltegger et al., 2016a, 2016b; Schneider & Clauß, 2020). Sustainable business models are designed to substantially enhance positive impacts or notably diminish negative impacts on the environment and society. This is typically achieved by altering how the company and its value network create, propose, deliver, and capture value, or by transforming their value propositions (Geissdoerfer et al., 2017). The focus of corresponding business models and their development (including processes of business model design, innovation, and evolution) can be on internal and external organisational structures and processes and/or offerings, i.e. products and services, with positive impacts on the natural environment, society, and economic outcomes (Kaipainen & Aarikka-Stenroos, 2022; Pinkse et al., 2023; Sheldon & Lüdeke-Freund, 2023).

While the currently most established lines of research on SBMs acknowledge the importance of going beyond a purely business-centric

view and considering system-level impacts (e.g. Dembek et al., 2023; Lüdeke-Freund & Dembek, 2017), the focus remains largely on the level of single companies and sometimes networks (e.g. Aagaard, 2019; Aagaard & Ritzén, 2019; Bocken & Geradts, 2020; Mignon & Bankel, 2023). Business models for sustainability transitions are much wider in scope and emphasise industries and society at large with a focus on solving societal needs through sustainable production and consumption systems (Aagaard et al., 2021). Consequently, BMfST are seen as encompassing enduring, multifaceted, and essential processes of change, during which entrenched socio-technical systems evolve towards modes of production and consumption that are more sustainable (Markard et al., 2012). The current quest for business models for sustainability transitions is a response to currently dissatisfying developments in terms of globally increasing unsustainability, calling for fundamental changes at all levels and increased transition and transformation dynamics to significantly move beyond business-as-usual (Markard et al., 2020). This quest integrates two rapidly growing, but often disconnected fields of research: research on sustainable business models—which aims to advance sustainable modes of organisational value creation—and research on socio-technical and sustainability transitions—which aims to advance system-level changes and system-level sustainability (Aagaard et al., 2021; Bidmon & Knab, 2018).

Contemporary scholarly discourse highlights the pivotal role of companies and their business models in catalysing transitions towards sustainability (Köhler et al., 2019; Sarasini & Linder, 2018). Notwithstanding this acknowledgement, there is a noted deficiency in conceptual development at the micro-macro intersection. Specifically, there is a scarcity of studies concentrating on niche innovations and niche actors such as single firms and their partners, with the aim of comprehensively understanding the myriad of dynamic (inter)organisational activities (Binz & Truffer, 2017; Pinkse et al., 2023). This indicates important gaps in common theoretical frameworks regarding firms, particularly a lack of analysis from the macro-perspective provided by sustainability transitions (Bidmon & Knab, 2018). The intrinsic systemic characteristics of transitions towards sustainability necessitate the shaping of markets via engagements among diverse stakeholders, encompassing entities both

within and external to established organisations and networks (Bankvall et al., 2017). Contrary to merely leveraging current technologies through innovative applications (e.g. Palo & Tähtinen, 2013), these transitions are propelled by significant innovations that possess the potential to exert long-term and disruptive impacts on prevailing socio-technical frameworks (Köhler et al., 2019). To foster in the development of BMfST, it is essential to take into account the contextual elements within production and consumption domains (Aagaard et al., 2021). As noted by Huijben et al. (2016) and Wesseling et al. (2020), these contextual factors exert a substantial impact on the potential for innovation on the level of single actors, companies, and business models. Furthermore, Massa et al. (2018) emphasise the importance of acknowledging the complex dynamics of subsystems within the overarching business model framework, particularly when adopting a sustainability transitions approach.

As discussed above, it is commonly recognised that transition processes encompass diverse pathways, frequently elucidated through singular case studies (e.g. Geels, 2019; Geels & Schot, 2007). Each act of business model design, innovation, and evolution constitutes an incremental data point within the broader context of socio-technical transitions, serving as a nuanced element within this complex narrative. These instances of change can either facilitate the emergence of new transition pathways or contribute to the perpetuation of existing structures, enabling incumbent entities to resist transformative change (Bidmon & Knab, 2018). Transition pathways thus emerge as environments that foster or are fostered by innovative and transformational business models, driven by disruptive technological advances, regulatory changes, and shifts in market dynamics. This reciprocal relationship illustrates how transition processes and business models are mutually constitutive, each shaping the opportunities and constraints of the other as indicated by the "spiral framework" in Fig. 5.1.

To enhance comprehension of the mechanisms behind propelling business models for sustainability transitions, we originally introduced the "spiral framework" (Aagaard et al., 2021). This framework was

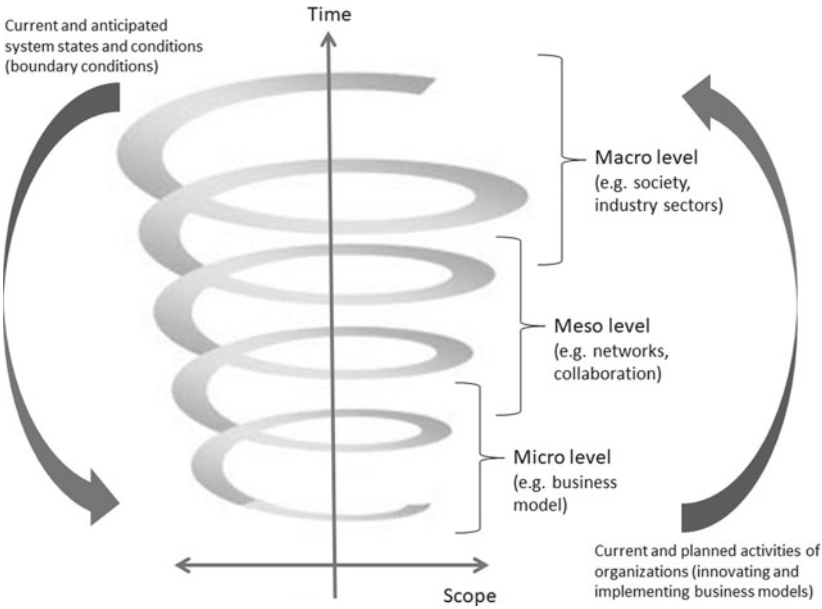

Fig. 5.1 The "spiral framework" connecting business models to sustainability transitions (*Source* Aagaard et al. [2021])

conceived in response to the complexities inherent in scrutinising business models within sustainability transitions. It integrates micro-, meso-, and macro-levels, accounts for temporal dynamics, investigates the scope of business activities, acknowledges the duality inherent in system structures and patterns of action, and it considers the influence and constraints associated with both business models and system-level conditions. In the following, we extend the "spiral framework" by illustrating some potential BMfST examples as well as the implications of facilitating business model design in sustainability transitions.

Three Illustrations of Business Models "Catalysed" by Sustainability Transitions

To begin our exploration of potential business models for sustainability transitions, we present some examples that represent three major categories of business models commonly discussed in the SBM field. These include so-called circular business models, platform business models, and service-oriented business models. These three categories are coming from a longer list of so-called sustainable business model patterns that were identified in prior research (Lüdeke-Freund et al., 2018, 2022, 2024). The following illustrations, adapted from Lüdeke-Freund et al. (2022), were chosen to illustrate that BMfST result from and bring about various changes across the micro-, meso-, and macro-levels as indicated by the "spiral framework".

Circular Business Models

Rizhao Economic and Technology Development Area (Yu et al., 2015)

Since its establishment in 1991, the Rizhao Economic and Technology Development Area (REDA) has been at the forefront of advancing the concept of a circular economy in China. Initially focused on achieving economic benefits through reductions in waste management costs and taxes, the initiative has since progressed to encompass the exchange of by-products and the utilisation of shared infrastructure. Recognised by the Chinese government as a model eco-industrial park for circular economy practices in the Rizhao region, REDA accommodates industrial companies spanning automotive and parts, pulp paper and printing, packaging, and cereal and oil food processing sectors. These companies actively participate in dozens of inter-firm by-product exchanges.

Kalundborg Symbiosis (Ecology Center, 2019)

In Denmark's Kalundborg, a renowned example of industrial symbiosis emerged in 1972. Originating from a desire among local industries to profit from exchanging by-products and adhering to new regulations, the network has expanded to include several private and public companies. Among them are Asnaes power station, Statoil A/S oil refinery, Gyproc Nordic East plasterboard producer, Novo Nordisk A/S pharmaceutical plant, the municipality, and waste company Kara/Noveren I/S. This collaborative effort involves around 20 material, water, waste, and energy exchanges, yielding ecological benefits by reducing raw material usage and waste while generating economic advantages through cost reduction in inputs and waste management.

Platform Business Models

Turo (Turo, 2021)

An exemplary instance of a platform that facilitates peer-to-peer (P2P) car-sharing is Turo (previously RelayRides). Through Turo's online platform, private car owners have the opportunity to rent out their vehicles, thus enhancing vehicle utilisation and generating income. Turo ensures insurance coverage for car owners and deducts a portion of their earnings for each rental.

FLOOW2 (FLOOW2, 2024)

The startup FLOOW2 operates a business-to-business (B2B) sharing marketplace catering to various industries. Companies can make use of FLOOW2's platform services to initiate sharing, swapping, renting out, or selling of their underutilised assets, materials, and services. FLOOW2 facilitates different types of sharing marketplaces. For instance, Dutch PharmaSwap serves as a specialised B2B sharing platform for pharmacists. It aids in redistributing pharmaceuticals nearing expiration among

pharmacists, thereby preventing wastage and reducing costs for the Dutch healthcare system.

Service-Oriented Business Models

Tesla Solar Roof (Tesla, 2021)

Tesla, the US-based automobile manufacturer, not only specialises in electric vehicles but also aims to promote the adoption of solar photovoltaic (PV) systems among homeowners. This initiative aligns with their approach to charging electric cars. Their Solar Roof services include several enticing features: removal of old roofing, installation of a seamless solar PV roof, Over-the-Air updates for Tesla's solar converter, and a self-service app for energy monitoring. While customers may initially hesitate due to uncertainties about solar PV, Tesla assures a financially beneficial solution with reduced electricity costs and enhanced convenience through various services. Moreover, Tesla's energy storage technology, including the Powerwall, enables customers to establish a fully integrated energy infrastructure, encompassing their power needs, including vehicle charging.

Philips' "Pay-per-lux" (Ellen MacArthur Foundation, 2017)

Philips' "Pay-per-lux" model offers customers high-quality lighting solutions for large office buildings without the need for ownership or maintenance. Instead, Philips manages the entire lighting system lifecycle, from installation to disposal. This innovative service-oriented approach sells light as a service rather than a product, with businesses paying a regular fee for the light provided. This shift away from selling lightbulbs emphasises efficiency as Philips is incentivised to minimise resource usage in its lighting systems. The model follows principles of sustainable product design, while additional services such as take-back management and product upgrading further enhance resource efficiency.

Eight Tentative Principles of Designing Business Models for Sustainability Transitions

Sustainability transitions represent a new imperative that extends beyond individual organisational change and encompasses various types of micro-, meso-, and macro-level transformations. This approach advocates systemically scrutinising and realigning socio-technical modes of production and consumption, where sustainability principles catalyse structural shifts across entire economic systems. Sustainability transitions challenge businesses not only to adapt and innovate within their operations but also to drive and respond to shifts in market dynamics, regulatory landscapes, and societal expectations on a broader scale. By applying a multi-level perspective, sustainability transitions emphasise the interconnectedness of businesses within wider socio-technical systems, advocating for collaborative efforts that extend beyond traditional activity systems and industry boundaries to foster sustainable development on a systems level. This perspective is critical for achieving comprehensive and enduring impacts on sustainability, highlighting the role of business models in (re)shaping and adapting to the evolving contours of sustainability transition pathways.

The academic discourse surrounding BMfST is still premature but evolving, with scholars such as Stubbs (2017) and Bohnsack et al. (2021) providing critical insights into the complexity of redesigning business models. These transitions are recognised not only for their potential to mitigate environmental impacts but also for their capacity to foster economic and social value. The eight tentative principles of designing BMfST proposed below are meant to reflect and generalise some insights that can be found in this newly emerging field of research.

For instance, the call for systemic thinking and strategic vision is echoed in the works of Geels (2011) and Massa et al. (2018), who discuss the significance of applying a multi-level perspective in understanding socio-technical transitions on the one hand, and the systemic nature of business models on the other hand. And authors such as Waddock (2017) and Pedersen et al. (2021) add to this by emphasising cross-sector collaboration and partnerships and their transformative potential.

The role of innovation ecosystems and open innovation in driving business models for sustainability is a central theme in the works of Chesbrough and Bogers (2014), who advocate for the dismantling of traditional innovation silos in favour of more collaborative and open approaches. The necessity for long-term investments and innovative financing models is further elucidated by Clark et al. (2018), who explore the role of sustainable finance in supporting transitions towards sustainability.

The strategy of policy engagement and institutional change finds resonance in the contributions of Meadowcroft (2009), who examines the dynamics of political processes in enabling sustainability transitions. Societal engagement and transparency are fundamental to building the public trust necessary for sustainability transitions, a theme explored by Owen et al. (2012) in their analysis of responsible innovation practices as well as Norris (2024) from the perspective of dealing with information asymmetries between stakeholders and the importance of sustainable value communication.

Adaptive leadership and organisational agility are discussed as being crucial for navigating the uncertainties inherent in sustainability transitions. This theme is addressed by authors such as Uhl-Bien and Arena (2017), who propose a framework for adaptive leadership in complex environments. Lastly, the importance of sustainability metrics and impact assessment is highlighted by Dembek et al. (2023) and Fichter et al. (2023), who advocate for comprehensive frameworks to evaluate the sustainability effects of organisations, also with a view to the importance of time, respectively impact forecasting.

Taken together, these themes underscore the multifaceted and interconnected nature of the challenges and opportunities associated with sustainability transitions and corresponding business models. We have summarised these aspects as eight tentative principles which are nothing but a first attempt to structure our thinking about how to approach BMfST from the perspective of business model design.

1. Systemic thinking and strategic vision

Business model designers must adopt systemic thinking to understand and influence the complex interactions within socio-technical systems. This involves developing a strategic vision that aligns business objectives with societal sustainability goals, recognising the role of business in driving system-level change. Models that support new energy systems against incumbent systems, such as in the case of solar power services, are instances of such an approach.

2. Cross-sector collaboration and partnerships

The development of BMfST requires collaboration across industries, sectors, and disciplines to co-create solutions for sustainability transitions, as illustrated by the circular collaboration models in the REDA and Kolundborg cases. Business model designers should seek and foster partnerships across sectoral boundaries, for example with governments, NGOs, academia, or other industries to leverage collective resources, knowledge, and political influence.

3. Innovation ecosystems and open innovation for sustainability transitions

To accelerate sustainability transitions, business model designers should engage in and contribute to innovation ecosystems. This involves embracing open innovation approaches, sharing knowledge, and co-developing solutions with external partners, including startups, research institutions, and communities. Setting up ecosystems of diverse stakeholders that co-develop new models such as FLOOW2's open approach to developing multi-stakeholder illustrate this principle.

4. Long-term financing and revenue models

Financing BMfST necessitates long-term investment strategies that prioritise long-term system-level impact over immediate financial returns. Business model designers should explore and develop innovative financing models, such as impact investing, green bonds, crowdfunding,

and public-private partnerships to secure the necessary capital for transformative projects. Alternative revenue models, such as service fees or time-based subscriptions as in the Philips case, can replace product sales-based revenues.

5. Policy engagement and institutional change

Actively engaging with policymakers and advocating for supportive regulatory frameworks is essential for enabling sustainability transitions. Business model designers have a role to play in lobbying for and even shaping policies that encourage transformational innovation and remove systemic barriers, contributing to institutional change. Although corporate lobbyism typically aims to block more challenging requirements, the political support for the right to repair shows that change in favour of alternative business models is possible.

6. Societal engagement and transparency

Building public trust and societal support for sustainability transitions requires transparent communication and active engagement with the wider community. Business model designers should communicate the societal benefits of their BMfST, involve citizens in co-creation processes, and demonstrate accountability in their sustainability efforts to build acceptance and legitimacy for their alternative ways of doing business. Current research deals with the importance particularly of transparency and communication about companies' ways of creating value.

7. Adaptive leadership and organisational agility

Leading the development, implementation, and continuous adjustment of BMfST requires adaptive leadership capable of navigating uncertainty as well as fostering an organisational culture of agility, resilience, and continuous learning. Business model designers must empower teams, encourage experimentation, and be prepared to pivot their strategies in response to emerging sustainability challenges and opportunities as well as changes in political and public support.

8. Sustainability metrics and impact assessment

To guide and evaluate the progress of sustainability transitions, business model designers must develop and utilise comprehensive sustainability metrics and impact assessment tools. These should measure not only environmental and social impacts but also the contribution to systemic change and the achievement of sustainability goals at the societal level. Crucial is the ability to assess company-level performance and outputs, stakeholder-level outcomes and value creation, and system-level impacts as well as to anticipate future effects of present business model designs.

These tentative principles are meant to point to the need for a transformative approach to business model design, emphasising systemic change, cross-sectoral collaboration, and a deep commitment to societal sustainability goals. Business model developers can play a pivotal role in steering their companies and industries towards a more sustainable future, requiring a profound rethinking of traditional business practices, the meaning of value and value creation, and a dedicated effort to drive and govern the complex processes of sustainability transitions (Aagaard et al., 2021). In summary, driving and governing business models for sustainability transitions demands a holistic approach that integrates sustainability deeply into strategic planning, operational practices, and organisational culture. Business model developers play a crucial role in leading these transformations, requiring a blend of visionary leadership, strategic foresight, and operational excellence to navigate the complexities of following and supporting sustainability transition pathways.

Outlook

The field of business models for sustainability transitions (BMfST) has witnessed initial growth, yet critical gaps persist, impeding a comprehensive understanding and implementation of transformative business practices. We briefly outline a future research agenda and delineate key areas for academic inquiry to advance our understanding of BMfST. Through

sector-specific analyses, exploration of the role of digital technology, investigation into systemic sustainability transitions, and examination of socio-political dimensions, this agenda seeks to deepen scholarly insights and inform practical strategies for fostering sustainability transitions.

1. *Sector-specific dynamics:* While existing research offers a broad understanding of BMfST, there is a dearth of sector-specific studies that account for unique industry challenges, opportunities, and regulatory landscapes. Investigating these nuances can provide actionable insights for practitioners and policymakers seeking to foster sustainability transitions within specific sectors.
2. *Role of digital technologies:* Digitalisation holds immense potential to support sustainable business practices, yet comprehensive research on the specific technologies enabling BMfST is lacking. By examining how technologies such as blockchain, IoT, and AI can facilitate sustainable business model design, implementation, and scaling, scholars can uncover opportunities and challenges in leveraging digital tools for sustainability.
3. *Interplay between business model design and systemic transitions:* While business models play a pivotal role in driving systemic sustainability transitions, the mechanisms through which micro-level innovations aggregate to influence macro-level outcomes remain poorly understood. Investigating this interplay can inform the development of theories elucidating the relationship between business model design and systemic sustainability transitions.
4. *Socio-political dimensions:* The socio-political context profoundly influences the development and adoption of sustainable business models, yet this dimension is often overlooked in existing literature. Understanding how power dynamics, institutional structures, and policy frameworks shape the landscape of BMfST is crucial for crafting effective strategies to overcome barriers to sustainability transitions.

Addressing these research agendas requires interdisciplinary approaches and collaboration across various fields. By delving into sector-specific dynamics, exploring the role of digital technologies,

understanding the interplay between business model design and systemic transitions, and considering socio-political dimensions, scholars can contribute to a deeper, more nuanced understanding of BMfST, ultimately advancing sustainability goals and informing practical interventions.

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