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EXPLORING DYNAMIC CAPABILITIES AND GREEN INNOVATIONS IN BORN SUSTAINABLE FIRMS*

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Abstract. Born sustainable firms aim to regenerate the environment and drive positive societal changes since their establishment. Therefore, they need to leverage dynamic capabilities and their micro-foundations to reach their strategic aims. This paper investigates how dynamic capabilities—and their micro-foundations—influence the transition of such firms towards carbon neutrality. It assumes a holistic approach, analyzing the contribution of the firm's ecosystem to the development of its dynamic capabilities. Finally, the role of green innovations on the path toward carbon neutrality is evaluated. The adopted research method is based on a single longitudinal case study concerning a small organic wine-born sustainable firm implementing a sustainable and circular business model. Our findings clearly show that a firm's dynamic capabilities—belonging to the sensing, seizing, and reconfiguring clusters—play a critical role even in the case of micro and small companies, which are rarely investigated in the extant literature. However, due to the traditional resource poverty characterizing such companies, dynamic capabilities must be rooted in micro-foundations developed through interactions with partners within the firm's ecosystem. At the same time, developed capabilities allow the company to create and exploit a set of green innovations, which, in turn, push forward the net zero goal.

Keywords: dynamic capabilities; born sustainable firm; ecosystem; green innovation; wine sector; sustainability

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1. Introduction

Over recent decades, crafting environmentally sustainable strategies has emerged as crucial for compliance with the 2030 Agenda for Sustainable Development and the global climate target of reaching net zero emissions set by the Paris Agreement (Bombelli et al., 2019). To tackle sustainability challenges, firms must transcend conventional business practices and pioneer innovative methods to achieve carbon neutrality (Hoffman, 2005). Within the realm of sustainability-focused businesses, born sustainable firms (BSFs) represent a distinct category from other enterprises. Knoppen and Knight (2022) define them as firms “which were established with explicit strategic intent to operate in a sustainable manner from the outset. BSFs seek to contribute directly to regenerating the environment and driving positive societal changes” (p. 1790). According to the authors, such firms do not pursue the traditional competitive advantage but rather a more specific “sustainability advantage.” To achieve such a sustainability advantage, BSFs must develop dynamic capabilities (DCs) (Teece et al., 1997). These are conceptualized as the firm’s ability to integrate, build, and reconfigure internal and external competencies to cope with rapid changes in the dynamic business environment. Moreover, DCs are defined as the capacity to ‘orchestrate’ successful innovation and value capture over time. However, it must be considered that BSFs are traditionally micro, small, and medium enterprises (M&SMEs) (Knoppen & Knight, 2022). Therefore, they diverge from larger counterparts in three crucial ways: a) they often face ‘resource poverty’; b) they typically maintain simple organizational structures, with owner-founders playing a pivotal role as relationship and network managers; and c) they frequently operate without external shareholder accountability. Therefore, the development of DCs within such companies deserves special attention.

The DC framework has been previously applied in both strategic management (e.g., Zahra et al., 2006) and corporate sustainability studies (e.g., Kabongo & Boiral, 2017). However, Daddi et al. (2018) point out that the DC framework is scarcely investigated in the context of sustainability management. Moreover, Wu et al. (2012) highlighted that “how firms develop and apply dynamic capabilities to address the distinctive challenges involved in corporate change toward sustainability is yet to be fully explored” (p. 233). Finally, Amui et al. (2017) call for further research to better appreciate how DCs affect sustainable innovations.

It is also worth noting that DCs are rooted in micro-foundations that competitors cannot imitate (Teece, 2007). These micro-foundations are related to the adjustment and recombination of existing DCs, through which management, supported by organizational processes, senses and devises a business model to seize new opportunities and determine the best configuration for the organization (Teece, 2018). Khan et al. (2020) point out that the development of DCs’ micro-foundations has been scarcely investigated in the extant literature, especially in firms implementing sustainability strategies.

The development of DCs involves a pivotal role played by the firm’s “ecosystem.” While this term has been employed in the field of strategy for a long time (Moore, 1993; Iansiti & Levien, 2004), its applicability has greatly expanded over the last decade. Teece (2007) defines it as “the community of organizations, institutions, and individuals that impact the enterprise and the enterprise’s customers and suppliers” (p. 1325). According to some scholars, sustainability-oriented strategies (such as those aiming to develop a path towards carbon neutrality) require interaction with diverse stakeholders (Kortus & Gutmann, 2023). This is even more important in the case of “innovation ecosystems” (Jacobides et al., 2018), which may support the development of “green innovations” along the path toward net zero, as shown by De Marchi (2012).

Such innovations are defined as “measures by relevant actors (firms, private households...), which: (i) develop new ideas, behaviours, products, and processes, apply or introduce them, and; (ii) contribute to a reduction of environmental burdens or to ecologically specified sustainability targets” (Rennings, 2000, p. 322). While traditional innovations encompass creating novel products, materials, processes, services, and organizational structures to secure a competitive edge, green innovations strive to foster novel concepts, goods, services, processes, or management frameworks tailored to address environmental challenges (Rennings, 2000). Therefore, they support BSFs in developing a sustainability advantage (Knoppen & Knight, 2022).

Our paper aims to shed more light on the DC framework by exploring how their micro-foundations impact the path towards the net zero goal, specifically focusing on BSFs. In so doing, we investigate the impact of ecosystems on the development of the firm's DCs, which, in turn, allow the company to create green innovations. To sum up, we raise the following research questions:

1. RQ1: What kind of DCs' micro-foundations characterize firms implementing sustainability strategies towards the net zero goal?
2. RQ2: What is the role of the ecosystem in developing DCs?
3. RQ3: What types of green innovations are developed based on developed DCs?

The paper is structured as follows. Section 2 provides an overview of the available literature on DC to develop an integrated theoretical framework to support the evolutionary path towards the net zero goal. Section 3 describes the research method, which consists of a longitudinal single case study of an Italian wine-making BSF implementing a sustainable business model and organic production. The main findings are presented in Section 4 and discussed in Section 5. Limitations and suggestions for future research avenues are discussed in the final section.

2. Theoretical background

The existing literature on dynamic capabilities (DCs) occupies a significant place among the various theories in management studies. The first scholars to highlight the relevance of DCs were Teece et al. (1997), who defined them as “the ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments” (p. 516). The DC approach has advanced as an extension of the resource-based view of the firm, embracing the dynamic and evolutionary dimensions of firms' resources and capabilities as they move towards the next stage of organizational growth or encounter new obstacles. The DC perspective delves into how organizations navigate rapidly changing environments by creating new resources and adjusting or renewing their resource composition (Teece et al., 1997).

In 2007, Teece further explained DCs by identifying three enterprise-level capacities: 1) sensing and shaping threats and opportunities; 2) seizing opportunities; and 3) maintaining competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring tangible and intangible firm assets. Sensing involves recognizing and evaluating opportunities for sustainability, exploring different facets of the ecosystem, understanding customer needs, analyzing competitors, exploring technological advancements, interacting with suppliers, and evaluating markets. Seizing entails harnessing internal and external resources and capabilities to capitalize on opportunities and extract value from them. As Teece (2007) argued, from the viewpoint of DC, a firm's capacity to create and execute innovations is integrated within a network of interconnected actions aimed at producing, obtaining, and integrating a diverse array of resources and skills. Finally, reconfiguring involves ongoing revitalization and coordination of resources to align the company's resource portfolio with changes in the business landscape. These reconfiguring capabilities empower a company to maintain its evolutionary flexibility and mitigate any rigidity that may develop over time due to accumulating resources and established routines (Teece, 2007).

For each of the three enterprise-level capacities, Teece (2007) identifies a set of micro-foundations. Based on this framework, Khan et al. (2020) analyzed start-ups and recently established firms implementing a circular economy approach, identifying 11 specific micro-foundations interconnected with the three “clusters of DCs” proposed by Teece (2007). This set of micro-foundations can serve as a reference for any firm's sustainability strategy.

A further contribution offered by Teece et al. (1997) regards the source of DCs; in this respect, external competencies and their integration within the company emerge as fundamental issues. Mousavi et al. (2018) point out that firms develop solutions to environmental problems (e.g., through green innovations, as defined by Rennings (2000) by developing knowledge links with a wide range of external actors within their ecosystem. Several scholars underscore the critical role of external knowledge and information sources in fostering innovation towards sustainability (e.g., Bocken et al., 2014). Some authors also pointed out that the greater the

variety of partners a company collaborates with, the higher the likelihood of effectively innovating for sustainability (Dangelico et al., 2017; De Marchi, 2012). Due to their “resource poverty” (Knoppen & Knight, 2022), such collaborations are even more relevant for M&SMEs, including BSFs (Knoppen & Knight, 2022).

Based on the earlier discussion, the proposed integrated framework for the analysis of BSFs’ sustainable strategies towards net zero is summarized in Figure 1.

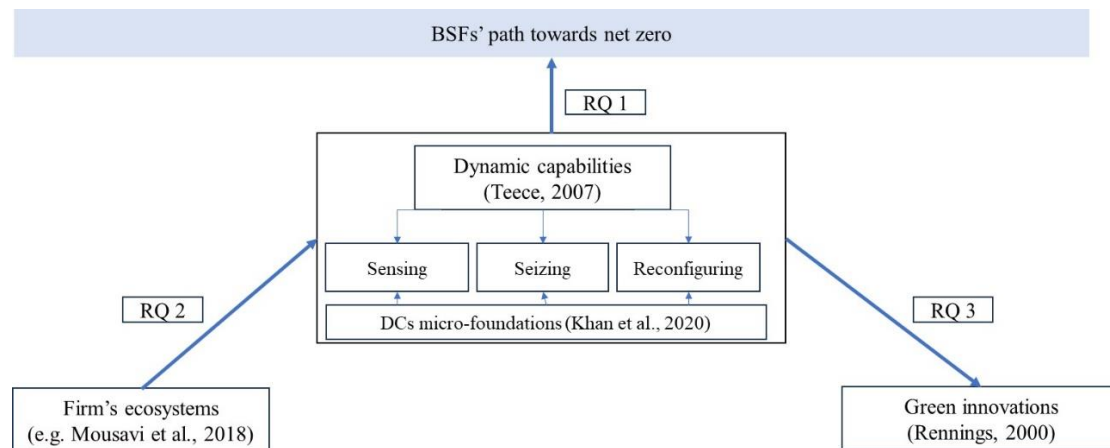


Figure 1. The proposed integrated framework
Source: Our elaboration

3. Methodology

As stated earlier, this paper adopts an integrated framework based on the dynamic capabilities (DC) approach (Teece, 2007; Teece et al., 1997). Specifically, it aims to investigate the nature and micro-foundations of the capabilities (Teece, 2007) adopted by born sustainable firms implementing strategies toward the net zero goal. It is assumed that a company can cultivate a range of capabilities, including interactions with its ecosystem, to facilitate the development of green innovations. The focus on ecosystems is emphasized by Knoppen and Knight (2022) as a crucial perspective in analyzing BSFs’ development.

Due to the novelty of the topic, a qualitative research method was chosen. Qualitative research based on a case study can generate a detailed and multifaceted understanding of a complex issue within its real-life context (Schwandt & Gates, 2018). To achieve this objective, a longitudinal case study was selected (Jensen & Rodgers, 2001). This approach aligns with Knoppen and Knight (2022), who suggest adopting a longitudinal approach due to the importance of the time horizon for sustainable advantage. For instance, BSFs may encounter challenging financial periods, compelling them to prioritize financial outcomes while deferring their intended environmental impact. Additionally, Yin (2003) stated that the longitudinal approach is a rationale for using a single case study to develop a research project. Therefore, a longitudinal single case study was selected through a purposive sampling approach to investigate the previously defined research questions. Scholars have pointed out that a case study selected through predefined criteria would increase the study's reliability (Etikan et al., 2016).

The case selection was based on the following criteria where the firm should:

1. belong to an industry characterized by a high level of engagement in sustainability. Santini et al. (2013) pointed out that sustainability plays a key role in the wine industry, as demonstrated by the increasing interest of academia, policymakers, and practitioners. Some companies have implemented sustainability strategies based on green innovations. Bandinelli et al. (2020) identified 20 different sustainable practices within the wine industry;
2. be a micro or small enterprise, due to their “resource poverty” (Knoppen & Knight, 2022), which obliges them to develop relational advantages in collaboration with partners in their ecosystem.

3. directly manage the entire wine production process, from vine cultivation to winemaking and bottling. Ferrer et al. (2022) state such characteristics are necessary to define the business model as highly sustainable in the wine sector.
4. The company should be classified as a BSF, having implemented a sustainable and circular business model since its establishment.

Based on these criteria, a small winemaking company located in central Italy emerged as an interesting case study. It was established by an entrepreneur with a strong commitment to sustainability. His business idea was to develop a new wine firm according to a sustainable business model (Geissdoerfer et al., 2020). This entrepreneurial aim originated from both his family heritage and his involvement in several environmental initiatives. His relatives owned a large vineyard in northern Italy, and he participated in grape harvests and wine production from childhood. This experience led him to pursue a Master's degree in agronomy. Given his environmental orientation, he also took courses on sustainability in agriculture and agroecology during his university period. He decided to establish a new company in the same province as his university. After carefully selecting land suitable for organic agricultural techniques, he established the company in 2002 and started constructing an eco-sustainable underground wine cellar, completed in 2005. In 2006, the firm's first organic product was launched. The company achieved carbon neutrality, producing minimal GHG emissions offset by carbon removals resulting from sustainable land management in the vineyards (Chiriaco et al., 2019). Moreover, the company developed several collaborations with universities and research centres and implemented some green innovations (Mura et al., 2023; 2024). Finally, it adopted both LCA and LCC measurement tools (Chiriaco et al., 2019; Mura et al., 2023; 2024).

Based on this evidence, the company may be classified as a BSF. It was previously investigated using a life cycle thinking approach related only to some of its sustainable initiatives (Chiriaco et al., 2019; Mura et al., 2023; 2024). However, no prior study has assumed a longitudinal and global perspective, considering all the firm's sustainability-oriented initiatives since its establishment. Moreover, previous analyses did not aim to investigate the DCs micro-foundations and their relationships with the firm's ecosystem and green innovations. In this regard, it is worth noting that previously available studies serve as useful secondary sources for data triangulation, a fundamental element of research focused on BSFs (Knoppen & Knight, 2022).

The authors contacted the company, and the research aims were presented to the entrepreneur, who agreed to collaborate and make his network of relationships available with actors in the firm's ecosystem. Based on this availability, the authors selected a set of key informants (see Table 1). Semi-structured interviews with the selected key informants were held via MS Teams, audio-recorded with permission, and lasted about 60 minutes. These interviews were conducted between November 2023 and March 2024.

Table 1. Primary sources for data collection

Primary data collection	Entrepreneur
(Semi-structured interviews)	Employee in charge of communication activities with company visitors Sustainability expert at a research centre collaborating with the selected company
	University professor acting as Principal investigator in two applied research projects involving the selected firm
	Firm's business customer (restaurant) involved in a reverse logistics project

Source: Authors' elaboration

All interviews were transcribed and manually coded to ensure rigorous qualitative data analysis, then sent to the interviewees for confirmation of the content. If further information needs emerged during the data analysis, the key informants were contacted again. Finally, a draft of the paper was sent to the company entrepreneur to provide an opportunity to comment, review the results, and give final approval.

Consistent with other studies (e.g., Khan et al., 2020), we triangulated the interview data to minimize interviewer bias and other issues typically present in qualitative research. Additionally, secondary data from the firm were analyzed, using not only previously available studies but also archival sources such as firm reports, press

releases (including interviews with the entrepreneur), final reports of applied research projects, and the firm's website.

Data analysis was supported by a coding activity conducted through a data-driven open-coding approach (Gibbs, 2007). Collected data were separately analyzed by each author to define the different phases of the DCs development along the path toward net zero. For each phase, authors autonomously conducted the coding activity to identify: a) which of the micro-foundations proposed by Khan et al. (2020) in relation to companies implementing circular economy strategic approaches were involved; b) the corresponding cluster of DCs (sensing, seizing, and reconfiguring) (Teece, 2007); c) the actors within the firm's ecosystem and their contribution to DC development; d) the set of green innovations (if any) developed in each phase. Such innovations were then classified according to the Oslo Manual (OECD/Eurostat, 2018).

After comparing the coding activity outputs, no relevant differences emerged. Findings collected and classified according to the described research methodology are presented and discussed in Section 4.

4. Results

During the first phase, the firm developed an initial collaboration with the local university, where the entrepreneur was enrolled. The company served as a case study for a practical application of Life Cycle Assessment (LCA) during a Master's course. Specifically, the environmental impact in terms of greenhouse gas (GHG) emissions was assessed using a 0.75L bottle as the functional unit (FU). Despite the occasional nature and specific focus of the collaboration, it proved highly beneficial for the company. The 'sustainability expert' involved in the LCA application during the Master's course noted: "*The application of the LCA was useful for the firm to define a first-ever overview of its impact in terms of greenhouse gas emissions. This was the first time the company had calculated the emissions generated.*" The valuable results obtained through the LCA approach were later coupled in 2022 with those emerging from the Life Cycle Costing (LCC) based on the same FU. These findings led the entrepreneur to implement several sustainability strategies.

According to the proposed analytical framework, the primary ecosystem actor is the local university, represented by the director of the Master's program, who will be the principal investigator of future research projects involving the company and other professors the entrepreneur met during his academic experience. The assessment of environmental impacts through the LCA method revealed that the main source of GHG emissions was from the wine packaging. This prompted the entrepreneur to seek new solutions in this area, resulting in three green marketing innovations: a) a lighter glass bottle for 95% of the total production (2011); b) a fabric label for aged wines (2012); and c) a recycled cardboard box for all product lines (2013). Due to the inability to use the lighter glass bottle for aged wines, a specific green organizational innovation was implemented based on a reverse logistics approach. Business customers, particularly those in the hotel, restaurant, café (Ho.Re.Ca.) sector, were asked to return empty glass bottles, fabric labels, and shellac to the wine firm. This project increased Ho.Re.Ca. customers' engagement despite some operational challenges. One customer noted: "*The only negative aspect of this initiative is the space needed to store the empty bottles, which then need to be returned. For us, it is not a problem because we have a large available area. However, for others with smaller warehouses, this could discourage participation.*" Despite the wide participation of the company's business customers, the project remains at the logistics level and has not been leveraged for storytelling to Ho.Re.Ca. end customers, who are only informed about the organic nature of wine production and the company's local roots.

Based on the previously described coding activity, three of the micro-foundations proposed by Khan et al. (2020)—'experiential learning,' 'strategic planning,' and 'best practice adaptation'—emerged. These belong to each of the three clusters proposed by Teece (2007): sensing, seizing, and reconfiguring. Table 2 summarizes all the analytical findings related to Phase 1.

Table 2. Phase 1 description

Phase	Phase Description	Ecosystem's Involved Actors	Phase Outputs			Classification according to Khan et al., 2020	
			Sustainability Assessment Tool	Other Outputs		Micro-foundations	Clusters of Dynamic Capabilities
				Description	Green Innovations Classification		
1	Informal collaboration with the University	University (Master's programme) Bottles suppliers Local supplier of textile fabric labels Suppliers of recycled cardboard boxes B2B Customers (Ho.Re.Ca.)	LCA (product unit)			(Using LCA to assess potential environmental impacts of products) - Experiential learning	Sensing
				Adoption of lightweight bottles (2011)	Marketing (packaging)	(Finding strategic partners) - Strategic planning	Seizing
				Adoption of fabric label (2012)	Marketing (packaging)	(Finding strategic partners) - Strategic planning (Collaborating with suppliers to acquire recyclable materials) - Collaboration	Seizing
				Adoption of a recycled cardboard box	Marketing (packaging)	(Finding strategic partners) - Strategic planning	Seizing
			LCC (reverse logistics)	Reverse logistics	Organizational	(Finding strategic partners) - Strategic Planning	Seizing
						(Implementing new business practices) - Best practices adaptation	Reconfiguring

Source: Authors' elaboration

The second phase involves consolidating the relationship between the firm and the university through a more structured collaboration, which included other research centers. Prompted by an external stimulus from the university, the company participated in its first public call for funding industrial research projects in the agricultural sector. Although the initial attempt was unsuccessful, a subsequent application the following year was successful. The approved project aimed to reduce the farm's environmental impact (achieving zero impact) and to produce a new product line of high-quality eco wines, furthering the firm's sustainability strategy. The project focused on three main areas: agronomic, technological, and ecological.

Referring to the proposed framework, the firm's ecosystem expanded due to the activation of additional relationships with new research institutions introduced by the local university. Notably, the university, represented by the same professor managing the Master's degree, not only initiated the new collaboration but also acted as a gatekeeper.

In terms of outputs, six green innovations were stimulated by the results obtained through the collaboration – one at the product level and five at the process level. The process innovations are:

1. Use of self-produced organic compost – derived from the firm's organic pomace and other plant residues – for soil improvement purposes (2011) (agronomic project area);
2. Implementation of a microsenors system within the cellar to reduce energy consumption (technological area);

3. Creation of a cell for conditioning and dehydrating grapes, where ozone treatments were also tested. The cell was built with local materials (chestnut wood and cork) to reduce environmental impact and was equipped with dehumidification and refrigeration systems for further energy efficiency (technological area);
4. Adoption of ozone in the dehydration phase, grape washing phase, and container cleaning. This process innovation reduced the use of chlorine and sulfur (technological area);
5. Creation of an integrated water management system, involving the collection of all water resources used in the company – cellar wastewater and rainwater collected from roofs – and a plan for their reuse (ecological area).

Regarding product green innovation, an eco-wine line characterized by no added sulfites was launched, thanks to the use of ozone for grape washing (2012 and 2022).

A special role in this project was played by the LCA (Life Cycle Assessment) method. The entrepreneurs highlighted: *“The three paths were all under the same sustainability umbrella, and the LCA acted as the common denominator for the entire project. The idea was to evaluate the firm’s impact before and after the development of these technologies. The goal was to certify the company’s sustainability through all the innovations implemented.”* Specifically, the LCA method was applied not only to the 0.75L glass bottle as the functional unit (FU) but also to the unit of cultivated land, i.e., 1 ha of vineyard. This approach allowed for more comprehensive GHG (greenhouse gas) accountability, as assessing GHG per unit of land provides a more detailed estimation of the firm’s contribution to climate change. Various studies (Chiriaco et al., 2022) demonstrate that the carbon footprint assessed by product units for agricultural products is not always fair, as it is primarily related to yields. Intensive management with high agricultural inputs per hectare generates higher GHG emissions in absolute terms per unit of land, which can be overshadowed by higher productivity when the carbon footprint is assessed per unit of product. The newly introduced carbon footprint per unit of land better reflects the actual agricultural contribution to climate change, driven by land-atmosphere GHG fluxes, independently of the number of bottles produced. The sustainability expert researcher stated: *“With this project, we went further and, for the first time – or at least we were among the first – applied LCA by land unit. We considered the entire territorial unit occupied by the company and how it is managed.”* Finally, the integrated approach – considering both the agricultural phase and the wine production phase – was evaluated (2022) using the LCC (Life Cycle Costing) approach. Table 3 summarizes the findings related to Phase 2.

The third phase is still characterized by exogenous stimuli promoted by a spin-off of the same local university. More specifically, it was proposed to integrate the LCA results developed in the previous phase with those derived from the use of the so-called “eddy covariance technique” (Baldocchi, 2003). The new integrated method allowed for the inclusion in the LCA of not only the anthropogenic GHG emissions attributable to the production process but also the overall biogenic GHG fluxes resulting from the agricultural management of the vineyard. This revealed that the farm was already carbon neutral in the field phase since the sustainable practices applied in the vineyard turn the system into a net carbon sink (i.e., -0.27 Mg CO₂-eq per ha per year), capable of completely offsetting the anthropogenic emissions associated with vineyard management (i.e., 0.24 Mg CO₂-eq per ha per year) (Chiriaco et al., 2019).

Table 3. Phase 2 description

Phase	Phase description	Ecosystem’s Involved Actors	Phase Outputs			Classification according to Khan et al., 2020	
			Sustainability assessment tool	Other Outputs		Micro-foundations	Clusters of Dynamic Capabilities
				Description	Green innovations classification		
2	Structured Collaboration with University	University Research Centres	LCA (Integration of product unit with unit of land)			Experiential Learning - Collaboration	

				Launch of 3 new wines without added sulphites (2012 and 2022)	Product	Undertaken activities to increase the stock knowledge - Knowledge Creation (Collaboration with universities and research centres) - Collaboration (Formulating a strategy for sustainability) - Strategic Planning	
			LCC (Production phases)	Organic Compost (2011)	Process	Undertaken activities to increase the stock knowledge - Knowledge Creation (Collaboration with universities and research centres) - Collaboration (Implementing new business practices) - Best practices adaptation	Sensing Seizing Reconfiguring
				Micro-sensorization (2012)	Process	Undertaken activities to increase the stock knowledge - Knowledge Creation (Collaboration with universities and research centres) - Collaboration (Technological modifications in existing machinery and infrastructure) - Technological Upgradation	
				Grape pomace drying room (2012)	Process	Undertaken activities to increase the stock knowledge - Knowledge Creation (Technological modifications in existing machinery and Infrastructure) - Technological Upgradation	
				Ozone Utilization (2012)	Process	Undertaken activities to increase the stock knowledge - Knowledge Creation (Implementing new business practices) - Best Practices Adaptation	
				Phytodepurati on and biolake (2013/2014)	Process	Undertaken activities to increase the stock knowledge - Knowledge Creation (Implementing New Business Practices) - Best Practices Adaptation	

Source: Authors' elaboration

Referring to the proposed analytical framework, the firm's ecosystem is further enlarged to include the spin-off; however, the university's gatekeeper role is confirmed. Given the specific contents of this new collaboration (integration of sustainable measurement tools), no green innovations were developed. Finally, the two micro-foundations involved in this phase ('experiential learning' and 'collaboration') belong to the sensing and seizing cluster (Table 4).

Table 4. Phase 3 description

Phase	Phase description	Ecosystem's involved actors	Phase Outputs			Classification according to Khan et al., 2020	
			Sustainability Assessment tool	Other outputs		Micro-foundations	Clusters of Dynamic Capabilities
				Description	Green Innovations Classification		
3	Collaboration with spin-off	University spin-off	LCA (integration among product unit, unit of land, and Eddy Covariance tool)			(Using LCA to assess environmental impacts) - Experiential learning (Collaborating with partners) - Collaboration	Sensing Seizing

Source: Author's elaboration

The fourth phase builds on the results described in Phase 3, motivating the firm to further collaborate with its scientific partners. Specifically, LCA results revealed a critical issue with the open-air production of organic compost: the emission of methane, which has a global warming potential 21 times greater than carbon dioxide (IPCC, 2022). Consequently, a new research project proposal was developed to address this issue, submitted for a public call in 2012. The primary aim of this project was to capture methane emissions from open-air compost fermentation and utilize them to meet the firm's energy needs. To support this recovery effort, the use of a closed, movable agricultural wagon was proposed for the compost fermentation phase. Methane emissions generated during this process would be used as biogas to supply the firm's gas boiler. Additionally, the organic residues from the fermentation process would be used to cultivate organic mushrooms for the local market. Finally, the remaining organic compost would be applied in the vineyard as a soil improver, mulch, and for anti-erosion purposes (Cirigliano et al., 2017).

Unfortunately, the research project found that the emitted methane was not pure enough to be used in the existing gas boiler. Consequently, the company decided to use the movable wagon solely for the production of organic compost, replacing the previous outdoor composting method. This change preserved a larger amount of the organic components, enhancing the quality of the compost. To produce higher-quality biogas, the wagon—initially a modification of an existing one—would have needed a complete redesign to ensure a more hermetic seal; however, budget constraints prevented this further step. Additionally, the mushroom business proved to be unprofitable and was discontinued in 2017. Therefore, during this phase, only the (partial) green innovation of the movable wagon was developed, which can be classified as a process innovation.

Regarding the firm's ecosystem, in addition to the established collaboration with the local university and its network of research centres, a critical role was played by the entrepreneur's involvement in the presentation of a book on the "blue economy." He noted, *"It was through the studies contained in the Blue Economy that I conceived the project to close the cycle. All company waste must be reused to become a resource: recover fermentation methane as biogas, use the substrate sterilized by fermentation along with coffee grounds sterilized by the coffee steam machine, and grow edible mushrooms to sell in the market."*

Finally, the relationships activated in this phase can be categorized under the 'collaboration' and 'technological upgradation' micro-foundations belonging to the seizing and reconfiguring clusters (Table 5).

Table 5. Phase 4 description

Phase	Phase description	Ecosystem's involved actors	Phase outputs			Classification according to Khan et al., 2020	
			Sustainability Assessment tool	Other outputs		Micro-foundations	Clusters of Dynamic Capabilities
				Description	Green Innovations classification		
4	Structured collaboration with universities and other ecosystem partners (institutional and business)	University research centres Engineering business company	LCA (integration among product unit, unit of land)			(Collaboration with universities and research centres) - Collaboration	Seizing
				Compost fermentation wagon/bin (2016)	Process innovation	Undertaken activities to increase the stock knowledge - Knowledge creation (Collaboration with universities and research centres) - Collaboration (Collaboration with suppliers) - Collaboration (Technological modifications in existing machinery and infrastructure) - Technological upgradation	Sensing Seizing Reconfiguring

Source: Author's elaboration

The fifth and final phase concerns green innovations developed independently by the focal firm, without specific relationships with actors embedded in its ecosystem. However, these green innovations are supported by the dynamic capabilities (DC) previously developed through the interactions described in earlier phases. In other words, they are an indirect result of the firm's embeddedness in the ecosystem.

During the last phase (2017-2023), two green innovations were developed. The first concerns an additional element of the packaging for the eco wines in the product line of wines without added sulfites (developed as a result of Phase 3). Specifically, in 2017, a label produced using a mix of paper and cotton was adopted; this label can be easily removed and recycled as paper waste.

In contrast, the second green innovation pertains to the creation of a new service line, the so-called "Eco Wine Experience." This offers visitors the opportunity to tour the firm's vineyards and cellar and learn about the sustainability strategies being pursued. This activity serves as both a communication tool and an autonomous business unit related to experiential tourism, attracting customers who may not be primarily interested in wine sales. In this regard, the entrepreneur noted, "The Eco Wine Experience is becoming the most relevant activity within the firm. For us, it also represents a tool to disseminate the firm's sustainability values." Notably, these tours have been adopted by several universities, including the local one promoting the collaborations described in previous phases, as a training activity for students in agriculture-related degrees. To support this new business

activity, a new company was established to manage the catering service for participants of the “Eco Wine Experience” tours.

Table 6 summarizes the findings related to Phase 5.

Table 6. Phase 5 description

Phase	Phase description	Ecosystem's involved Actors	Phase outputs			Classification according to Khan et al., 2020	
			Sustainability Assessment Tool	Other outputs		Micro-foundations	Clusters of Dynamic Capabilities
				Description	Green Innovations classification		
5	Autonomously developed green innovations			Adoption of a differentiable label of mixed cotton paper for wine product line (2017)	Marketing (packaging level innovation)	Collaboration with suppliers to acquire recyclable materials - Collaboration. (Finding strategic partners) - Strategic planning	Seizing
				Supply of 100% sustainable power		(Collaborating with suppliers to acquire sustainable inputs) - Collaboration	
				Eco Wine experience Spin-off establishment	Product innovation (new service)	(Addition of a specialized unit) - Organizational restructuring	Reconfiguring

Source: Authors' elaboration

5. Discussion and conclusions

Our findings underscore the importance of the firm's ecosystem in implementing sustainability strategies, particularly for BSFs. Within such an ecosystem, a diverse array of actors was identified based on the competencies needed in the analyzed phases (e.g., applied research activities in Phases 2 and 4, sustainable packaging supply in Phases 1 and 5). This aligns with previous studies highlighting the significance of the firm's external relationships within its ecosystem (Kortus & Gutmann, 2023), particularly in developing green innovations (De Marchi, 2012). Among these actors, the university plays a pivotal role. Specifically, the local university contributes at multiple levels: a) education and training, fostering the entrepreneur's agronomic background and enhancing sustainability awareness (further developed through participation in environmental organizations); b) exposure to new knowledge, such as adopting LCA techniques; c) promoting participation in public-financed applied research projects; d) developing customized technical and technological solutions. The collaboration between the firm and the university is mutually beneficial, evidenced by the opportunity for university students and its spin-off to conduct on-ground experiments at the firm.

Despite the small size of the BSF, it succeeded in developing and implementing 15 green innovations. According to the OECD/EUROSTAT (2018) framework, seven of these innovations can be classified as process innovations, four as marketing (all related to packaging improvements), three as product innovations, and one as an organizational innovation. The organizational innovation pertains to adopting reverse logistics for the Ho.Re.Ca. channel. Ferrara and De Feo (2020) showed that, at least in Italy, reusing glass bottles is feasible only for customers within 100 km. This is consistent with data from the case study.

Regarding organizational innovations, special emphasis is placed on the sustainability training activities mentioned earlier. Product innovations also deserve attention, particularly those involving new wine product lines) and the Eco Wine Experience tours.

This wide range of green innovations was initially facilitated by participation in public calls offering financial aid for applied research projects. Here, the gatekeeper role of the local university emerges as a crucial enabling factor. However, developing green innovations is not without challenges, such as the inability to use impure methane produced during the compost fermentation process due to the lack of suitable small boilers. Additional financial resources were needed to further develop methane recovery for the firm's energy supply, but the firm's small size and limited budget prevented this. This finding aligns with Knoppen and Knight (2022), who noted that BSFs might face challenging financial periods, forcing them to prioritize financial outcomes over environmental impact, resulting in "light green" rather than "deep green" projects for survival.

Referring to the micro-foundations proposed by Khan et al. (2020) for companies implementing circular economy strategies, the findings showed that 10 out of 11 were present in the five analyzed phases. The only missing micro-foundation is related to 'Business model and governance', which includes redesigning business models or restructuring governance structures. For the focus company, a sustainable business model was adopted since its establishment, and the governance structure remained unchanged. It is noteworthy that multiple micro-foundations were found within the same phase, especially in Phases 1, 2, and 4, where collaboration with the local university occurred. Correspondingly, these phases involve the three clusters of DC proposed by Teece (2007): sensing, seizing, and reconfiguring.

In conclusion, collaboration with external partners embedded in the firm's ecosystem enables the development of green innovations through the development of DC. These innovations can be developed based on micro-foundations within a single cluster. However, involving all three DC clusters significantly enhances the quantity and quality of green innovations, as seen in Phases 1 and 2.

Finally, the adoption of sustainability assessment tools deserves special mention. Initially promoted by informal collaboration with the university (Phase 1), these tools led to early green innovations (e.g., adopting a lighter glass bottle). Subsequently, the firm incrementally adopted measurement tools, integrating LCA approaches based on product units (GHG per bottle) and land units (GHG per hectare) in Phase 2. An integrated approach using LCC and LCA was later adopted to evaluate the impact of green innovations in Phases 1 and 2. Unfortunately, the social impacts of the firm's sustainability strategies are not yet evaluated using life cycle-specific tools. The Eco Wine Experience tours are noteworthy for promoting sustainability awareness among visitors. The entrepreneur emphasized the importance of internal training to cultivate a sustainability-oriented culture among employees, stating, *"It [sustainability culture] is a pivotal point that I always specify to various trainees, students, or future workers on probation [... therefore,] it is a condition sine qua non to work within the firm, from seasonal grape pickers to full-time employees and external consultants."* This culture's real diffusion within the company is confirmed by the employee in charge of communication activities for Eco Wine Experience participants, who stated, *"Sustainability for the firm is the track that accompanies the production process. It's the driver of production choices; obviously, it has to be consistent with the need to consider also the firm's economic performance."*

The novelty of this contribution addresses several issues. Firstly, the paper offers a longitudinal analysis of the strategic path towards net zero implemented by M&SMEs. More specifically, the focus is on the case of a BSF, which was established to achieve a "sustainability advantage" rather than a traditional "competitive advantage." Secondly, to the best of our knowledge, this is the first attempt to investigate the interdependencies between DCs' micro-foundations and green innovations. Finally, the paper adopts a holistic approach, considering the relationship between the sampled BSF and its ecosystem.

To achieve the research objectives, a single longitudinal case study was conducted on a BSF established in 2003 in the wine sector in Central Italy. The company achieved net zero for agricultural activities in 2014 and implemented several green innovations, significantly reducing GHG emissions related to downstream activities

(wine production, bottling and packaging, and distribution). The benefits of the green innovations were measured using both LCA and LCC techniques. The local university, as a key actor in the firm's ecosystem, played a critical role in developing these green innovations.

From the collected data and the conducted analysis, several implications emerged for both scholars and practitioners. In terms of academic contribution, following Daddi et al. (2018), the DC framework was explored within the context of sustainability management. The case study was analyzed to verify the presence of the micro-foundations proposed by Khan et al. (2020), connected to the three DC clusters proposed by Teece (2007). These DC micro-foundations underpinned the green innovations developed by the BSF. Combining these theoretical approaches represents a significant advancement in business sustainability research, a field increasingly attracting scholars, particularly concerning BSFs (Knoppen & Knight, 2022). The paper also contributes to the DC debate, as the evolutionary mechanism of DC has not been systematically investigated (Zhang et al., 2020), requiring further discussion among scholars (Arndt et al., 2022). Our findings confirm that developing organizational capabilities allows M&SMEs to overcome constraints related to their small size and young age (Annunziata et al., 2018). Additionally, the paper provides empirical evidence for the debate on sustainability measurement tools (Kambanou & Sakao, 2020), offering a longitudinal perspective that monitors their incremental and integrated adoption (Mura et al., 2023).

When considering the practical implications of this paper, several advices emerge for practitioners and policymakers. Firstly, BSFs managers and entrepreneurs should carefully select the actors belonging to their ecosystem in order to create new DCs. This, in turn, promotes the development of green innovations, allowing the M&SMEs to advance toward net zero. Within the firm's ecosystem actors, local universities can provide valuable support through their three missions: lecturing, applied research, and the third mission (Abbate et al., 2021). Universities can also facilitate firms' participation in public calls for research project funding, which is crucial for M&SMEs that often lack the capacity to monitor these calls and apply for grants. Our findings also underscore the benefits of incrementally and jointly adopting environmental (e.g., LCA) and economic (e.g., LCC) sustainability measurement tools (Smith & Lal, 2022). Furthermore, public calls for financial support are essential for BSFs in adopting sustainability strategies, including developing and implementing green innovations (Benito-Hernández et al., 2023).

This paper has some research limitations. First of all, being based on a single longitudinal case study, generalizing the findings requires caution. Therefore, the study should be replicated in different geographical and industry contexts to account for unique factors. Additionally, the impact of sustainability orientation in the entrepreneur's business model and strategy, especially for BSFs, should not be underestimated. The investigated case study, where the entrepreneur embraced sustainability from the outset, represents an exceptional scenario. Future research should also examine small companies pursuing net zero strategies with varying degrees of sustainability orientation.

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