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Digitainability and open innovation: how they change innovation processes and strategies in the agrifood sector?

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By developing a conceptual analysis, this research explores the possibility of fostering a convergence between digitalization and sustainability, also named digitainability. This convergence is often seen as an opportunity to solve the various challenges the agrifood sector faces nowadays, especially those of feeding more people without deteriorating the environment and creating social divides and, at the same time, managing specific risks related to climate change, biodiversity loss, and hunger. The research describes how open innovation is becoming an imperative and explains the contribution of startups in the development of these new innovative initiatives. It also explains how sustainability considerations are closely linked to the development of servitization in the business context. Finally, it explores how these changes impact established companies, forcing them to develop ambidextrous innovation strategies to maintain and support their competitive advantage. In doing so, the paper illustrates some of the well-known effects of this ongoing change, while identifying the opportunities created and the challenges for which more research is still needed.

KEYWORDS

sustainability, digitalization, servitization, open innovation, ambidexterity, startups, digitainability, agrifood value chains

1 Introduction

The beginning of the use of digital technologies in the agrifood sector can be considered as having appeared with the creation of web pages (Bellon-Maurel et al., 2023). It started by presenting information, before considering the dematerialization of declarations, such as those related to fertilization practices, or developing new distribution channels, such as online platforms. Nowadays, digitalization is becoming an integral part of the development and evolution of the agrifood sector and agrifood value chains. These developments have been made possible due to two main important changes. The first one is the switch from a principle of product ownership to a logic of service access, which can be illustrated by the creation of platforms for sharing agricultural machinery or accessing local and cultural food. The second one relates to the establishment of startup ecosystems, characterized by a technological environment, a culture of innovation and risk, and an ability to push forward the limits of what already exists (Florez et al., 2022). At the same time, the agrifood sector is being asked to become more sustainable (UN—United Nations, 2015). Thus, the agrifood sector is looking for innovative solutions to deal with the multiple challenges that it has to manage, such as feeding a growing global population or dealing with climate change, resource depletion, or food waste

(Klerkx and Rose, 2020), while generating social impacts. Digitalization is as a way currently explores to meet meeting these sustainability requirements (FAO—Food and Agriculture Organization of the United Nations, 2021).

The emergence of digital technologies is fostered by the outburst of the startup phenomenon in every place in the world. Among these high-potential and high-growth companies, dedicated startups are seizing all kinds of opportunities offered by both digital technologies and sustainability objectives. They imagine new uses, develop new products, and even create new needs, by placing digitainability innovations—as a mix of digitalization and sustainability initiatives—at the core of their value propositions. By doing so, they are changing markets but also affecting how value chain stakeholders behave. As a result, startups are also influencing the way established companies embrace innovations. More specifically, they push for the development of ambidextrous innovative processes, where large companies rely on both internal and external innovations to engage in digitalization and open innovation initiatives (Piot-Lepetit and Florez, 2022).

This research relies on an extensive literature review and proposes a conceptual analysis, aiming at gaining insights on the ongoing changes occurring in the agrifood sector in regards to digitainability and open innovation. After describing what the sustainability and digitalization transformative trends imply for the agrifood sector, the paper explores how open innovation is contributing to the development and implementation of either digital sustainability, sustainable digitalization or digitainability. It also highlights the contribution of startups to these trends and the ambidextrous innovation process well-established companies developed.

2 Digitainability: bringing together the two powerful transformative trends of sustainability and digitalization

2.1 Sustainability as a driving trend of the undergoing changes of the agrifood sector

Sustainability is a very large concept integrating many aspects of the world and life. Indeed, sustainability does not only focus on the protection of the environment. It is also concerned with economic and social aspects (Ford and Despeisse, 2016). That is why sustainability is most frequently described by means of the well-known pillars of economic, environmental and social sustainability (UN—United Nations, 2015) and is considered as a process to improve human well-being, while contributing to the resilience of the economic, environmental, and social systems (Munasinghe, 2004).

However, sustainability is becoming a moral and economic imperative due to the intertwined connections between nature, society, and business activities (Del Rio Castro et al., 2021). Regarding the agrifood sector, sustainability is of real importance. Indeed, enabling the pursuit of current level of consumption, especially in developed economies, while allowing it elsewhere in the world, has been found incompatible with the required level of resource utilization (Lichtenthaler, 2021). In a context of growing population worldwide and increasing environmental concerns, sustainability covers a large set of issues, such as negative footprints, climate change, biodiversity loss, environmental pollution, inequality and social tensions. It is also concerned by changes in behaviors to deal

with all these issues (Del Rio Castro et al., 2021). At the same time, sustainability encompasses considerations related to scale and time aspects, as it is nowadays a worldwide concern with potential important impacts on future generations. Therefore, the concept of sustainability is a very complex one. In effect, the concept of sustainability is based on both a holistic perspective and a normative dimension. It encompasses both means and ends and can be seen as both a process and a destination (Johnston et al., 2007). That is why sustainability is so difficult to define. As most of the sustainability boundaries are not clear or explicit enough (Köhler et al., 2019), it is really difficult to evaluate or describe it without a context-based approach (Waas et al., 2011).

From a business perspective, Gartner (2021) proposes to define sustainability management as the focus on “products, services, the enterprise and supply chain,” while seeking to “optimally balance organizational performance and outcomes across economic, environmental, and social criteria over all time scale.” In this context, economic sustainability can be considered as the capacity of optimizing, in an efficient and responsible manner, the use of available resources, while maximizing profitability over time. Environmental sustainability is more focused on the natural ecosystems’ capacity to be preserved for future generations. Social sustainability is concerned with the society’s aspirations related to community well-being, equity, or justice but also trust and ethical behaviors (Osburg, 2017).

As sustainability is becoming an important concern worldwide, companies are embracing this new demand to develop their competitive advantage. Sustainability is considered by most of them as an opportunity to exceed competitors, in order to not only generate higher economic benefits, but also to develop environmental and social values (Parida and Wincent, 2019). Many firms have already established strategic initiatives aiming at exploring major opportunities for innovating through sustainability (Lichtenthaler, 2021). To enhance their sustainability outcomes, they are developing a triple bottom line approach, encompassing financial, environmental and social outcomes (Elkington, 2018). All the new initiatives developed by companies, which aim to achieve financial returns, while having a positive impact on both the environment and the society, are looking at the Sustainable Development Goals (UN—United Nations, 2015) to find guidance and directions. These initiatives foster different forms of innovations by focusing on either developing new products, services, processes, or business models, having potential positive impacts on their business activity (Pfitzer et al., 2013). Even though sustainability raises many challenges and uncertainties for individual entrepreneurs and companies, it represents a truly driving trend that needs to be embraced, so they can maintain and develop their competitiveness.

2.2 Servitization as a powerful sustainability strategy in the agrifood sector

The focus on sustainability is absolutely not a new thing for companies. However, it nowadays requires to undertake significant transformations to contribute to more of it worldwide (Parida and Wincent, 2019). That is why developing strategies and executing business development plans able to explore and exploit sustainability opportunities is becoming crucial to secure companies’ competitive advantage (Lahti et al., 2018). To embrace the sustainably challenge,

companies need to develop new ways of working and doing their business activities (Gupta et al., 2020).

One way to deploy sustainability initiatives is to move from a product-centric to a service-centric approach (Lenka et al., 2018a), meaning a transformation toward servitization (Vandermerwe and Lush, 1988). Servitization is a concept based on the service-dominant logic approach (Vargo and Lush, 2008), which emphasizes the importance of developing solutions for the customers and not just focusing on offering products (Lenka et al., 2018b). Thus, developing servitization requires companies and their stakeholders to switch from product-oriented business models toward either result- or outcome-oriented business models (Reim et al., 2015). A result-oriented business model business involves setting specific goals, measuring progress toward those goals, and adjusting strategies when needed. An outcome-oriented business model focuses on solutions to customers by developing more personalized and customers' specific offers. For instance, moving from unrenovable to renewable energy or allowing recycling and reuse can be implemented by means of measurable and verifiable goals to be achieved, so that progress toward these goals can be assessed. Improving maintenance commitments or providing on-demand services to customers develop a market culture that deeply changes the business models of previously product-oriented companies (Tukker, 2014) and call to develop a better knowledge of their partners and customers (Vargo and Lush, 2008).

The servitization transformational challenges, resulting of either goal setting or service provision, force practitioners, managers, entrepreneurs, or corporate leaders to rethink their organizational priorities and reorganize their business operations (Parida and Wincent, 2019). Indeed, servitization is not just a strategy of post-sales involvement that can become a source of additional revenues. It rather means that companies develop more integrated commercial offers (Reim et al., 2017), based on the provision of a mix of products and services answering to specific customer demands regarding not only economic aspects, but also environmental and social ones (Tukker, 2015). These new offers have greater potential for value creation, since they become able to fulfill unique customer needs. That is to personalize commercial offers by focusing more on the functionality of the solutions offered rather than on the commodities sold. Consequently, it implies that companies invest in developing new competencies and capabilities to enhance their integrated product-service offers (Parida and Wincent, 2019). If these transformations are well managed within and outside companies, especially with their network partners, companies can gain long-term competitiveness, mainly due to a higher customization of their offers. In doing so, companies are expected to become able to meet the always evolving needs of their customers (Parida and Wincent, 2019) or to design and develop new roles in traditional value chains (Reim et al., 2018).

Consequently, servitization involves that producers take full responsibility of their offers. It implies a complete redefinition of customer-supplier relationships. It thus implies a new way for companies and their stakeholders to engage with customers through the development of more fidelity and trust. Doing so is really challenging. Indeed, designing and selling product-service combinations are not an easy task. It needs an alignment of all the stakeholders' interests, a change of mindset of all the participants, and the management of the behavior of less careful customers in order to avoid any rebound effect (Ferreira et al., 2013). Not all companies have the necessary capabilities and skills to implement successfully

servitization. Main challenges most often result from immature service business models, misaligned internal processes, or underdeveloped service delivery networks. That is why many companies are struggling to develop and deliver servitization solutions effectively. To develop servitization, exploring digitalization capabilities is becoming a trend, companies are entering into.

2.3 Digitalization as a transformative trend in the agrifood sector

Digitalization is the result of the explosion of computation power and data-driven solutions (WEF—World Economic Forum, 2019) that has pushed forward the possibility to access new information and foster knowledge creation and sharing. Nowadays, digital technologies are developing across all segments of the economy and society, due to better connectivity, new capabilities to collect huge amount of data, and increased possibilities for generating, processing, analyzing, using, and transferring data and all kinds of information (Katz and Koutroumpis, 2013). As data are processed by intelligent algorithms and increasing computational capacities (Duan et al., 2019), they provide unprecedented opportunities to explore, understand, predict, optimize, and innovate (Del Rio Castro et al., 2021). Besides, digitalization refers to the social transformation triggered by the mass adoption and use of digital technologies. It refers to the changes in habits and ways of doing business due to the development of highly interconnected and more complex networks allowed by the development of digital technologies (Letouze and Pentland, 2018).

Digitalization has been at the top of the strategic agenda of numerous companies that are transforming by means of new opportunities offered by digital solutions, advanced data analytics, and artificial intelligence applications (Boldosova and Luoto, 2019). Digitalization helps companies optimize their business operations, while enabling them to create new commercial offers for their customers or developing new business activities (Haefner et al., 2021). For instance, numerous digital projects explore the potential of digitalization to enhance transparency, assess ESG—Economic, Social and Governance—performance (Kiron and Unruh, 2018), foster discovery (WEF—World Economic Forum, 2020), improve resource efficiency, generate evidence-based decision-making and prediction (GeSI—Global e-Sustainability Initiative, 2019), facilitate financial access (Tchamyu et al., 2019), and even reduce inequality (Asongu and Odhiambo, 2019), among others. However, digitalization also faces strong controversies and uncertainties, especially about the relationship between digitalization and sustainability (Saunila et al., 2019), the creation of power-asymmetries, or the generation of digital divides (ITU—International Telecommunication Union, 2017). Indeed, digitalization can have unintended environmental or social effects (Scholz et al., 2018), like the disposal of raw materials affecting biodiversity (WEF—World Economic Forum, 2020), the emission of pollutants, an increasing use of energy and water (ITU—International Telecommunication Union, 2017), and even health issues (WEF—World Economic Forum, 2020), implying that digitalization can create unsustainable outcomes. At the same time, technological impacts, derived from the digitalization process, are expected to be remarkable and have started to impact everyone in the world at an unprecedented pace (Bernstein and Raman, 2015).

Even though, no consensus has been achieved yet regarding the definition of digitalization, it can be defined, from a business perspective, as “*the use of digital technologies to change a business model and provide new revenue and value-producing opportunities*” (Gartner, 2019). As companies are becoming more digitalized, their ability to create data-driven activities increases. By allowing their products to collect data or be connected, more and more data are made available and can be used to improve analytics and generate new information and knowledge. That is why it becomes really important for companies to be aware of the consequences and impacts of digitalization, either positive or negative, when entering this trend (Porter and Heppelman, 2014). Security, privacy and digital ethics are aspects that need to be considered, since they imply new specific requirements that have to be taken into account when they develop innovative initiatives for the digital business environment. For instance, consumer privacy and transparent use of data are nowadays becoming a prerequisite for entering new markets or developing new commercial offers.

Even though the economic and social impacts of digitalization are under the fire of controversy, it must be acknowledged that digitalization has already started transforming many business domains and is a source of great opportunities to create and capture value (Parida and Wincenc, 2019). However, only a few companies are really able to truly benefit from the opportunities of digitalization, due to the transformational aspects it involves (Porter and Heppelman, 2014). Indeed, some of them still lack the tools, processes, knowledge, skills, or competences to generate useful information from data. But, at the same time, not considering digitalization can have a huge impact on the competitiveness and efficiency of businesses. For instance, working with systems that do not communicate to each other, leading to the replication of data collection or generating process bottlenecks, can create unnecessary delays (Parida and Wincenc, 2019), which in turn can reduce the competitiveness of companies due to lower reaction time than their main competitors. Although digitalization can be, at the very beginning, a source of important challenges for entrepreneurs and all types of companies (Malmström and Wincenc, 2018), it is also a genuine transformative trend. It may have important impacts on the future of companies' competitive advantage. That is why more and more companies have integrated it in their innovation strategies.

2.4 Digitainability: innovating by bringing together digitalization and sustainability

Digitainability is a concept created by Gupta et al. (2020) as the merging of digitalization and sustainability. Gupta et al. (2020) consider digitalization as a source of unique capacities that can significantly support robust societal and environmental disruption and describe digitainability as the cross fertilization between the digitalization and sustainability strategies of companies. Using an innovation-based theoretical perspective, Lichtenthaler (2021) introduces a conceptual framework allowing the positioning of companies depending on their level of digitalization and sustainability development and then identifies the best innovation trajectory they should embrace to capture the benefits of both the sustainability and digitalization trends.

In his conceptual framework, Lichtenthaler (2021) identifies four types of companies: (1) those that have established businesses with

limited levels of either digitalization and sustainability. The core of their business model does not specifically address, either separately or jointly, the strategies of digitalization and sustainability; (2) those with established sustainability initiatives, but with a low level of digitalization. Sustainability is at the core of their business model, with some initiatives specifically focusing on providing solutions to address the Sustainable Development Goals (UN—United Nations, 2015); (3) those involved in digitalization initiatives, with a low focus on sustainability. The core business of these companies is mainly related to digital solutions and information technologies; and lastly (4) companies where digitainability opportunities are explored, with a core business aiming at leveraging the unutilized potential of high levels of digitalization in combination with high levels of sustainability (Gupta et al., 2020).

Depending on their initial position, each type of companies faces different challenges and opportunities toward innovating in both the sustainability and digitalization trends and thus has to develop very specific strategies (Lichtenthaler, 2021). Indeed, for companies with established business models that have not really explored the potentialities of either sustainability or digitalization in their core business, a way to innovate is to investigate new initiatives and opportunities in one or another of the two trends or fostering the combination of both. For instance, starting new projects thought and developed, from the very beginning, for enhancing sustainability by means of specific digital tools and solutions can create new sources of value creation. Some digital tools aiming at increasing the efficiency and effectiveness of business activities are also designed to help companies improve their environmental and social results and can be considered to develop new innovation strategies. For companies with established sustainability initiatives, a digitalization strategic focus could be used to transform, extend, or complement their sustainability initiatives. By developing digital sustainability innovation initiatives, these companies can expand their activities in a way that meets the specific needs and expectations of their customers, through more personalized offers. For instance, the use of specific digital solutions, such as sensors, QR codes or blockchain can really support more transparency and communication on the sustainability activities of these companies. For companies involved in digitalization initiatives, an important strategy to strengthen their competitiveness can be to focus on enabling sustainable digitalization initiatives. That means finding ways to adapt or extend their digitalization programs or solutions, so they can contribute to more sustainability outcomes. For instance, intelligent digital solutions, based on big data analysis or artificial intelligence algorithms, can be developed and used for optimizing energy or water consumption, but also for better connecting producers and consumers through more information sharing. The main advantage that can be expected here is a reduction of the environmental impacts of digital technologies and solutions, while at the same time improving social interactions. Finally, for companies where digitainability opportunities are already explored, meaning that they are developing initiatives that consider both sustainability and digitalization, the main challenge they face with their innovation strategy is to find the right balanced between both trends. Indeed, balancing both trends adequately is a way to ensure that they are able to generate financial returns, while at the same time creating sustainable outcomes. When well-managed, this specific strategic orientation can become the source of high level of value creation and capture. However, if mismanaged, companies

cannot really be described as having a digitainability strategy, as one trend dominates the other, and thus, they have to face the same strategic challenges than the two previous groups, which either focus on sustainable digitalization or digital sustainability.

3 Open innovation: developing innovative initiatives in partnership

3.1 Startups as powerful open innovation organizations

Startups play a key role in the innovation process (Spender et al., 2017), as they focus on developing new ideas that, when they are carried out and launched on the market, can transform them into economically sustainable companies (Blank, 2013). Startups can be defined as very small or small enterprises working in a dynamic and agile environment, where the possibility of developing breakthroughs in conventional innovation processes or disruptive products and services that impact value chains and dominant market positions is made possible (Piot-Lepetit and Florez, 2022). Most often, their value propositions are driven by human motivations, such as the development of socially responsible behaviors, the provision of products and/or services aiming at achieving sustainability goals, or the improvement of the quality of life (Santos et al., 2021). However, for startups to develop their innovations and become scalable, they need a specific supportive environment that can be found in open innovation initiatives and partnerships.

Open innovation (OI) can be described either as a partnership process between new enterprises, as startups, and science-based innovation entities, such as universities or research institutions (Van Beers et al., 2008) or as the joint development between market-based partners, through collaboration with suppliers, customers, consumers, and even competitors (Hensen and Dong, 2020). Thus, developing networks is the core of the success of OI processes. It allows OI to create channels enhancing and fostering the acquisition of resources, such as knowledge or funding, but also facilitating the introduction of new products on the market (Lundberg, 2013). Working in networks is not without consequences, as networks mutually shape each participant's contribution and offer. Indeed, all main decisions are becoming intertwined as all the participants of the network contribute to defining the requirements for new products or services, producing new technological tools and solutions, which as a consequence modify the relationships among the network's participants (La Rocca and Snehota, 2014). At the same time, socio-economic environmental factors affect the strength and direction of networks (Spender et al., 2017). Depending of the structure, institutions, and organizational relationships within, around, and outside the network, IO processes and initiatives do not have the same scope, magnitude, and impact on the different participating parties.

For startups, OI implies an involvement in developing relationships with a large range of actors and connecting to external initiatives. For instance, the creation of venture capital funds is considered as partnerships between two types of partners: the startup managers and the investor advisors. It helps startups raise funds for innovative business models and develop their networks in several dimensions, related either to financial, commercial, or technology-based aspects. The launch of sectoral incubators or accelerators is another possibility to help startups develop, especially by supporting

the emergence of their innovative projects and providing services, such as training or office spaces (Spender et al., 2017). The establishment of startup studios focuses on the simultaneous launch of several projects, while providing many strategic and operational skills, such as business, legal, design, prototyping, development... Both the environment they are in and the mentoring they have access to allow startups to gain in agility but also accelerate the time to market of their projects by boosting their growth and facilitating their access to funding and the implementation of their commercial and operational strategies. The participation in private or public acceleration programs, most often around a specific theme, allows startups to develop their strategic intelligence, together with their access to financial and human resources. The contribution of innovation lab is very different. It covers services such as foresight (anticipation of the future in 5–10 years), agility and incubation, open innovation, facilitation of collaborations... Among the other OI initiatives, hackathons, reverse pitches, competitions, and other calls for projects facilitate the sourcing of external ideas and become research-action devices of the innovation ecosystem, where participants are not simply end-users but become actors and collaborators. It is particularly true for farmers and consumers, when they are placed at the center of the innovation process (Piot-Lepetit and Florez, 2022). These different approaches of OI are rarely exclusive, as some of them can be implemented in parallel, creating what is often called startup ecosystems. Those ecosystems are built upon the interconnections between different groups of organizations, including new ventures, universities, and public administrations, with startups and aim at supporting and fostering the success of these innovative organizations.

Among the most important systems that need to interact with startups, Spender et al. (2017) identify the financial system, the knowledge creation and diffusion system, and the governance system. They highlight not only their importance on the functioning and performance of startup ecosystems, but also their contribution to the facilitation of formal and informal relationships among various types of actors. More specifically, developing collaboration with different external innovation partners allows startups increase their exposure to “new ideas, gain access to a broader range of market information and complementary resources, benefit from the co-development of new products, or win new markets” (Piot-Lepetit and Florez, 2022). Indeed, research shows that the capability of startups to develop a large network, create a central position, and balance long- and short-term relationships with their network's partners has a very positive impact on their innovativeness. At the same time, the strength and complexity of the relationships within the network can have either be positive or negative, depending on the degree of uncertainty of the business environment there are in (Spender et al., 2017). Thus, the network, they are developing IO with, may have a very important impact on the innovation performance of startups (Wang and Fang, 2012), as it is able to foster or hinder their innovative capabilities.

In the face of the development of these OI initiatives, larger companies are adopting different approaches, such as corporate venture capital, internal incubators, strategic alliances, joint ventures with startups, new ventures, new spinoffs, or spinouts. However, the innovativeness, creativity, and growth of startups, as well as their ability to launch innovative-disruptive solutions, have been a real challenge for larger and well-established companies and have created the need to develop more agile and rapid means to engage with startups (Weiblen and Chesbrough, 2015). Indeed, larger companies, which henceforth

face an increased competition coming from startups, are forced, in one way or another, to take new risks, launch new initiatives, and develop a strategy of open innovation. These changes involve important internal transformations, related to either the corporate culture, working environment, or organizational management. It also requires increased capabilities to continuously digitize their activities in order to sustain their resilience and support the development of new activities. At the same time, companies need to improve their positioning on their current markets, while entering the new markets created by the unfolding of digital technologies and sustainability. This is most often done by either integrating promising startups, creating them, or co-developing innovations with them. However, whatever the options chosen, two main challenges remain. The first one is a financial and economic issue concerning the return on investment of OI initiatives, as it can take several years for startups or new activities to become profitable. The second challenge deals with the cultural and organizational transformation needed to move from a conventional innovation process to OI. The conventional innovation process mostly relies on specific research and development (R&D) programs, focusing on time-limited projects or supporting corporate incubation. At the opposite, OI initiatives require a continuous and more integrated approach of innovation (Piot-Lepetit and Florez, 2022).

3.2 Open innovation and organizational ambidexterity

As many well-established companies face an increased competition from innovative startups (Svahn et al., 2017), they need to develop their ability to offer products in a new way, invent new products, and create or participate to new markets, so they can avoid being overtaken by the competition. Thus, companies are reconsidering their innovation strategies and investigating open innovation (OI) initiatives (Piot-Lepetit and Florez, 2022). This requires accelerating either investments to gain expertise, the acquisition of promising startups, or the display of innovations in their value proposition focusing on either sustainability or digitalization. Consequently, innovation, which was previously based on products and developed internally, now emerges from multiple horizons and leads corporations to move from inside-out innovation processes to outside-in OI approaches, allowing them to be confronted with new ideas and, at the time, fostering their ability to renew (Weiblen and Chesbrough, 2015).

The strategic responses developed by established companies to preserve or expand their market shares, while facing unexpected innovations coming from startups, are varied. While a few companies choose to ignore the challenge and continue to invest in their business activities as usual, some companies embrace the new competition and try to adapt. Others not only adapt to the new competitive environment but also counter attack by developing new disruptive innovations (Alpkan and Gemini, 2016). However, most companies implement their new innovation strategy in two main directions. On the one hand, they pursue internal innovations within the company, the inside-out option, in the form of R&D projects, corporate incubators, or startup platforms (Weiblen and Chesbrough, 2015). On the other hand, they develop outside-in programs by sponsoring or partnering with startups through OI, or by sharing knowledge inputs and resources with external partners (Du et al., 2014). By doing so, they are developing an environment where innovations derive from both internal and external sources. From an organizational

perspective, they also transform themselves for developing more agility, so they can detect and seize market opportunities with speed and surprise. The transformative programs, they are carried out, aim to create a real culture of innovation, move toward a less hierarchical model with more horizontal structures helping promote collaborative work, develop multidisciplinary teams, and encourage individual initiatives. The main consequence of these changes is that their innovation processes are becoming more and more ambidextrous (Lewin et al., 2011). Indeed, companies try to stay aligned and efficient, while becoming adaptable and flexible to future changes (Tushman and O'Reilly, 1996). Their long-term success depends on their ability to exploit their current capabilities, while simultaneously exploring new competencies, products, technologies, and markets (Levinthal and March, 1993). Therefore, both inside-out and outside-out innovation processes are important for large companies. They allow them to achieve higher internal performance and develop both internal and external value-creating mechanisms, with as a constraint, the need to find an appropriate balance between their internal and external innovation components.

3.3 Some opportunities and challenges of open innovations fostering digitainability in the agrifood sector

The use of digital technologies is considered as a very relevant solution to empower the agrifood sector and meet sustainability objectives. It has the ability to enhance productivity and resilience, while reducing environmental and social impacts (FAO—Food and Agriculture Organization of the United Nations, 2020). By consequences, the way food is produced, processed, transported, distributed, and consumed is changing through the development and implementation of digital technologies and solutions as well as the request of meeting the sustainable development goals (SDGs) by 2030 (UN—United Nations, 2015). More specifically, digital technologies allow the collection, analysis, and utilization of data by means of sensors or imagery, advanced analytics or smart algorithms, while digital solutions focus more on providing software or platforms integrating different but complementary digital technologies. The SDGs are influencing the way current practices need to be thought about in order to develop more responsible approaches in value chains, such as reducing chemicals and food waste through changes in behaviors. Thus, digitalization and sustainability do not only affect on-farms productive processes but also changes entire agrifood value chains (Klerkx et al., 2019). Indeed, stakeholders of value chains, focusing on providing more traceability and information sharing, not only contribute to the development of new business models but also develop trust with their customers (Porter and Heppelman, 2014).

The development and deployment of these initiatives can come out from either micro enterprises, innovative startups, small and medium sized enterprises (SMEs) and of course large companies (Birner et al., 2020). However, startups can be looked at as key actors of digitalization (Kergroach, 2020) in the agrifood sector. More specifically, Florez et al. (2022) found that the digital technologies provided by startups are most often using artificial intelligence (AI), internet of things (IoT), big data, blockchain, cloud computing, robots and e-commerce. But, with a dominance of IoT and e-commerce in the production and retail/consumption segments of agrifood chains, while AI is deployed in all segments. At the same time, new startups

are more and more directing the development of their digital technologies and solutions in a way that supports sustainability initiatives (Liguori and Bendickson, 2020). Most often, their initiatives aim at achieving higher levels of productivity through resource efficiency, promoting local culture and products, or developing access to banking, insurance, and financial services in order to support the economic dimension of sustainability. Indeed, some startups focus on the environmental dimension of sustainability by means of more efficient use of natural resources, optimized application of chemicals, reduction of food waste, increased recycling and reuse, and improved resilience and adaptive capacities to climate hazards. Other startups provide solutions for social outcomes such as improving transparency, changing in consumption, production, and distribution behaviors, reducing food losses and wastes (Florez et al., 2022), fostering inclusiveness, or developing the sharing economy (Fauzi and Sheng, 2020). In doing so, startups are becoming important providers of inclusive and sustainable innovations using digital technologies. They are finding ways to create and capture value in very specific markets where digitainability initiatives are welcome, but also in every segment of agrifood value chains, where new digitainability solutions are expected to resolve complex sustainable issues. However, these startups also face important challenges. Most often, they lack of tangible and intangible resources (Wymer and Regan, 2005), involving very often financial and human issues. These issues hinder their possibilities of developing and supporting their new innovation processes. These limitations most often result from both their newness and smallness (Bogers, 2011). That is why to overcome these constraints, startups are adopting open innovation practices. Meaning that they are partnering with different stakeholders and integrated networks with the aim of supporting their development and growth.

At the same time, well-established companies confront the emergence of these new competitors by moving their value proposition toward more digitalization and sustainability innovation. This implies modifying their market positions and creating new services, sales models, or distribution and communication channels for all the participants of value chains (Piot-Lepetit and Florez, 2022). Consequently, innovating, by means of the incorporation of digital services in products, the development of new services, or the generation of initiatives fostering sustainability, is becoming strategic for many well-established companies, as they face an increased competition from innovative startups (Svahn et al., 2017). Thus, it strongly reinforces the importance of developing new innovation strategies helping them to embrace the ongoing digitainability transformation, as an important source of competitive advantage. However, it involves managing an ambidexterity innovation process and implementing the undergoing necessary organizational changes it requires, which remain an important challenge not to be overlooked.

4 Conclusion

The research developed a conceptual analysis examining the concept of digitainability, as the convergence amidst digitalization and sustainability, and the role of open innovation initiatives to support digitainability innovations in the agrifood sector. More specifically, the exploration of the literature shows that the digitainability concept is closely related to the aspects of servitization companies are trying to

develop to meet customers' specific needs. It also shows that digitainability is more easily developed by startups. Due to their smallness and innovativeness, they are more prone to take risks on new ideas and value propositions. Established companies are challenged by this new competition, implying a transformation of their innovation strategies toward open innovation and as a consequence their innovation processes that are becoming more and more ambidextrous, as they try to develop both inside-out and outside-in innovation initiatives. Besides, those changes do not only affect companies, whatever their size, they also have an impact on their overall value chains and network arrangements.

Concerning the agrifood sector, digital solutions have been identified as a potential answer to sustainability issues by many international organizations and governments. All over the world, initiatives are developed to create powerful and creative startup ecosystems able to explore the solutions that are needed to support and develop sustainability solutions relying on digital technologies. The analysis of the literature, conducted in this research, shows that this is not without impact on the way business activities are designed and developed, relationships among agrifood value chains' stakeholders are organized, and companies' innovation strategies are designed and implemented. However, digitainability expectations and open innovation initiatives are currently reconfiguring agrifood chains in ways that are not well explored yet. Both concepts are two important topics for which the current conceptual analysis provides new insights, but where additional research is still needed to gain a better understanding on the ongoing transformations digitainability and open innovation are generating in the agrifood sector.

Author contributions

IP-L: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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