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Article

Beyond green or tech: Cultivating entrepreneurial ecosystems for the twin transition

Scientific Papers of the University of Pardubice, Series D: Faculty of Economics and Administration

Provided in Cooperation with:

Faculty of Economics and Administration, University of Pardubice

Suggested Citation: Rodriguez Santiago, Jaime Joel (2024) : Beyond green or tech: Cultivating entrepreneurial ecosystems for the twin transition, Scientific Papers of the University of Pardubice, Series D: Faculty of Economics and Administration, ISSN 1804-8048, University of Pardubice, Pardubice, Vol. 32, Iss. 2, pp. 1-12,
<https://doi.org/10.46585/sp32022105>

This Version is available at:

<https://hdl.handle.net/10419/334834>

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Beyond Green or Tech: Cultivating Entrepreneurial Ecosystems for the Twin Transition

Scientific Papers of the University of Pardubice, Series D: Faculty of Economics and Administration 2024, 32(2), 2105.
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DOI: 10.46585/sp32022105
editorial.upce.cz/SciPap

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Abstract

The "twin transition" concept underscores the interconnectedness of digitalization and sustainability – two major transformative processes shaping our world. While these transitions have often been viewed separately, their interdependence and mutual reinforcement are increasingly recognized. Entrepreneurs are uniquely positioned to drive progress at the intersection of these twin transitions, as innovative actors capable of developing solutions that seamlessly integrate digital technologies and sustainable approaches. Within the entrepreneurial ecosystem domain, two bodies of literature have emerged – one focused on digital entrepreneurship and the other on sustainability-oriented entrepreneurship. Though these streams have developed in parallel, they remain largely siloed. This paper first analyzes the interplay between digital transformation and sustainability transitions, highlighting their synergies and tensions. Building on this foundation, the paper introduces a conceptual framework that outlines key dimensions for cultivating entrepreneurial ecosystems capable of leveraging the opportunities offered by both transitions. This framework provides a roadmap for policymakers, entrepreneurs, and ecosystem actors interested in creating an environment that contributes to a sustainable planet in a digital age.

Keywords

Entrepreneurial ecosystems, Twin Transition, Sustainability, Digitalization, Sustainable Transitions, Digital Transformation

JEL Classification

L26, M13, Q56

Introduction

Digitalization and climate change have independently set in motion two major transformative processes: the digital and green transitions, frequently referred to as the "twin transitions". On the one hand, the digital transformation process aims to harness the potential of emerging digital technologies – ranging from artificial intelligence and big data analytics to the internet of things – to improve efficiency, enhance productivity, and drive competitiveness across all sectors of the economy (Bianchini et al., 2023; Fouquet & Hippe, 2022; Rosário & Dias, 2022). On the other hand, the green transition seeks to fundamentally reshape production and consumption patterns to mitigate environmental degradation, reduce greenhouse gas emissions, and foster climate resilience (Bianchini et al., 2023; Söderholm, 2020). Interestingly, while these two transitions have often been viewed and addressed separately, a growing body of research and policy discourse has begun to highlight the inherent linkages and potential synergies between them.

Recently, the concept of entrepreneurial ecosystems has emerged and grown as one of the major fields in entrepreneurship research. Entrepreneurial ecosystems are "a set of interdependent actors and factors coordinated in such a way that they enable productive entrepreneurship within a particular territory" (Stam & Spiegel, 2016). This includes entrepreneurs, investors, support organizations, educational institutions, research centers, government agencies, and other key stakeholders. Together, these elements collectively create an environment that nurtures and sustains entrepreneurial activity. The entrepreneurial ecosystem research field has recently witnessed the emergence of two new sub-streams with specific focuses on sustainability and digitalization. An increasing number of scholars (Elia et al., 2020; Huang et al., 2023; Neumeyer & Santos, 2018; Raposo et al., 2022) have examined how these two themes influence the development of entrepreneurial ecosystems. However, the existing literature on entrepreneurial ecosystems has primarily explored the dynamics of digitalization and sustainability separately, largely overlooking the potential to cultivate entrepreneurial ecosystems that can simultaneously support the digital and green transformations (Bakry et al., 2024; Hussain et al., 2021). Furthermore, prior studies have revealed conflicting logics between digital and sustainable transitions (Bianchini et al., 2023; Kirov, 2023; Kovacic et al., 2024; Meijer, 2024). Neglecting the emerging discussion on twin transitions and developing sustainable and digital

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entrepreneurial ecosystems separately can result in overlooking the consequences of these conflicting logics in the research on entrepreneurial ecosystems.

This paper aims to address this gap by proposing a conceptual framework for developing entrepreneurial ecosystems that can effectively foster the twin goal of digitalization and sustainability. The recognition that sustainability and digital technologies are increasingly interdependent and mutually reinforcing components of a broader transformative agenda holds the promise of addressing some of the most pressing challenges facing our societies and economies. Realizing this potential, however, requires a deeper understanding of how entrepreneurial ecosystems can be effectively cultivated to simultaneously drive the digital and green transitions. To that end, this study delves into the critical role that entrepreneurial ecosystems can play in enabling and accelerating the twin transition towards a more sustainable and digitalized future.

The paper will be structured as follows: The first section includes a literature review on the synergies between the green and digital transitions, highlighting their complementarities. The next section covers an analysis on the conflicting logics or tensions between the two processes centered on three areas: resource use; business models; and, cultural dimensions. The discussion section explores the extant literature on entrepreneurial ecosystems and discusses two emerging streams of research within the literature: sustainable and digital entrepreneurial ecosystems. Building on this foundation, a conceptual framework is introduced which outlines three interrelated elements required in developing entrepreneurial ecosystems that can foster the twin green and digital transitions. The final section offers a summary of the paper's contributions as well as potential research questions that can further bridge the study of entrepreneurial ecosystems and the twin transition.

Literature Review

The synergies of the green and digital transformations

In 2019, the European Union (EU) put forward the European Green Deal, an ambitious policy framework aiming to transform the EU into the world's first climate-neutral continent by 2050. At the same time, the EU's 'Digital Agenda for Europe' has outlined a strategy to harness the power of digital technologies to improve the lives of European citizens, drive economic growth, and enhance the continent's global competitiveness. Though these policy initiatives were initially conceived as separate agendas, they were not only presented as naturally compatible, but as mutually reinforcing components of a unified transformative vision (Kovacic et al., 2024). As the European Commission has emphasized, "Europe must leverage the potential of the digital transformation, which is a key enabler for reaching the Green Deal objectives" (The European Green New Deal, 2019, p.7).

The interconnectedness between the digital and green transitions is reflected in how digital technologies can serve as powerful enablers and accelerators of the green transition, allowing for the development and implementation of innovative sustainable solutions across various sectors. Conversely, the imperative to address pressing environmental challenges can spur the creation of novel digital tools and applications that contribute to environmental conservation and restoration efforts, thereby shaping the trajectory of digital innovation (Bianchini et al., 2023; Fouquet & Hippe, 2022; Rosário & Dias, 2022; Yilmaz et al., 2023).

For instance, digital technologies can enhance the monitoring and management of environmental resources, enabling more efficient use of energy and materials (Palmié et al., 2024), as well as better forecasting and mitigation of environmental risks (Jindra & Leusin, 2024; Mas et al., 2024). Furthermore, digitalization lowers transaction and communication costs, making it easier for sustainable businesses to connect with suppliers, partners, and customers, thereby expanding their reach and impact (Dabbous et al., 2023). The capabilities of digital technologies also bring together multiple actors to engage in community development and co-creation processes, further expanding the impact of sustainable business models (Gregori & Holzmann, 2020).

The capabilities offered by digital tools, such as enhanced data analytics, automation, and decision-making, can be leveraged to facilitate the development and deployment of innovative solutions that are critical for the green transition. These solutions include circular business models (Ahmadov et al., 2024), corporate greenhouse emissions monitoring and reporting, smart cities (Šulyová & Kubina, 2022), sustainable supply chains (Mlčúchová, 2022), and mobility solutions (Kirejev et al., 2024) that reduce emissions and promote environmentally-friendly modes of transportation (Bianchini et al., 2023; Rosário & Dias, 2022).

At the center of this dynamic interplay between the digital and green transformations lie entrepreneurs and their ability to identify, create, and scale up innovative solutions (Duch-Brown & Rossetti, 2020). Digital technologies enable sustainable entrepreneurs to craft value propositions that blend environmental, social, and economic value, appealing to a broader customer base (Gregori & Holzmann, 2020). Digital platforms, in particular, allow for impact complementarities, where the capture of one form of value (e.g., financial) corresponds with the capture of other forms of value (e.g., social and environmental). In recent years, a number of companies have sought out to launch sustainable versions of their products or new products altogether that cater to environmentally-conscious consumers. Incidents where companies falsely advertise their products as environmentally friendly have heightened consumer skepticism (a phenomenon known as 'greenwashing') (Farooq & Wicaksono, 2021). Digital tools, including blockchain and radio frequency identification (RFID) technologies, enhance transparency and

traceability in supply chains, building trust with consumers concerned about the sustainability of products (Palmié et al., 2024).

Conversely, the sustainability imperative has driven the creation and diffusion of digital innovations that have the potential to address environmental challenges at scale. Specifically, digital technologies have been developed to support climate change mitigation and adaptation efforts, such as early warning systems, carbon capture and storage solutions, and technologies to enable renewable energy production and distribution. Additional digital solutions have been developed in the service of biodiversity conservation, waste management, and pollution reduction, further underscoring the interdependent nature of the digital and green transitions (Lichtenthaler, 2021; Truong, 2022).

The intertwined relationship of these two transformative processes is summed up as the "twin transitions." And though the term is frequently used within the EU policy landscape (Damioli et al., 2024; Fazio et al., 2024; Montresor & Vezzani, 2023), it has not yet gained widespread global recognition. However, the underlying concept of pursuing digital and green transitions in a synergistic manner is gaining traction worldwide (Bianchi et al., 2024; Ferreira et al., 2024). Many countries and organizations recognize the interconnectedness of these transformations and are developing strategies to align their digital and sustainability agendas, making the core idea of the "twin transitions" increasingly relevant on a global scale.

Conflicting logics between the digital and green transitions

While the digital and green transitions are mutually reinforcing in many ways, there can also be tensions and conflicting logics between the two that need to be carefully navigated. These tensions arise from the inherent differences in the drivers, priorities, and outcomes associated with each transition and can be summarized in three key areas: (1) resource use; (2) business models; and (3), cultural dimensions. This section draws on existing literature on the green and digital transitions as well as from the literature on ecology to identify and examine these areas of tension and synthesizes the findings (Table 1) where potential opportunities are juxtaposed against the challenges.

Resource use patterns

The first conflicting logic stems from different ways of using resources. The digital transition is inherently linked with increased energy and material consumption, as the proliferation of digital devices, data centers, and computing infrastructure requires significant amounts of electricity and raw materials. The information and communications technology (ICT) sector alone is estimated to account for 14% of the world's electricity consumption by 2030, the highest of any industry (Andrae, 2020).

One evident example is the efficiency paradox. While digital technologies can enhance efficiency and reduce resource consumption in certain areas, they can also lead to rebound effects (Herring & Roy, 2007). For example, digital manufacturing technologies offer incumbent firms the opportunity to transform their operations and business models to achieve energy efficiency improvements (Moschko et al., 2023). However, studies have shown that firms use their energy efficiency gains to increase the utility of their products and services or increase their production output to maintain competitive advantage (Galvin, 2015) which paradoxically leads to an overall increase in energy consumption (Wang & Nie, 2018).

Similarly, mining metals and (scarce) minerals required for digital hardware production, including those associated with the green transformation, such as lithium batteries found in electric vehicles, has significant environmental impacts (Sonter et al., 2020). The global shift towards electric mobility and renewable energy sources such as wind and solar power to reduce carbon emissions and combat climate change heavily relies on lithium-ion batteries (Flexer et al., 2018). Estimates suggest the demand for lithium-ion batteries will reach 2.2 million tonnes by 2030 (Kaunda, 2020). The 'Lithium Triangle' in the Andean plateau, which spans the borders of Argentina, Bolivia, and Chile, holds the world's largest lithium reservoirs (Flexer et al., 2018). While crucial for global lithium production, studies have pointed to significant social and environmental challenges the region faces due to the rapid expansion of mining activities such as the depletion of aquifers vital to local ecosystems and communities (Flores Fernández & Alba, 2023; Kaunda, 2020), loss in biodiversity (Gutierrez et al., 2022), and conflicts with local and indigenous communities (Liu et al., 2019).

According to the 2023 Extracted Forests Report by the World Wildlife Foundation (Gagen et al., 2023), mining and its associated infrastructure is one of the largest drivers of deforestation and biodiversity loss, with approximately 20% of mining sites situated in biodiversity hotspots, or areas with large numbers of endemic species.

Another important aspect is the issue of electronic waste (e-waste), which is the fastest-growing waste stream globally (Purchase et al., 2020). As digital technologies become more ubiquitous and their lifecycles shorten, the volume of e-waste is rising by 2.6 million tons annually and projected to increase by 33% between 2022 and 2030. Meanwhile, less than one quarter of the e-waste mass is being properly collected and recycled (Baldé et al., 2024).

In all cases, many of the concerns regarding the potential negative effects of digitalization are often offset by examining or revisiting aspects associated with manufacturing or supply chain practices. However, sourcing

materials and energy from sustainable sources alone might prove insufficient if we fail to question the intended use of such technologies (Kovacic et al., 2024) as well as the underlying consumption patterns that drive their production in the first place.

Table 1. Summary of synergies and conflicts between the digital and environmental transitions.

Synergies	Conflicts
Digital technologies can facilitate climate change mitigation and resource efficiency (Jindra & Leusin, 2024).	Production and disposal of digital devices contribute to e-waste and raise ethical concerns about mineral extraction (e.g., lithium and cobalt) (Müller et al., 2024).
Digitalization can drive innovation in green technologies and sustainable business models (Mäkitie et al., 2023).	Increasing energy consumption from data centers and blockchain technologies can strain efforts to reduce carbon emissions (Mäkitie et al., 2023).
Data analytics and AI can optimize resource use, reduce waste, and enhance sustainable production and consumption (Dabbous et al., 2023; Kirov, 2023).	The benefits of digitalization can be unevenly distributed, leading to a digital divide and potentially widening existing inequalities (Satalkina & Steiner, 2020).
Digital platforms can connect stakeholders, fostering collaboration and knowledge sharing for sustainability initiatives (Gregori & Holzmann, 2020).	The complexity of managing the twin transitions can lead to policy conflicts and implementation challenges (Bianchini et al., 2023).
Digital tools can enable transparency and traceability in supply chains, promoting ethical sourcing and sustainable practices (Myshko et al., 2024).	The use of digital tools to promote sustainability without genuine commitment to sustainable practices can result in greenwashing (Tiba et al., 2020).
Digital technologies can empower individuals to adopt sustainable behaviors through awareness-raising and behavior change initiatives (George et al., 2020; Veit et al., 2024).	The focus on digital solutions can distract from addressing underlying social and economic inequalities that contribute to environmental problems (Müller et al., 2024).
Digitalization can enhance efficiency and productivity, potentially freeing up resources for investment in sustainability initiatives (Kren & Lawless, 2024).	The dominant economic logic might prioritize profit maximization over social and environmental considerations, potentially leading to the misuse of digital technologies for short-term gains at the expense of long-term sustainability (Meijer, 2024).
Digital tools can facilitate remote work and virtual collaboration, reducing transportation needs and associated emissions (Dabbous et al., 2023; Kirov, 2023).	"Suggested solutions" for environmental challenges often rely heavily on digital technologies, potentially neglecting alternative approaches and overlooking the potential downsides of digitalization (Meijer, 2024; Müller et al., 2024).
The integration of digital and sustainability strategies can foster a more holistic and integrated approach to business and societal transformation (George et al., 2020).	A lack of awareness and understanding of the potential synergies and conflicts between the twin transitions can hinder effective policymaking and implementation (Kovacic et al., 2024).
Collaboration and knowledge sharing between the digital and sustainability sectors can lead to the development of new solutions and business models (Chaudhary et al., 2023; Palmié et al., 2024).	There is a potential for a knowledge gap between the digital and sustainability sectors, hindering the development of integrated solutions (Ferreira et al., 2022).
The twin transition can create new market opportunities and drive economic growth in both the digital and green sectors (Bianchini et al., 2023).	Incremental digital innovations that focus on optimizing current systems might unintentionally perpetuate unsustainable practices (Mäkitie et al., 2023).
Investment in research and development for both digital and green technologies can lead to technological breakthroughs and accelerate progress (Kren & Lawless, 2024).	

Source: Author's compilation.

Business model misalignments

The second conflicting logic is associated with the misalignment of sustainability- and digitalization-oriented business models. The profit-driven logic that often dominates the digital economy can create tensions with sustainability objectives, as the emphasis on rapid scaling and network effects can lead some digital businesses to prioritize growth over environmental and social considerations (Feroz et al., 2021). This is exemplified by the "scale-up" mentality that is prevalent in the tech industry (Kuratko et al., 2020), which places significant emphasis on expanding user bases and market share, frequently relying on practices like planned obsolescence, aggressive data extraction, and disruptive business models that overlook social and environmental considerations (Borning et al., 2018; Wieser, 2016). Incremental digital innovations focused on optimizing current systems might inadvertently reinforce unsustainable practices rather than driving systemic change. This emphasizes the need to distinguish between digital innovations that promote efficiency within existing systems versus those that enable transformative

change (Mäkitie et al., 2023). On the other hand, sustainable businesses tend to focus on longevity, circularity, and balancing profitability with positive social and environmental impact (Bocken et al., 2014).

Cultural dimensions and value systems

The third type of conflicting logic in twin transitions is related to cultural dimensions and value systems. Beyond the resource use and structural tensions, the digital and green transitions may also come into conflict on the cultural level. Digitalization is often associated with a culture of speed, convenience, and hyper-connectivity (Fortier & Castellanos Juarez, 2017), which can clash with the more gradual and mindful approaches required for sustainable transformation (Wöhler & Haase, 2022).

Sustainability is inherently a value-oriented concept, encompassing ethical considerations and a normative vision of how social-ecological systems should evolve (Ploum et al., 2018). This value system often clashes with the economic logic of profit maximization. This is more evident in investment patterns, where the fast-paced, high-return mentality of venture capital (Lerner & Nanda, 2020) and tech investment have dominated over more patient and impact-oriented investment vehicles that are better suited to support sustainable development (Bellucci et al., 2023). The prevailing economic paradigm often prioritizes short-term economic gains over long-term social and environmental considerations (Ploum et al., 2018). This can lead to the misuse of digital technologies for profit maximization at the expense of recognizing the long-term benefits and potential competitive advantages of sustainability (Ferreira et al., 2022).

In addition, there are cultural notions surrounding digitalization that perceive it as immaterial and virtual. Since digital technologies are presented to us in terms such as “cloud” and “artificial”, where its impact is abstracted away from the usage (Monserrate, 2022), it can lead to a disconnection from the underlying material realities. This can obscure the tangible environmental impacts of digital technologies, as mentioned earlier, and undermine the urgency of addressing them.

The twin transitions present a complex interplay of opportunities and challenges (see Table 1 for summary). While digitalization can act as a powerful enabler for sustainability, it is crucial to be mindful of potential conflicts and trade-offs.

Discussion

To better understand how digital and green transitions can be mutually reinforcing and supportive, it is essential to explore the pathways through which the two processes can be aligned and leveraged within entrepreneurial ecosystems.

Entrepreneurial ecosystems, defined as the interconnected set of actors and factors that enable productive entrepreneurship within a particular territory (Stam & Spigel, 2016), are increasingly recognized as crucial mechanisms for fostering innovation, economic development, and societal transformation. These ecosystems, which are characterized by the dynamic interactions and synergies among diverse stakeholders such as entrepreneurs, investors, research institutions, anchor organizations (Harima et al., 2024), and enabling policy frameworks, are uniquely positioned to catalyze the integration of digital technologies and sustainability considerations.

As a research field, entrepreneurial ecosystems has rapidly developed (Wurth et al., 2022) and empirically covered aspects such as the interdependence and the link between ecosystems and outputs, or the causal mechanisms amongst cultural, social and material factors (Spigel, 2017). Beyond their objective of fostering entrepreneurial activity in general, ecosystems' have been linked to a wider set of social and economic outputs such as its contribution to economic growth (Acs et al., 2018), regional development (Erina et al., 2017), the enabling of knowledge spillovers (Lafuente et al., 2016), and even the fostering social entrepreneurship in nations whose cultural conditions do not seem to be supportive of entrepreneurship (Harms & Groen, 2017).

As highlighted in by Gibbs & O'Neill (2012), the influence of entrepreneurial ecosystems on the green transition goes beyond individual entrepreneurial ventures. Rather than viewing entrepreneurs as lone heroes, the research suggests that entrepreneurial ecosystems facilitate green entrepreneurship through a network of support organizations, informal networks, and policy frameworks that work in tandem to create an enabling environment for sustainable business creation and growth. This systemic perspective on entrepreneurial ecosystems is particularly relevant for understanding how they can drive the convergence of digital and green transformations.

Within the broader field of entrepreneurial ecosystem research, two distinct yet interconnected streams have emerged that are particularly relevant to the alignment of digital and green transitions: sustainable entrepreneurial ecosystems and digital entrepreneurial ecosystems.

Sustainable Entrepreneurial Ecosystems

The sustainability orientation of entrepreneurial ecosystems has been a subject of growing scholarly interest in recent years. Introduced by Cohen (2006), the concept of sustainable entrepreneurial ecosystems highlights the importance of aligning entrepreneurial activities with environmental and social sustainability goals. In a sustainable

entrepreneurial ecosystem, “an interconnected group of actors in a local geographic community committed to sustainable development through the support and facilitation of new sustainable ventures” (Cohen, 2006, p.3). In this context, the community actively works to foster sustainable entrepreneurship. Sustainable entrepreneurship is defined as, “the preservation of nature, life support, and community in the pursuit of perceived opportunities to bring into existence future products, processes, and services for gain, where gain is broadly construed to include economic and non-economic gains to individuals, the economy, and society” (Shepherd & Patzelt, 2011, p.142).

Sustainable entrepreneurship fundamentally differs from traditional entrepreneurship in its intended impact and realized outcomes and the fact that their success hinges on the support they receive from others (Volkman et al., 2021). While entrepreneurship can be understood as a mix of attitudes, resources, and infrastructure resulting in exploring and exploiting new opportunities (Chaudhary et al., 2023), sustainable entrepreneurship stems from the need to address pressing societal issues like climate change and social inequity. Sustainable entrepreneurial activities focus on tackling fundamental societal challenges that align with the UN Sustainable Development Goals (SDG), which span economic, environmental, and social areas. Consequently, the research at the intersection of sustainable entrepreneurship and entrepreneurial ecosystem, as identified by Theodoraki et al. (2022) has centered primarily on examining i) ecosystem configuration and evolution; ii) determining the indicators that influence the performance of entrepreneurial ecosystem actors; and, iii) the strategic interactions between ecosystem elements. Though exploring the recognition of sustainable opportunities as well as understanding the contextual factors (Volkman et al., 2021) that facilitate sustainable development within an entrepreneurial ecosystem is important, the current body of literature has not yet fully addressed the role of digital technologies in enabling and shaping sustainable entrepreneurial ecosystems.

Digital Entrepreneurial Ecosystems

The second research stream explores the development and evolution of digital entrepreneurial ecosystems, a term that stems from the overlap of digital entrepreneurship and entrepreneurial ecosystems (Sussan & Acs, 2017). Existing studies have examined the role of digitalization on entrepreneurship, identifying how digital technologies facilitate the emergence of new business models and the disruption of traditional industries (Elia et al., 2020; Zhang et al., 2023). This research stream has also explored how the unique characteristics of digital entrepreneurial ecosystems (Nambisan, 2017), such as the centrality of digital platforms, the importance of data-driven decision-making, overcoming resource scarcities through digitalization (Marquardt & Harima, 2024), and the global reach of digital ventures, shape the dynamics and performance of entrepreneurial activity (Kotha et al., 2022).

A much smaller set of studies such as Herman (2022) have highlighted that there is a positive correlation between the level of digital entrepreneurship and the achievement of Sustainable Development Goals, particularly SDG 8 and SDG 9. Others like Baranauskas & Raišienė (2022) have proposed conceptual frameworks for understanding the interplay between sustainability aspects in digital entrepreneurship with a focus on management and value co-creation in digital business ecosystem models.

Yet, despite the linkages between the digital and green transitions, the literature streams concerning the development of sustainable entrepreneurial ecosystems as well as digital entrepreneurial ecosystems are kept largely separate. To fully harness the potential of entrepreneurship to drive the twin transitions, greater integration between these two emerging research fields is needed. Entrepreneurial ecosystems research and practice needs to recognize the converging demands and conflicting logics of digital and sustainable transformations and explore how ecosystem-level strategies can foster entrepreneurial activities that address both.

Entrepreneurial Ecosystems and the Twin Transition

Ferreira et al. (2022) highlight the crucial role of entrepreneurial attitudes, abilities, and aspirations in driving both the digital and environmental transitions. Yet, entrepreneurs do not operate in isolation, but are embedded within a broader context that shapes their opportunities, constraints, and ultimate impact. By adopting a systemic perspective, the entrepreneurial ecosystems concept can help unpack how this broader context can be structured to create an enabling environment for entrepreneurial activities that support the dual objectives of digital and green transformations.

Building on this foundation, this paper introduces a conceptual framework (see Fig. 1) that illustrates how sustainable and digital entrepreneurial ecosystem factors can be aligned to drive the twin transitions. At the core of this framework is the recognition that digital and green transitions are closely interconnected, with both conflicting logics and potential synergies, influencing the elements of the entrepreneurial ecosystem (Stam & van de Ven, 2021) based on Isenberg’s (2010) domains model.

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This conceptual framework highlights three interrelated dimensions that should be considered to develop entrepreneurial ecosystems that can simultaneously support the green and digital transitions.

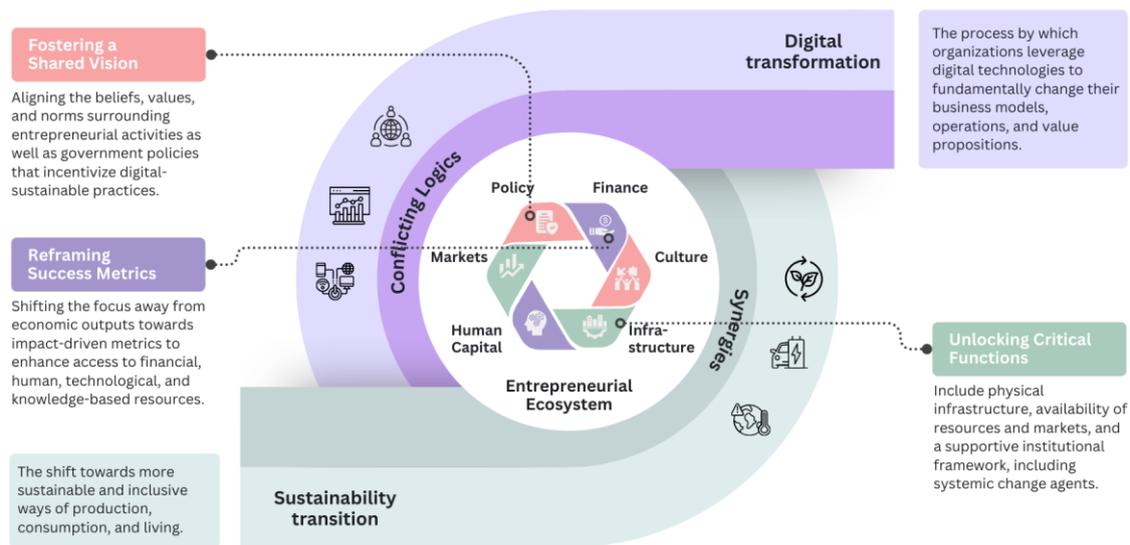


Fig. 1. Conceptual framework

Source: Author's own creation, based on Isenberg's (2010) domains

Specifically, this paper proposes that fostering entrepreneurial ecosystems capable of simultaneously supporting digital and green transformations requires considering three interrelated dimensions:

1. **Fostering a Shared Vision:** Entrepreneurial ecosystems are embedded within complex institutional environments that shape the beliefs, values, and norms around entrepreneurial activities. To foster ecosystems that can support both digital and green transformations, it is crucial to align the institutional logics that underpin the entrepreneurial ecosystem with the complementary yet potentially conflicting demands of digital and sustainable entrepreneurship (Gregori & Holzmann, 2020; Muldoon et al., 2023). This dimension touches upon the elements of culture and policy. A crucial step within this dimension is to acknowledge the interconnected nature of digitalization and sustainability. Chaudhary et al. (2023) highlight supportive culture and a shared sustainability intention among actors within the ecosystem. Governments can create incentives for businesses to adopt digital-sustainable practices, invest in research and development of green technologies, and implement regulations that encourage sustainable production and consumption patterns (Ahmadov et al., 2024; Cloitre et al., 2024; Collini & Hausemer, 2023; Tiba et al., 2020; Timmermans et al., 2023).
2. **Unlocking Critical Functions:** Raposo et al. (2022) and Bank et al. (2017) discuss the importance of a "conductive physical environment" for nurturing new venture emergence. This includes not just physical infrastructure like broadband connectivity and transportation networks (Kirejev et al., 2024; Šulyová & Kubina, 2022), but also the availability of resources, markets, and a supportive institutional framework that facilitates entrepreneurial activities. Within this dimension, we can also find supporting networks and entrepreneurial support organizations (ESOs). Bank et al. (2017) and Cloitre et al. (2024) emphasize the significant role of ESOs, such as incubators, accelerators, and science parks, in facilitating the twin transition. These organizations provide essential resources, mentorship, networking opportunities, and knowledge spillovers, enabling entrepreneurs to develop and implement digital-sustainable business models. For example, ESOs can connect entrepreneurs with investors focused on sustainability-driven businesses, facilitating access to funding. They can also facilitate knowledge transfer between universities and startups, bridging the gap between research and commercialization of sustainable technologies. Collini & Hausemer (2023) introduce the concept of "systemic change agents" such as local clusters and trade

associations. These agents influence the twin transition by framing the narrative, piloting new initiatives, and driving the scaling up of successful solutions. Political entrepreneurs, in particular, can play a significant role in advocating for policy changes that promote the integration of digital and green goals.

3. **Reframing Success Metrics and Investment Criteria:** Entrepreneurs that exhibit strong pro-environmental attitudes along with the capacity to identify opportunities and the motivation to turn those into viable businesses can be vital agents in aligning these transformations. However, these entrepreneurs often face barriers in accessing the specialized resources (e.g., financial capital, human capital, technology) needed to develop and scale their ventures. The emphasis on economic outputs like revenue and customer growth needs to be broadened to include social and environmental outcomes. This requires developing new metrics and assessment tools that capture the multifaceted nature of sustainable entrepreneurship, such as the level of social and environmental impact achieved, and the contribution to SDGs. Entrepreneurial ecosystems should therefore focus on facilitating a diverse set of resources - including financial, human, technological (Mičúchová, 2022), and knowledge-based resources - that can enable the emergence and growth of sustainable digital ventures. (Dean & McMullen, 2007; Gregori & Holzmann, 2020; Yılmaz et al., 2023). This dimension relates to the elements of finance and human capital. Traditional venture capital, impact investors, and crowdfunding platforms can play a crucial role in supporting businesses developing and implementing digital-sustainable solutions (Raposo et al., 2022; Volkmann et al., 2021).

Ultimately, the proposed conceptual framework highlights the need to take a holistic, ecosystem-level approach to fostering entrepreneurial activities that can simultaneously drive the digital and green transformations. Collaborative efforts from policymakers, ESOs, investors, entrepreneurs, and researchers are crucial for creating a dynamic environment where digital innovation and sustainable development can thrive in tandem.

Conclusion

According to Welter et al. (2019): "the world changes: indeed, it changes in part as a result of entrepreneurship." This paper has argued that entrepreneurial ecosystems, when properly structured, can be powerful engines for driving the digital and green transformations that are urgently needed to address the pressing economic, social, and environmental challenges of our time.

The proposed conceptual framework highlights three key dimensions that public and private actors should consider in nurturing entrepreneurial ecosystems capable of supporting these twin transitions: fostering a shared vision, unlocking critical functions, and reframing success metrics. By aligning these dimensions, entrepreneurial ecosystems can cultivate a culture of sustainable digitalization, provide essential resources to support green-digital ventures, and activate a diverse set of systemic change agents to scale up successful solutions.

Equally essential are the interlinkages between various stakeholders within the entrepreneurial ecosystem, including governments, private enterprises, universities, and communities. These stakeholders, through collaborative efforts, can create an enabling environment that supports the emergence and growth of green and digital startups, fostering innovation and adaptability (Suchek et al., 2022). Governments, for instance, can implement policies and incentives that incentivize sustainable entrepreneurship, while also investing in digital infrastructure and skills development (Suchek et al., 2022). Private enterprises can engage in partnerships with startups, providing access to resources, mentorship, and market opportunities (York & Venkataraman, 2010). Universities can cultivate an entrepreneurial mindset among students, offering specialized programs and incubator facilities, and serving as hubs for cutting-edge research and development (Boh et al., 2016).

This study recommends that future scholars pay closer attention to the interplay between sustainability and digitalization transitions in entrepreneurial ecosystems. As this study demonstrates, these interplays can involve both synergies and conflicts. Though this study is an initial step in understanding the linkages between these fields, this study is conceptual in nature and does not provide empirical evidence to support the proposed framework. Future research should empirically validate the relationships and dynamics highlighted in the framework. Though this framework calls for the alignment of the digital and green transitions through three dimensions, the practical exercise of combining social, environmental and digital logics will inherently come with its own challenges. To address these challenges, additional dimensions may emerge, suggesting future iterations of the model. Additionally, the concept of the twin transition emerges from a particular policy context comprised mainly by developed countries, and its applicability and nuances may need to be further examined across diverse global settings with varying economic, social, and environmental conditions. Examples of promising research questions include: "How can digital and sustainable transitions create synergetic effects that catalyze the evolution of entrepreneurial ecosystems?", "How do advancements in digital entrepreneurial ecosystems enable or hinder the development of sustainable entrepreneurial ecosystems, and vice versa?", and "What conflicting logics exist between sustainable and digital entrepreneurial ecosystems?"

Humanity faces the dual challenge of environmental issues stemming from our actions, as well as remarkable technological advancements that enhance our quality of life. Technology can be a key part of the solution, but only if we intentionally design and deploy it in service of sustainable development. A collective decision to prioritize this

outcome is first needed, followed by collaborative efforts to achieve it. Entrepreneurial ecosystems, when designed with the right institutional logics, resource flows, and enabling mechanisms, can be a crucial locus for realizing this vision.

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