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Laying the foundation: Value capture in collaborative, digitally-enabled business models for sustainability

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ABSTRACT

Firms increasingly adopt digital technologies to generate environmental benefits. To maximize the impact of these technologies, they must be embedded in business models that allow the partners involved to capture economic value by collaboratively generating environmental benefits. This study examines nine cases within a European agri-food project using different value capture models to deploy digital technologies with the goal to make farming practices environmentally sustainable. We analyze and compare these cases to identify the different value capture models, the factors leading to their choice, and which implications the choice of the initial value capture model has for the potential to add more participants to the business model. Based on our findings, we develop a typology of value capture models for digitally-enabled business models for sustainability and discuss the link between value capture models and impact scaling. Our findings advance research on digitally-enabled business models for sustainability and inform practitioners of the implications tied to the choice of different value capture models.

1. Introduction

Research shows that digital technologies can be critical for the development of business models for sustainability (Broccardo et al., 2023; Ciulli et al., 2022; Parida et al., 2019). Business models for sustainability are business models that "create significant positive and/or significantly reduced negative impacts for the environment and/or society" (Bocken et al., 2014, p. 44). For instance, digital technologies such as sensors, radio-frequency identification (RFID), or the Internet of Things (IoT) enable firms to monitor their processes and reduce resource use, making their activities more environmentally sustainable and cost-efficient. Additionally, these technologies help firms meet growing customer demand for sustainable supply chains, thereby creating new revenue opportunities (Broccardo et al., 2023). Hence, digital technologies create new opportunities to generate economic value (e.g., cost savings, new revenue streams) through the creation of environmental benefits (Broccardo et al., 2023; Caputo et al., 2021; Evans et al., 2017; Ghisellini et al., 2016).

In many sectors, firms partner to collaboratively establish business models that leverage digital technologies to achieve sustainability-related goals, i.e., *digitally-enabled business models for sustainability* (DBMfS). Collaboration is often essential for creating environmental value through the use of digital technologies. For instance, when retailers aim to inform customers about their supply chain's sustainability, they need to collaborate with producers, who have to adopt smart tracking tools to provide relevant sustainability-related data on their production processes. Collaboration can also help to overcome the challenge of initial technology investment. The deployment of digital technologies often requires substantial financial investments. Smaller firms, in particular, may struggle with the initial costs of acquiring digital technologies, as well as the expenses related to installation, operation, and data management (Groot et al., 2019). The expected financial returns deriving from digitalization and environmental value creation, however, can encourage partners to find collaborative solutions. For instance, retailers can support producers in making investments or multiple producers may join forces to make investments.

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This, however, inevitably raises questions of value capture, which refers to how the investments, costs, and revenues from value creation are agreed upon and distributed among the participating partners (Chesbrough et al., 2018; Dyer et al., 2018).

The literature on collaborative business modeling for sustainability has acknowledged that discussions about value capture can lead to tensions between partners (Pedersen et al., 2021). Yet, it has not paid much attention to the question of which *value capture models* partners adopt. This is somewhat surprising, given the centrality of ensuring partners' value capture for sustaining collaboration and making it attractive for more partners to join the business model. While agreements about knowledge sharing or interest alignment are also important, how partners agree to split investments and returns on investment, i.e., the value capture model, may be the decisive factor for ultimately being able to realize the business model. Not least, the attractiveness of the value capture model should also determine the incentives for other stakeholders to join or replicate the business model, which is important to scale the impact of DBMfS, i.e., to create environmental value on larger scale. Therefore, this study aims to answer the following research questions: *What different value capture models do partners adopt when establishing a DBMfS and why? What implications do the value capture models selected have on the options to scale the DBMfS?*

Our focus is on the initial value capture model as agreed between the first partners involved in setting up a DBMfS. The European agri-food sector is our setting to explore these questions. The agri-food sector is an ideal setting for studying DBMfS, as many digital technologies, such as decision support systems, smart farming and traceability solutions are currently being deployed to create environmental value (Uztürk and Büyüközkan, 2024). In Europe in particular, the EU institutions support the digital transformation of the agri-food sector to attain sustainability-related goals (EU, 2023; MacPherson et al., 2022). We adopted a multiple case study approach (Yin, 2018), building upon 9 pilot projects that were part of a three-year European project, to study the value capture models these pilot projects adopted at the start, the factors driving this choice, and the implications of choosing a particular value capture model for attracting other partners to the DBMfS, in order to scale impact.

The study makes the following contributions to the literature on DBMfS (Adelekan and Sharmina, 2024; Bencsik et al., 2023; Böttcher et al., 2024) and to research on collaborative DBMfS (Ordonez-Ponce et al., 2021; Pedersen et al., 2021):

First, we provide an in-depth characterization of the different value capture models partners can adopt, which introduces nuance to the oftentimes generic concept of 'value capture'. It is widely acknowledged that, while economic value is an inherent part of any business model for sustainability, economic value capture and environmental value creation are often difficult to reconcile (Davies and Chambers, 2018; van Bommel, 2018). Our study provides a new perspective to this discussion by showing that efforts to reconcile these two dimensions entail the agreement on a value capture model. We show, in particular, that partners may select four different value capture models to capture economic value by collaboratively generating environmental benefits. These models reflect different relationships between the partners. Moreover, we shed light on the factors influencing the selection, and offer an empirical framework outlining the process that lead partners to determine a suitable value capture model. Therefore, our study provides empirical insights into the important step of partners agreeing on the distribution of investments and returns when setting up a novel DBMfS. Our theoretical contribution extends beyond research on producer-retailer collaborations, as collaborations that leverage digital technologies for sustainability are becoming increasingly important in contexts such as the circular economy or smart cities. In these settings, actors frequently encounter financing challenges for initial technology investments, and must find models to capture economic value by collaboratively generating environmental benefits (Bencsik et al., 2023; Trevisan et al., 2023).

Second, our findings offer insights that advance the understanding of impact scaling of DBMfS, and BMfS in general (e.g., Derks et al., 2022). While it is known that impact scaling is challenging, the influence of choices related to value capture is poorly understood. We suggest that, to understand the potential for scaling the impact of DBMfS, it is critical to gain deeper insights into value capture models adopted and identify those that allow partners to continuously capture economic benefits. Based on our findings, we outline the distinct opportunities and challenges associated with different value capture models and propose avenues for future research. Here, we especially point to trade-offs that may arise during impact scaling. Thus, our study also answers to calls that the interplay of economic and environmental sustainability in digitally-enabled BMs remains poorly understood (Bencsik et al., 2023).

Our findings are practically relevant for managers and entrepreneurs who aim to develop DBMfS, as we provide a typology that can support them in the choice of a suitable value capture model. Moreover, they raise awareness around the factors that may affect their decision and attune practitioners to the implications of different value capture models for scaling the impact of their DBMfS.

The remainder of this work is structured as follows. In Section 2, we detail the current knowledge on DBMfS and value capture. In Section 3, we describe the research design employed for our work and provide insights on the data used to support our research. In Section 4, we describe and discuss the identified value capture models and illustrate them with examples. In Section 5, we discuss the outcomes of our work and devise contributions to research and practice. In Section 6 we conclude our work.

2. Theoretical background

2.1. Digitally-enabled business models for sustainability

At its core, a business model is a description of how an organization creates and captures value (Baden-Fuller and Mangematin, 2013; Teece, 2010; Zott et al., 2011). Business models have been ascribed particular importance in the context of bringing novel technologies to the market. For instance, Chesbrough (2007, p. 12) posits that "[a] better business model often will beat a better idea or technology". In order to be successful on the market and allow an organization to create and capture value, a novel technology needs to be embedded in a viable business model (Chesbrough and Rosenbloom, 2002). The use of digital technologies can also enable completely new business models which, for instance, allow manufacturers or producers (traditionally focused on selling a tangible product) to sell data-related services to retailers or end users (e.g., Aas et al., 2020; Hanelt et al., 2015). Against this background, an increasing number of studies have started to investigate "digitally-enabled business models", i.e., business models that leverage digital technologies for value creation and capture (e.g., Bencsik et al., 2023; Remane et al., 2017; Trischler and Li-Ying, 2023).

Rising concerns about sustainability have fueled interest in the question of whether and how digitally-enabled business models can create environmental value. This question has brought scholars to link research on digitally-enabled business models to another body of work, which focuses on 'sustainable business models' (e.g., Bocken and Geradts, 2020; Lüdeke-Freund et al., 2018; Oskam et al., 2021) or 'business models for sustainability' (e.g., Pedersen et al., 2021; Roome and Louche, 2016; Schaltegger et al., 2016). These concepts, usually employed interchangeably (Ciulli et al., 2022), denote business models that "create significant positive and/or significantly reduced negative impacts for the environment and/or society" (Bocken et al., 2014, p. 44).

The combination of these two streams has given rise to the literature on '*digitally-enabled business models for sustainability*' (DBMfS), which posits that digitally-enabled business models can indeed be key to leveraging digital technologies for tackling environmental issues. For instance, DBMfS may allow to leverage digital platforms to reduce food waste (Amaral and Orsato, 2022), and IoT solutions to foster environmental sustainability in a smart city context (Bencsik et al., 2023).

Both the literature on digitally-enabled business models and the literature on sustainable business models emphasize the necessity of collaboration but have slightly different perspectives on it. For instance, the literature on digital business models shows that leveraging digital technologies for value creation, delivery, and capture often hinges on the collaboration with other stakeholders (Miehé et al., 2023). It emphasizes interoperability and resource exchange between stakeholders, for instance that smart solutions and data-as-a-service models must be designed to interact with the solutions offered by other manufacturers, used by customers, delivered by distributors, maintained by different service partners, and operated by third parties (Adelekan and Sharmina, 2024; Kohtamäki et al., 2019) and that collaboration helps to realize digital business models by combining capabilities, exchanging resources, and sharing the burden of necessary investments (De Man and Luvison, 2019; Laudien et al., 2024). This literature discusses that collaboration between partners may be hampered by conflicts about technical availability, expected performance or the degree of use, which can be alleviated by risk-reward sharing or through performance-based incentives as part of contractual agreements (Linde et al., 2021). The literature on digital business models thus looks at collaboration from a rather transactional point of view. It has paid less attention to the relational dynamics between partners.

The literature on sustainable business models, on the other hand, looks at collaboration from a broader perspective, viewing value as encompassing more than economic benefits. For instance, this literature has studied what value means to the different stakeholders involved (Oskam et al., 2021) and how stakeholders decide to allocate responsibilities to avoid power imbalances or conflicts (Ciccullo et al., 2022). This literature thus has focused on the relational dynamics of different stakeholders coming together. For instance, researchers in this stream have frequently considered 'tensions' that occur in collaborative business modeling (Oskam et al., 2021; Rey-Garcia et al., 2021; Tschiedel et al., 2024). One source of such tensions is disputes about value capture, such as around technology investments, asset management, or data access (Adelekan and Sharmina, 2024). The literature on sustainable business models acknowledges that it is essential that each stakeholder captures a portion of value for the continuation of the collaborative efforts. Yet, this literature has not yet paid much attention to the question of how stakeholders align on (monetary) value capture, also because the focus of this literature lies relatively more on the realization of environmental benefits.

2.2. Value capture in digitally-enabled business models for sustainability and its relevance for impact scaling

Value capture refers to how the investment, costs, and returns from value creation are agreed upon and distributed among participating stakeholders such as providers, customers, and partners (Chesbrough et al., 2018; Dyer et al., 2018). Agreements on value capture are part of the very early phases of designing a business model. In these phases, it is key to incentivize each party to participate (Oskam et al., 2021; Stål et al., 2022). Failing to determine how value captured can be distributed can lead to significant tensions, and may complicate business model development (Stål et al., 2022). For example, Stål et al. (2022) show that when designing business models to support mobility service hubs, partners may be reluctant to invest if not coupled with clear outcomes in terms of value capture. It is thus fair to say that the initial value capture model that partners agree upon is a decisive factor in further developing the business model. While agreements about knowledge sharing, interest alignment, or competition between stakeholders are also important (DiVito et al., 2021), how partners agree to split initial investments and returns on investment, i.e., the *value capture model*, may be the single most important factor in ultimately being able to realize the business model. Thus, in our study, we focus on the investment and returns on investment that partners agree upon, as outlined in their initial agreement.

What is interesting herein is that the same digital product or service can be combined with different value capture models. For instance, partners can agree to evenly split investments and return on investments or not. This makes it interesting to consider (i) why a certain value capture model is chosen (or not), and (ii) what this implies for the options to scale the impact of the DBMfS. The choice of the value capture model most likely affects the extent to which partners' interests are prioritized or marginalized in the use of the DBMfS, which, in turn, is likely to impact the incentives for other stakeholders to join or replicate the business model. Having other stakeholders join or replicate the business model is essential for achieving maximum environmental benefits.

A relevant stream of literature has underscored the importance of scaling impact in initiatives with sustainability-related objectives. Scholars have also emphasized that digital technologies can facilitate the scaling of environmental value (Gregori and Holzmann, 2020). Various approaches to scaling impact have been identified (e.g., Bauwens et al., 2020; Dees et al., 2004; Desa and Koch, 2014), predominantly centered on the expansion of a single organization (Derks et al., 2022; Han and Shah, 2020). However, a subset of studies has stressed that, given the complexity and breadth of several environmental issues, it is often paramount to pursue impact scaling by involving an increasing number of stakeholders in a business model (Bauwens et al., 2020; Derks et al., 2022). This may for example entail scaling impact via replication or diffusion, by getting multiple actors to adopt a sustainable solution or technology, such as renewable energy technology, used or provided by the focal organization (Anokhin and Eggers, 2023; Bauwens et al., 2020). The specific type of actor varies depending on the DBMfS. For example, when a retailer wants to increase its supply chain's sustainability, it is key that as many producers as possible in its supply chain adopt smart tracking tools, to provide data on the sustainability of their production processes. Hence, in this context, the "subject" (Palmié et al., 2023) that needs to increase, in order to scale impact, is the number of actors that adopt a digital solution that creates environmental value. Indeed, achieving sustainability-related goals often requires the involvement of an increasing number of organizations, rather than relying solely on the growth of a single organization committed to this goal. It is necessary for this commitment to be embraced among an increasing number of organizations, leading them to change their practices and adopt new technologies.

Hence, this study conceptualizes impact scaling as increasing the environmental impact achieved by a DBMfS through the involvement of a wider array of stakeholders in utilizing a digital technology. Although prior literature highlighted the need to engage other stakeholders for impact scaling, it has predominantly adopted an organization-centric view, focusing on how individual organizations make strategic decisions to scale their impact through internal capabilities (Bocken et al., 2014). This perspective tends to overlook the complexity introduced when multiple partners collaborate within a collaborative business model. Thus, our study seeks to explore the implications for impact scaling when partners collaborating as part of a new business model employ different value capture models. This focus also addresses recent calls from scholars for deeper insights into the relationship between collaboration and scaling in the context of sustainable business models (e.g., Broccardo et al., 2023; Ciulli et al., 2022).

3. Research design

In this section, we present the research design of our study. We begin by describing the research strategy, followed by a description of the set of cases we analyzed, data collection and analysis.

3.1. Research strategy

To investigate our research questions, we employed a multiple case study research design (Yin, 2018). Case studies enable multiple observations of complex processes (Eisenhardt, 1989) and are particularly useful for developing insights into novel phenomena (Edmondson and McManus, 2007), such as the design of DBMfS. A multiple case study approach is appropriate in our context as it allows us to identify, compare and contrast the different value capture models adopted by the various partners within DBMfS, providing a good understanding of the variations and similarities between them (Eisenhardt and Ott, 2017). A single case study, on the other hand, would limit our ability to generalize findings and identify cross-case patterns.

A sector with a high likelihood of observing the phenomenon of interest, i.e. where we currently see different DBMfS emerging, is the agri-food sector.

3.2. Empirical setting

In the agri-food sector, stakeholders such as farmers, farmer cooperatives, and retailers, as well as technology providers, advisory (agronomical) service providers, and insurance providers currently experiment with different business models to use digital technologies, such as sensors, robotics, drones, decision support and control systems, for creating environmental benefits.

The sector faces significant challenges in terms of sustainability. In order for the agri-food sector to thrive sustainably, stakeholders need to ensure an efficient use of resources, match food supply and demand, tackle power imbalances in the supply chain and reduce air, water and soil pollution (Annosi et al., 2020). Research emphasizes the important role digitalization may play to improve the sustainability of agri-food systems (Bahn et al., 2021; Rolandi et al., 2021). For instance, digital technologies such as sensors, robotics, or drones can enable precision farming solutions and provide farmers with guidance on activities such as crop rotation, harvesting, and soil management. Data collected through these technologies can be used to interpret past performance or predict future farming outcomes (Janssen et al., 2017). Through continuous monitoring or analytics, farmers can make informed decisions on how to improve their farming operations sustainably (Eastwood et al., 2017). Additionally, these digital technologies can help farmers to explain their environmental efforts to other agri-food stakeholders, by means of traceability of activities, products and offerings (Klerkx et al., 2019). Hence, there has been a significant uptake of digital technologies in the agri-food domain in the past two decades (MacPherson et al., 2022). However, this process has encountered a set of challenges related to characteristics of the sector. Specifically, farmers have limited financial resources to invest in in high-precision technologies. Retailers, thanks to their substantial financial means as well as their interest to make their supply chain more environmentally sustainable, could represent a valuable partner for the investment in digital technologies. Yet, the relationship between farmers and retailers is characterized by high power imbalances. In the past, producers engaged in different initiatives to counter the retailers' negotiating power, for instance through establishing farmer cooperatives (Glavee-Geo et al., 2022). The importance of adopting digital technologies for environmental sustainability and the multiple partners required for this endeavor make the agri-food sector a particularly suitable empirical context to investigate the different value capture models selected in DBMfS and their implications for impact scaling.

3.3. Case selection

The European Commission has identified the use of digital technologies as critical to "build a more sustainable and efficient food system" for the "future of farming" (EU, 2023). Therefore, it has established several initiatives to promote the digital and sustainable transformation of agriculture (EU, 2023) and, thus stimulated emergence of DBMfS. Hence, we consider the European Union context particularly suitable to explore our research question.

As cases, we selected pilot projects that were part of a larger European project on sustainable farming via adopting digital technologies. This project ran from September 2020 to September 2023. It involved multiple pilots in various European countries, all deploying DBMfS to support environmentally sustainable farming efforts. The pilot projects were selected by the European project through a careful process to ensure a heterogeneous mix that would provide insights into various challenges and solutions within agri-food systems (Eisenhardt and Graebner, 2007). Selection criteria focused on representing a wide

Table 1
Description of pilot cases.

Pilot	Country	Aim of the pilot	Digital technology considered	Stakeholders involved
Pilot 1	Greece	Increase transparency and promote sustainable, high-quality production of fruit products.	Traceability system, sensors, prediction model	Technology provider, farmer, cooperative, retailer
Pilot 2	Italy	Promote sustainable and farmer-friendly production of high-quality grains, with a focus on environmentally responsible practices and the financial well-being of farmers.	Sensors, parametric insurance service, carbon farming system, decision support system	Technology provider, farmer, cooperative, insurance provider, retailer, certification provider
Pilot 3	France	Empower consumers through crowdsourcing technologies and connected traceability solutions, while increasing transparency and trust in the food supply chain.	Traceability system, sensors	Technology provider, farmer, cooperative
Pilot 4	Spain	Enhance the efficiency, sustainability, and brand recognition of the horticulture greenhouse value chain through the implementation of traceability solutions.	Sensors, decision support system	Technology provider, farmer, retailer, cooperative
Pilot 5	Ireland	Showcase the benefits of smart farming on rural farms and promote co-creation of new food products and services within the wider agri-food community.	Sensors, prediction model	Technology provider, farmer
Pilot 6	Slovenia	Optimize farming practices to improve efficiency, reduce environmental impact, and enhance the quality of crops.	Drones, sensors, prediction model	Technology provider, advisory service provider, farmer
Pilot 7	Cyprus	Develop a new traceability and labelling system that will enable wine producers to provide consumers with more comprehensive information about their products and promote more sustainable and socially responsible practices among wine producers.	Traceability system, sensors, prediction model	Technology provider, wine grower, retailer, advisory service provider
Pilot 8	The Netherlands	Improve agricultural soil management practices and promote the use of transparent and partnered farmer-based CO2-compensation programs.	Carbon farming system	Technology provider, cooperative, farmer, retailer, certification provider
Pilot 9	Spain	Introduce IoT solutions to the agri-food sector through a platform, with the goal of generating synergies between tourism and agriculture.	Traceability system, sensors	Technology provider, cooperative, greenhouse grower, retailer

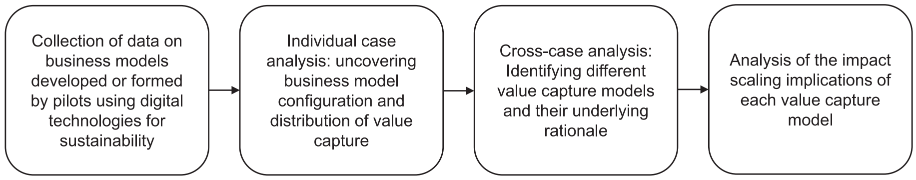

Fig. 1. Research process deployed.

Table 2
Data collected per pilot.

Pilot	Number of workshops	Data collection period	Topics workshops	Total duration workshops	Number of one-on-one interviews	Other documentation
Pilot 1	5	20 months	Value proposition statement; Data models and usage; Customer journey; Business model design; Theory of Change; Business model evaluation	10 h	1	Project deliverables; website; Miro board
Pilot 2	6	12 months	Value proposition statement; Data models and usage; Customer journey; Business model design; Theory of Change; Business model evaluation; Reflection	12 h	1	Project deliverables; website; Miro board
Pilot 3	4	6 months	Value proposition statement; Data models and usage; customer journey; Business model design; Theory of Change	8 h	2	Project deliverables; website; Miro board
Pilot 4	5	14 months	Value proposition statement; Data models and usage; Customer journey; Business model design; Theory of Change; Business model evaluation;	10 h	1	Project deliverables; website
Pilot 5	6	9 months	Value proposition statement; Data models and usage; Customer journey; Business model design; Theory of Change; Business model evaluation; Reflection	12 h	2	Project deliverables; website; Miro board
Pilot 6	6	12 months	Value proposition statement; Data models and usage; Customer journey; Business model design; Theory of Change; Business model evaluation; Reflection	12 h	2	Project deliverables; website; Miro board
Pilot 7	3	5 months	Value proposition statement; Data models and usage; Customer journey	6 h	2	Project deliverables; website; Miro board
Pilot 8	6	12 months	Value proposition statement; Data models and usage; Customer journey; Business model design; Theory of Change; Business model evaluation; Reflection	12 h	1	Project deliverables; website; Miro board
Pilot 9	4	6 months	Value proposition statement; Data models and usage; Customer journey; Business model design; Theory of Change	8 h	2	Project deliverables; website; Miro board

variety of value chains and incorporating unique combinations of approaches. Specifically, the pilots engaged 11 farmers' organizations and farmers' businesses, representing over 240,000 farmers, 5 food industry companies, 12 SMEs, 3 traders/distributors, and 2 organizations representing consumers, along with 6 NGOs. The pilots represent different agricultural sectors, including arable farming, horticulture (both open fields and greenhouses), perennials, livestock, and dairy production. Furthermore, the pilots utilized a range of advanced technologies such as satellites, drones, proximal sensors (e.g., IoT devices and weather stations), blockchain, AI, crowdsourcing, and semantic technologies.

Table 1 provides an overview of the cases. The table includes a detailed description of the digital technologies deployed in each pilot project and the key stakeholders involved. For more information, please refer to Appendix A.

3.4. Data collection and data analysis

Fig. 1 depicts how our research proceeded. We collected data on the DBMfS the pilot projects developed. For each pilot, we then performed an individual case analysis focused on the value capture model set up by the partners involved in the project. Once we had established this for each case, we engaged in a cross-case analysis focused on the question of which types of value capture models were chosen and for what reasons. Lastly, we identified patterns linked to each value capture model, and especially the implications of each value capture model for scaling impact. In what follows, we explain data collection and data analysis in more detail.

3.4.1. Data collection

To understand the business models for the pilots, we used observations from business modeling workshops, both taking place online and offline, with all pilot actors involved and conducted one-to-one interviews with pilot leaders (see Table 2). The interviews allowed us to dive deeper into the project leaders' perspectives, while the workshops were important for incorporating the views of other actors who were part of the pilot initiatives. The workshops provided a collaborative space where all relevant stakeholders could share their views and contribute to the discussion on the business models.

In the workshops, each business model was documented and visualized. Two of the authors participated in the workshops, i.e. we employed a participant observer strategy to trace the discussions and gain more in-depth insights than looking only at the workshop documentation would have allowed[1] (Ciesielska et al., 2018; Johnson et al., 2006). In the workshops, we acted as mere participants. We did not have a direct stake in the business model development but focused on observation and documentation rather than decision-making. The other authors were not directly involved with the workshops. They were more involved in the data analysis, which included cross-verifying the collected data, critically examining and discussing the interpretations with the participant observers, and providing alternative perspectives (Corley and Gioia, 2004; Lincoln and Guba, 1985).

In addition, we gathered documentation such as project deliverables, dissemination of the outputs of the project as well as working documents such as notes captured as part of interactive sessions with pilots (through Miro boards) to further complement our data collection. The goal was to generate insights for each pilot on its characteristics, challenges faced by

[1] Our role was to document the business model designs emerging through the pilots and to evaluate these designs with stakeholders involved, acting as sparring partner for the pilots.

the focal partners involved, the role of the technological solutions proposed in solving these challenges, and stakeholders needed to support the business model.

In the workshops and interviews, we focused on mapping key business model elements to understand the product or service being offered, theories of change, and the rationale behind partners' choices regarding roles and responsibilities. By analyzing these elements, we aimed to understand how relationships between partners were structured, what motivated their choices, and how they envisioned investment and value capture models. These insights allowed us to understand partners' ideas behind their business model configuration.

Table 2 offers an overview of the total data collected.

3.4.2. Data analysis

We followed several steps in our analysis: To start, we performed an individual case analysis, which involved examining each pilot to understand the context, stakeholders, and dynamics at play. This understanding then provided the foundation for the subsequent cross-case analysis. One important result of the initial data analysis was the insight that the central relation with regards to value capture was the one between producers (i.e., farmers, farmer cooperatives) and retailers. In the subsequent steps, we thus chose to focus on these two parties as the key partners involved in setting up the initial value capture model.

We documented our observations on the value capture model in each case under the labels '*investments*' and '*return on investment*' (see Table 3 in the Findings section). This helped us understand how the basic value capture model was configured. Cross-comparing cases then allowed us to group the pilots into four types of (generic) value capture models: producer-led, collaborative producer, retailer-led, and collaborative producer-retailer. In defining the labels for the types of value capture models, we purposefully chose terms that point to the actor(s) that are central for the value capture. Next, we analyzed the factors that influenced the choice of a value capture model. We derived these factors inductively from the data, rather than from pre-existing theoretical frameworks. The factors that emerged from the data as most important for the choice of a value capture model were what we labeled '*power dynamics*' between retailer and producer(s), the '*willingness*' to achieve environmental impact, and the '*ability*' to make investments. Once these insights were established, we used them to refine and contextualize our descriptions of the value capture models. Third, we connected the influencing factors with the four types to examine how the factors influenced the adoption of value capture models.

Ultimately, we used the four types to look at the data once again, checking for similarities and differences within each type regarding the question of how the pilots reflected on the involvement of more producers in the business model, in order to scale the DBMfS's environmental impact. This analysis revealed that each value capture model is associated with distinct challenges related to scaling impact.

4. Findings

In this section, we elaborate on the value capture models identified. We first present the results of our data analysis, classifying each pilot case based on how investments for digital technologies were structured

Table 3
Distribution of empirical cases per value capture model.

Pilot cases	Influencing factors			Value capture model		Classification of value capture model
	Willingness	Ability	Power dynamics	Investments	Return on investment	
Pilot 1	Retailer has significant willingness to achieve environmental impact	Retailer has abilities to invest in technologies. Producers have limited abilities to invest in technologies	High, retailer is large and has significant resources as opposed to producer, producer is dependent on retailer	Retailer makes initial investments towards technologies	Retailers capture initial value after which producers are rewarded based on individual contributions	Retailer-led
Pilot 2	Both producer and retailer recognize importance of environmental impact	Retailer has abilities to invest in technologies. Producers have limited abilities to invest in technologies	Low, retailer and producer have long-term relationships to achieve impact	Retailer makes initial investments towards technology	Fixed and formally agreed upon percentage of value captured by retailer is offered to producer	Collaborative producer-retailer
Pilot 3	Both producer and retailer recognize importance of environmental impact	Both retailer and producer have abilities to invest in technologies	Low, retailer and producer have long-term relationships to achieve impact	Investments towards adoption of technology are shared between producer and retailer	Fixed and formally agreed upon percentage of value captured by retailer is offered to producer	Collaborative producer-retailer
Pilot 4	Cooperative of producers recognizes importance of environmental impact	Individual producers have limited abilities to invest in technologies	Medium, producers at cooperative are competitors but can bundle resources to achieve impact	Cooperative makes investment towards technology	Value captured by cooperative is distributed to its members based on individual contribution	Collaborative producer
Pilot 5	Producers recognize importance of environmental impact	Producers have abilities to invest in technologies	Medium, producers can freely select retailers but are dependent on retailers to support operations	Producer makes investment towards technology	Producers agree with retailers on how value capture is shared based on investments made	Producer-led
Pilot 6	Producers recognize importance of environmental impact	Producers have abilities to invest in technologies	Low, producers are relatively large and can freely select retailers to support operations	Producer makes initial investment towards adoption of technology	Producers agree with retailers on how value capture is shared based on investments made	Producer-led
Pilot 7	Retailer recognizes importance of environmental impact	Retailer has abilities to invest in technologies. Producers have limited abilities to invest in technologies	High, retailer is large and has significant resources as opposed to producer, producer is dependent on retailer	Retailer makes initial investment towards adoption of technology	Retailers capture initial value after which producers are rewarded based on individual contributions	Retailer-led
Pilot 8	Both retailer and producer have significant willingness to achieve environmental impact	Both retailer and producer have abilities to invest in technologies.	Low, retailer and producer have long-term relationships to achieve impact	Producer makes initial investment	Value capture by retailer is shared with producer to compensate for investments made	Collaborative producer-retailer
Pilot 9	Cooperative of producers have significant willingness to achieve environmental impact	Individual producers have limited abilities to invest in technologies.	Medium, producers at cooperative are competitors but can bundle resources to achieve impact	Cooperative makes initial investments towards adoption of technology	Value captured by cooperative is distributed to its members based on individual contribution	Collaborative producer

and distributed, and what factors played a role in driving this choice. Through this, each pilot case can be classified into one of four value capture models (producer-led, collaborative producer, retailer-led, and collaborative producer-retailer). In addition, we present an empirical framework describing the process producers and retailers go through for the selection of a specific value capture model based on our case analysis. We explain each type in more detail and describe how the various types have been employed using examples from our pilot cases.

As our typology focuses on the interaction between producers and retailers, we close this section by also reflecting on the role of other stakeholders involved for the DBMfS we studied, and how these stakeholders may impact the value capture models considered.

4.1. Value capture models for DBMfS in the agri-food sector

Following our data analysis approach, Table 3 describes the classification of pilots based on the characteristics of the value capture model selected. Out of the nine pilot projects we studied, two were classified as producer-led, two as collaborative producer, two as retailer-led, and three as collaborative producer-retailer.

Table 3 provides information on the characteristics of pilots in relation to: 1) factors affecting the value capture model (such as the willingness of retailers and producers to achieve environmental benefits, their capacity to invest, and the power dynamics between them), and 2) the value capture model demonstrated by investments in digital technologies and the distribution of value to facilitate returns on those investments. More empirical details can be found in Appendix B.

Based on these findings, we propose an empirical framework (see Fig. 2) explaining the process that retailers and producers go through in arriving at a suitable value capture model to support the adoption of digital technologies. As illustrated in Fig. 2, the selection of a specific value capture model is driven by the willingness of either the producer or retailer (or both) to support the adoption of digital technologies for environmental sustainability, as well as their respective ability to act on this willingness. The lack of either willingness or ability can influence which value capture model is selected. For instance, it can be the case that producers are driven by the willingness to have a positive environmental impact, but cannot afford the necessary investments to do so. Accordingly, this drive producers to seek co-invest opportunities, either in collaboration with other producers (collaborative producer model) or through collaboration with other retailers (collaborative producer-retailer model). In contrast, if producers are able and willing to invest in digital technologies for environmental sustainability, we see from the case studies that, in principle, they would opt to do so (a producer-led model). It should however be noted that producers can still choose to collaborate with other producers or retailers, even if they are willing and able to make investments for digital technologies.

For retailers, we observed that they are dependent on producers to achieve environmental impact. Here, retailers either identify willing producers (leading to a collaborative producer-retailer model) or are required to incentivize producers (i.e., retailer-led model) to achieve the adoption of digital technologies and to reap environmental benefits. Note that, in our case studies, we have not observed any scenario in which the environmental sustainability driver does not exist for the retailer.

In the following, we describe each value capture model identified in more detail, and describe how these value capture models have been employed in our case studies.

4.1.1. Producer-led model

The producer-led model refers to a value capture model in which producers, here the farmers, lead the adoption and use of digital technology to generate environmental impact. This model is characterized by producers who have the financial resources or access to funding from banks, investment funds, or subsidies to invest in technological solutions such as carbon sequestration or smart farming services. Hence, at the technology investment layer, producers lead the investment decisions, using their capital or secured funding to implement digital solutions that align with their environmental sustainability goals. Consequently, the producers maintain control over these technologies and, at the value capture layer, decide how the value generated is distributed, typically capturing the majority of the benefits themselves. In this value capture model, collaboration takes place between producers through knowledge sharing and dissemination of best practices, but producers themselves make investments in the adoption of new technologies.

The scaling of the producer-led value capture model is driven by the producer through expanding the value capture model to other producers (adopting similar technologies). Collaboration with other producers often takes place through knowledge sharing and the exchange of best practices to help scaling efforts. However, each producer remains in charge of its own adoption efforts (meaning that collaboration with other producers is loosely considered). As a result, the efforts to scale impact may be limited by the individual producer's capacity and resources, prompting the producer to subsequently venture into different value capture models, such as (formal) collaborations with retailers or other producers, to support impact scaling aspirations.

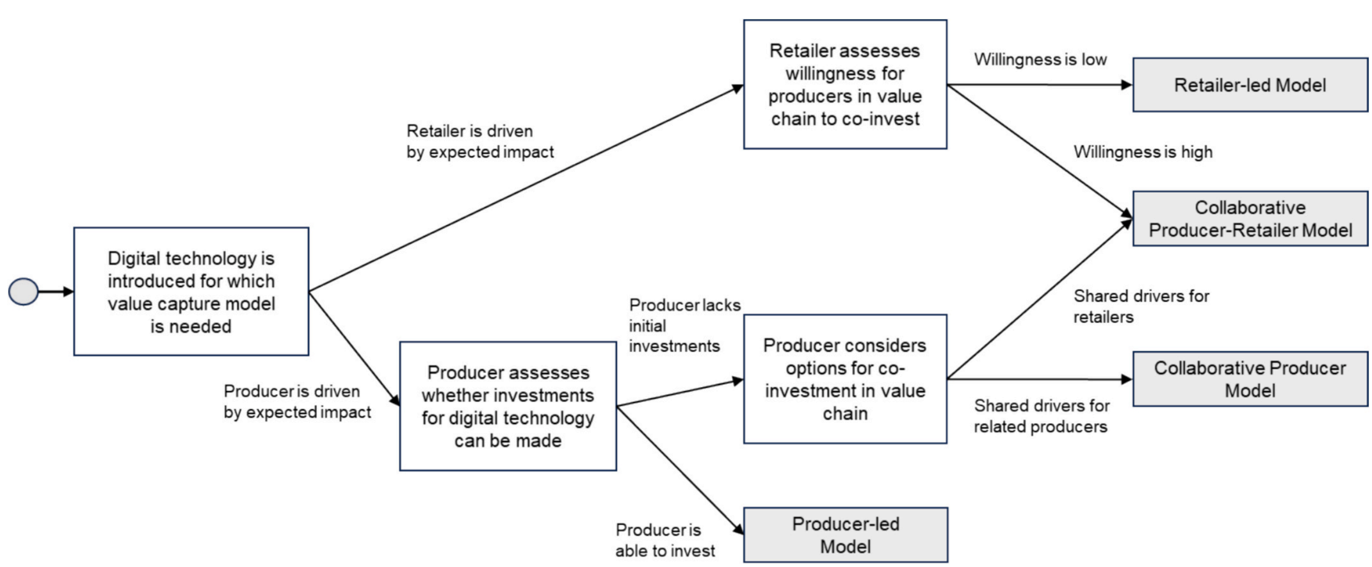

Fig. 2. Empirical framework for the selection of value capture models.

The case of the Slovenian pilot (pilot 6) can be considered as an instance of the producer-led model. In this pilot, the farmers owned large agricultural landholdings where farming operations were executed. The variations in soil characteristics across the vast areas of their landholdings led to varying needs. The farmers in the pilot recognized the potential of smart farming solutions for improving soil conditions and reducing the carbon footprint. To address the challenge of monitoring such large areas, drones and IoT sensors were employed. This led to the development of a smart farming solution able to give producers data-driven insights on how well their soil and crops were performing. The smart farming solutions not only allowed for efficient monitoring but also generated insights on areas that required additional fertilization, thus reducing the overall fertilizer needed. Investments required were high and differed substantially between farmers who already possessed certain equipment and others who did not, but farmers preferred to do investments on their own, often trying to access national and international subsidies, such as Global GAP (a farm assurance program). To overcome the resource constraint challenge faced by farmers in scaling impact, farmers also considered other solutions, including (long-term) collaborations with agricultural service providers and technology providers. These collaborations aimed to provide external support to farmers by granting them access to agronomical expertise and support, collective knowledge development, as well as favorable investment schemes, such as subscription-based models to access digital technology. Importantly, all these agreements were initiated and driven by the producers.

In both producer-led pilots, farmers exhibited a strong willingness to engage in environmental sustainability efforts and stimulate wider adoption of the technology. This was demonstrated through open day workshops, at which farmers presented their journey towards the adoption of digital technologies, illustrating the expected (environmental) performance achieved through the use of these technologies, as well as discussions on best practices identified with other neighboring farmers.

The capacity to invest was present, though the ability to scale impact remained constrained by access to resources. Power dynamics in these cases were balanced (low to medium), with farmers having considerable influence over the supply chain due to their market size and autonomy. In terms of investments, farmers were responsible for the initial capital outlay and committed investments towards the adoption of digital technologies. As a consequence, farmers were able to maintain control over how value was captured as a result of using these technologies and the prices at which their produce was sold.

4.1.2. *Collaborative producer model*

The collaborative producer model aims to achieve economies of scale by exchanging and sharing resources of producers to finance access to digital technologies. Farmer communities or cooperatives are often formed as independent legal entities to safeguard and satisfy the goals and needs of their farmers. At the technology investment layer, farmers contribute resources, usually in the form of subscription fees that are used to invest in digital technologies. Each associated farmer can influence decision-making through governance boards, to ensure that the overall goals set for the cooperative align with the individual goals of the farmer.

At the value capture layer, the size of the cooperative (bundling the resources of individual producers) enables the cooperative to make investments in the adoption of digital technologies. Subsequently, the cooperative can determine how value captured is distributed.

The impact scaling of this model is dependent on the number of producers that are part of the cooperative. Increasing the number of producers enables additional resource pooling and scaling of farming operations. However, aligning the objectives of the cooperative to the individual interests of the producers involved is a challenge. New producers may differ in their characteristics, objectives, and perceptions towards technology adoption or environmental impact creation. As a collective decision-making body, the cooperative's decisions must align with the perceptions and objectives of individual producers or motivate them to invest in new technologies.

An example of the collaborative producer model is the Spanish pilot (pilot 4). In this case, greenhouse growers, as part of a large cooperative, recognized the importance of using digital technologies to contribute to and explicate environmentally sustainable farming efforts. The cooperative structure facilitated access to digital technologies for environmental sustainability, enabling individual farmers to adopt and use these innovations in practice. The cooperative was able to comply with expected regulatory developments, dictating transparency on the environmentally sustainable nature of the crops produced. Moreover, this enabled the cooperative to target different markets that valued sustainably produced crops. Individual farmers could sell their crops at a premium through the cooperative structure, after which value captured was distributed to individual farmers based on the yield they contributed.

In terms of scaling the business model, the cooperative began with an initial set of tech-savvy greenhouse farmers, who acted as first adopters. Pilot results and word-of-mouth promotion stimulated other farmers in the cooperative to support the adoption of technologies for carbon neutrality. This resulted in an overall increase in sustainably produced yield, enabling the cooperative to improve its negotiation position with retailers and food producers.

In both pilots following this type, individual producers were limited in their ability to invest independently in technology, but the formation of cooperatives allowed them to achieve greater impact. Power dynamics within the cooperative were characterized by a medium level of influence, as producers within the cooperative were both collaborators and competitors. The cooperative took charge of the investment in technology and distributed the resulting value among members according to their individual contributions.

4.1.3. *Retailer-led model*

The retailer-led model is characterized by the retailer taking on the responsibility of stimulating the adoption of digital technologies by producers. At the technology investment layer, the retailer actively makes investments in new digital technologies for environmental sustainability such that access to its features can be provided to producers. Consequently, through (mandated) use of the digital technologies by farmers, retailers can reap environmental sustainability benefits. As the retailer provides farmers with free or discounted access to these digital technologies, it allows retailers to control how the technologies are used.

Regarding the investments and return on investments, the retailer makes initial investments to provide access to digital technologies, enabling the retailer to control how value captured is distributed. Consequently, the retailer predetermines how value captured is shared with producers before the use of the digital technologies, offering incentives to producers using the technologies to achieve economic or environmental impact.

Scaling the impact of this business model occurs through incorporating additional producers. This entails investing in access to digital technologies by (new) farmers and ensuring that the farmers adopt the technology to work towards environmental impact generation. The challenge is to ensure that newly onboarded producers adopt the digital technologies as intended.

An example of this value capture model was found in the Greek pilot (pilot 1) in which the retailer pursued the environmentally sustainable production of traceable fruits to meet the demands of their clients. These clients (large-scale food producers) faced market pressure to be able to clarify how fruits have been produced and to explicate to what extent actions towards environmental sustainability were taken into account. As the retailer was dependent on its associated farmers in terms of production, these farmers should be stimulated and motivated to adopt digital technologies to achieve these environmental outcomes. To do so, the retailer invested and covered the expenses of farmers to access and use the digital technologies in order to stimulate adoption, and offered guidance through agronomist services on how the digital technologies should be used to reap benefits. To compensate for the investments in digital technologies made, the retailer contractually agreed with farmers that a share of the profits generated would feed back to the retailer. Accordingly, a payback scheme was configured to ensure that the retailer would be able to generate return(s) on investment through this value capture model.

To scale the business model, the retailer explored opportunities to include additional farmers to further support technology adoption and to increase the (environmentally sustainable) production of fruits. Here, contractual agreements were arranged with a fruit producer's cooperative, for which individual farmers would use the smart farming solutions to reduce carbon emissions and to avoid the overuse of fertilizers and scarce materials. Through the cooperative structure, decisions on the use of the smart farming solutions were delegated and shared (i.e., the cooperative would be responsible for ensuring that the adequate use of the solutions was followed). Again, the access to and use of technological solutions was supported by the retailer, for which the retailer would generate a return on investment through additional sales of environmentally sustainable produce.

In both pilots following this type, retailers demonstrated a strong willingness to achieve environmental impact and they were responsible for the majority of the investment in technology. Farmers, by contrast, had limited ability to invest and were dependent on the retailers for access to these innovations. The power dynamic in these pilots heavily favored the retailer, who controlled both the investment process and the initial value capture. Producers were compensated at a later stage, based on their contributions to the environmental sustainability initiatives.

4.1.4. *Collaborative producer-retailer model*

In the collaborative producer-retailer model, both the producer and retailer make investments towards the adoption of digital technologies aimed at promoting environmental sustainability. At the technology investment layer, both the retailer and producer work towards the acquisition, access, and use of technology. This collaboration often arises from mutual (shared) objectives of achieving benefits in terms of environmental sustainability or is the product of an existing long-term relationship between the two parties with heavily aligned interests.

At the value capture layer, the retailer and producer operate in a cooperative manner, jointly deciding on how the value generated from these digital technologies is distributed. This shared decision-making ensures that both parties benefit from the investments and environmental sustainability outcomes, leading to aligned incentives for continued collaboration.

Impact scaling is achieved through augmenting the scope of the producer's activities with the backing of the retailer, or by forming supplementary partnerships with either retailers or producers, thus creating a network of collaborative allies. The key challenge for impact scaling is to ensure that objectives, as well as the resources and capabilities of the retailer and producer, are properly aligned. Any discrepancy between strategic objectives can jeopardize the collaboration or may result in investments that do not generate any significant value.

An example of the collaborative producer-retailer model can be found in the Dutch pilot (pilot 8). In this case, a biological wholesaler established a long-term partnership with its farmers to promote the production of biological products in its value chain. The collaboration was largely feasible as the participating farmers already prioritized environmentally sustainable farming practices. The biological wholesaler aimed to achieve carbon neutrality in its operations, which would enhance its core proposition of selling carbon-neutral biological products. However, it was unable to lower the carbon emissions generated by its logistics. To mitigate this, it planned to purchase carbon credits to offset the carbon emissions. Although carbon credits can be obtained from open markets, it engaged its associated farmers to generate (and subsequently purchase) carbon credits, as this was aligned with the farmers' intention to support environmentally sustainable farming practices. As such, both the wholesaler and farmers would make joint investments in carbon sequestration solutions for the farmers' use. Subsequently, the carbon effects produced by the farmers could be measured and monetized through carbon credits, which were then procured by the wholesaler to achieve carbon neutrality. Consequently, both the wholesaler and farmers were able to contribute to the creation of environmental impact and benefit from this collaboration.

The pilot project's scaling efforts were contingent upon the continuous alignment of capacity and objectives between the biological

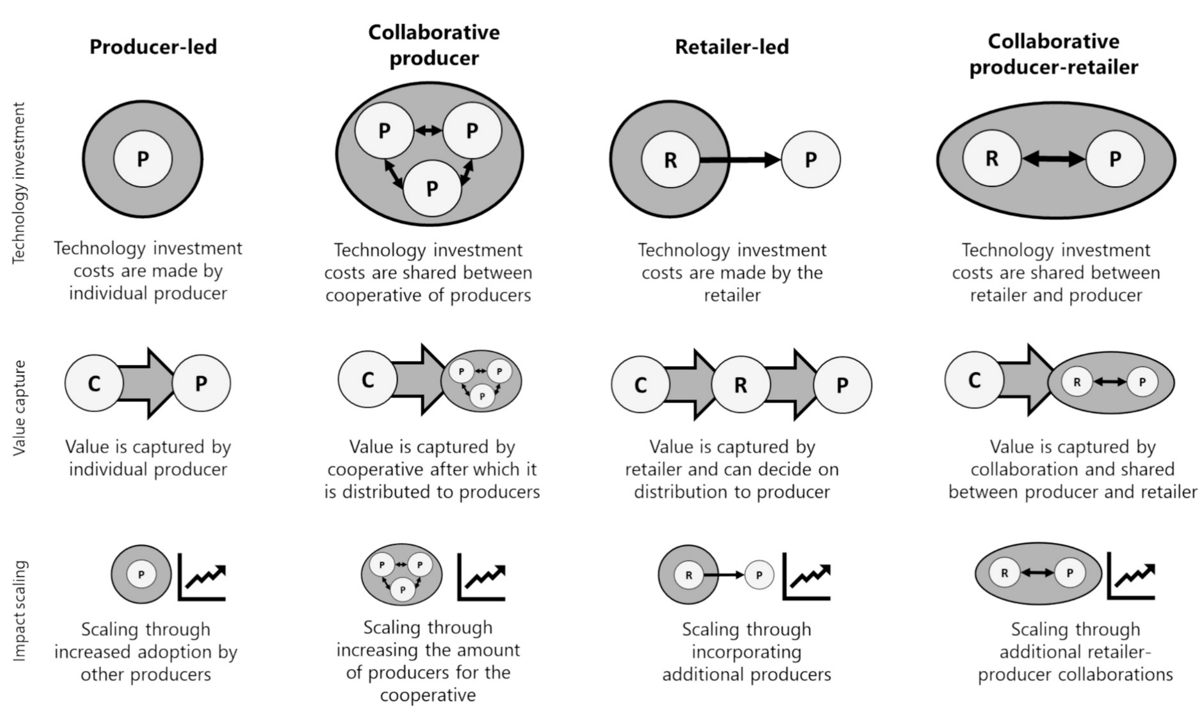

Fig. 3. Value capture models of DBMfS and implications for scaling impact.

wholesaler and the associated farmers. The sequestration initiatives undertaken by the farmers enabled the wholesaler to offset its carbon emissions entirely. Any remaining carbon credits were sold to interested parties to foster further sequestration efforts. To this end, the wholesaler collaborated with regional development projects interested in reducing carbon emissions generated through construction work or through production facilities, as well as additional wholesalers. However, the challenge was to ensure that the interests of the farmers aligned with those of the partners involved, and to prevent the adoption of practices that could be considered as "greenwashing". Accordingly, farmers were involved in the selection and decision-making process on what projects or collaborations with wholesalers were considered.

In all pilots following this type, both retailers and farmers recognized the importance of environmental sustainability and were willing to invest in the necessary technologies. Although retailers had greater financial resources, producers were able to contribute to the investment process. The long-standing relationships between these parties ensured a collaborative approach to decision-making. Pilot 8 also exemplified this collaborative producer-retailer model where both parties were equally committed to environmental sustainability goals and shared the financial responsibility for technology adoption. The value distribution was agreed upon based on the respective investments made by the retailer and the farmers.

In these cases, the shared willingness of both retailers and producers to achieve environmental impact was evident. Although retailers typically led the investment process, producers were also able to contribute financially. The distribution of value was based on pre-agreed terms, reflecting the contributions made by both parties.

We can summarize the value capture models by means of Fig. 3, offering an overarching view of the value capture models. Here, the symbols P, R, and C denote producer, retailer, and customer, respectively. Whereas our analysis focused on producer (P) and retailer (R), we depict the customer (C) in the figure to highlight the value flow that is associated with the value capture model. The three layers summarize, for each type, how technology investments are done (upper layer), how investments are made, how return on investment is achieved, and by whom – value capture (middle layer), and the implications for scaling impact (bottom layer).

4.2. Role of stakeholders beyond producers and retailers

As explained, for our typology, we focus on the role of producers and retailers in working towards the adoption of digital technologies for environmental sustainability. In addition to producers and retailers, several other stakeholders influenced the value capture models selected for the nine cases studied. These stakeholders can either lower the barrier for investments, increase the ability or willingness of producers or retailers to adopt new technologies or support the return on investment through new digital technologies (through contributing to additional value capture). For our pilot cases, technology providers, insurance providers, and advisory service providers were influential stakeholders.

Technology providers are responsible for providing smart farming services that generate data-driven advice on farming practices, setting up decision support systems for farmers, and providing sensors for data generation at farms. In terms of value co-creation and capture, they contribute towards customizing and adapting smart farming solutions to the needs and preferences of producers. In addition, some of the technology providers collaborate with producers to offer favorable finance mechanisms (pay-per-use or flexible subscription fees). Such mechanisms help farmers overcome financial barriers towards accessing and using digital technologies, fostering the adoption of such technologies in practice and increasing their ability to invest.

Insurance providers offer timely financial protection through parametric insurance contracts. Accordingly, insurance providers reduce the risk that producers may perceive when investing for during the use of digital technologies, as unforeseen losses of productivity or yield are compensated through insurance payouts. As a result, insurance providers may offer a more stable ground for producers to support the adoption of digital technologies in practice, increasing the ability of producers to invest.

Advisory service providers offer data-driven advice coming from smart farming technology products used at farms, while certification providers validate and certify carbon credits accumulated by carbon farming. Through these services, these stakeholders can aid producers in improving their value creation and capture or offer further means of value capture to producers. For example, the validation of carbon credits offers trust to parties interested in purchasing carbon credits from the producers. This can ease the trade of carbon credits in practice. Similarly, advisory services can help producers to improve and optimize their production processes based on data collected, resulting in higher quality produce or increased production efficiency. As a result, such services can reduce the barrier for producers to invest in new digital technologies or collaborate with retailers to do so, as the potential of value captured in return is expanded.

5. Discussion

This study sought to explore the different value capture models that partners adopt when establishing a DBMfS. Due to the increasing use of digital technologies to generate environmental benefits in many sectors, this research field is still nascent and in need of further development (Adelekan and Sharmina, 2024; Bencsik et al., 2023; Böttcher et al., 2024). Our findings provide empirical insights into the important step of agreeing on the distribution of investments and returns between partners when setting up a novel business model. We provide an in-depth characterization of four value capture models and the main factors driving their choice. We further elaborate on the implications of the value capture model partners chose for impact scaling. In the following sections, we elaborate on the theoretical contributions and managerial implications of our study, and we outline its limitations and promising avenues for future research.

5.1. Theoretical contributions

Our study makes two contributions to the literature on DBMfS and collaborative business modeling for sustainability. First, we provide an empirically grounded typology of value capture models (producer-led, collaborative producer, retailer-led, and collaborative producer-retailer), which introduces nuance to the often generic concept of value capture in the context of DBMfS. This typology shows that the initial agreements partners make when developing a DBMfS can vary significantly, offering new perspectives on the economic and environmental dimensions of value capture. Indeed, while many scholars have emphasized the importance of value capture for developing effective business models and sustaining collaborative business models (e.g., Adelekan and Sharmina, 2024; Oskam et al., 2021; Stål et al., 2022), we thus far have limited knowledge into what these agreements might entail. This is even more surprising for BMfS, as it is widely acknowledged that reconciling economic value capture and environmental value creation can be difficult (Davies and Chambers, 2018; van Bommel, 2018). Our study suggests that reconciling these dimensions also depends on the partners' agreement on a suitable value capture model. Our research addresses the limited knowledge about the specific agreements partners establish to distribute captured value (Bencsik et al., 2023).

Moreover, our study provides empirical insights into the important step of partners agreeing on the distribution of investments and returns when setting up a novel DBMfS. We shed light on the factors influencing the selection of a value capture model, and offer an empirical framework outlining the process that lead retailers and producers to determine a suitable value capture model. The theoretical contribution of these findings extends beyond research on producer-retailer collaborations, to the study of other types of collaborations that leverage digital technologies for sustainability. For instance, in the context of digital services for the circular economy or for smart cities, multiple actors have to collaborate and also encounter financing challenges: Bencsik et al. (2023) highlight the difficulties in securing funds for smart city services, while Trevisan et al. (2023) show that financial barriers hinder the adoption of digital technologies for circularity. Nevertheless, actors in these settings are often willing to collaborate on financing the deployment of digital technologies (Bencsik et al., 2023). Our study signals to researchers examining these collaborations the importance of investigating the value capture models partners adopt and their implications. As such, our study also challenges the traditional actor-centric view in business model research, which often focuses on individual firms, by highlighting the importance of collaborative frameworks in modern industry practices (Kanda et al., 2021).

Second, our study provides insights into the role of value capture models for impact scaling in DBMfS, and BMfS more broadly (Bauwens et al., 2020; Derks et al., 2022). These insights advance the understanding of how economic value capture relates to the creation of environmental/social value, when organizations pursue impact scaling. Specifically, they offer a novel perspective on this relationship, which helps to reconcile the different views offered by prior literature. For instance, some studies suggest the risk of misalignment between sustaining economic value capture and scaling environmental/social benefits (e.g., Bloom and Chatterji, 2009; Lyon and Fernandez, 2012). Other studies argue that digital technologies may facilitate the complementarity between environmental creation and economic value capture in a scaling endeavor (Gregori and Holzmann, 2020). However, this body of work largely adopted a "monolithic" view of economic value capture, overlooking the fact that different value capture models may be adopted in a collaborative setting. Our findings indicate that the choice of the value capture model in the initial setup of a DBMfS, or a BMfS more widely, significantly affects the available options for impact scaling. By showing that each value capture model presents distinct opportunities and challenges for diffusing a digital solution among additional partners, our study emphasizes the importance of examining specific value capture arrangements, when investigating the scaling of collaborative DBMfS.

As such, our study offers insights into the link between value capture models and impact scaling (Bauwens et al., 2020; Derks et al., 2022). Discussing this connection advances the understanding of the relationship between economic, environmental (and social) value in sustainable business modeling. Prior literature acknowledged that short-term economic incentives are often necessary for initiating sustainable business models and creating long-term, environmental benefits. While the higher collective goal of sustainability motivates partners to come together, each partner needs to capture value in the short term in order to establish a collaborative business model (Oskam et al., 2021; Stål et al., 2022). Although our findings focus on the initial setup of DBMfS, they already reveal that the initial value capture model significantly influences the options for scaling impact by involving more participants in the business model (Bauwens et al., 2020; Derks et al., 2022). For instance, in the retailer-led model, additional farmers can join the business model without needing resources. In contrast, in the cooperative model, additional farmers first need to buy into the DBMfS. Given that digital technologies can help to generate environmental benefits, it is important to understand these different pathways to impact scaling.

5.2. Managerial implications

Producing companies, but also many others, are currently grappling with the integration of digitally-enabled, new service offerings (Linde et al., 2021). This transformation extends beyond the adoption of these technologies, as it has significant implications for how companies operate and create and capture value. This development has profound impacts on companies' possibilities to increase environmental benefits but also simultaneously affects their investments, costs, revenue streams, risk management strategies. Companies must be able to handle these complexities while ensuring that their operations remain financially viable and scalable. We know that finding the right value capture mechanisms for digital services, can be particularly challenging (Parida et al., 2019), and this can become even more complex when partners are involved in collaborative business models. Here partners, each with their own objectives, have to align their interests to achieve shared sustainability goals. The integration of digital service offerings therefore demands a careful reconsideration of how value is distributed and sustained across different actors.

Yet, there is little research on value capture models to steer such collaborations. The lack of empirical insights makes it difficult for practitioners to develop business models that balance economic viability with environmental impact. Our findings are thus practically relevant for managers and entrepreneurs who aim to develop DBMfS, as we provide a typology that can support them in the choice of a suitable value capture model. Moreover, our insights raise awareness for the factors that may affect their decision and alter practitioners to the implications of different value capture models for scaling the impact of their DBMfS.

Beyond its immediate managerial relevance, our study shows a broader shift in the way companies must approach collaboration in the digital era. The emergence of digitalization has a profound impact on the need to collaborate, suggesting that success with these business models for the single partner depends on the ability to move away from a merely transactional to a relational form of engagement (Linde et al., 2021).

5.3. Limitations

Our research is subject to limitations. First, our analysis was based on a limited set of nine pilot cases within a European project in the agri-food sector. This sample small sample size as well as the sector-focus limit the generalizability of our findings. Future research should expand the number of cases studied to increase the robustness of the value capture models identified in the agri-food sector and beyond. While we selected the agri-food sector because it is a good example for a sector engaged in the use of digital technologies for sustainability and for the setup of DBMfS, it is also a sector with some specific characteristics (e.g., traditionally high-power imbalances between farmers and retailers, strong physical and local component in business model) that can limit the transferability of our findings to other sectors. On the other hand, we believe that the overall dynamics and types of value capture models we identified can help to study DBMfS in other contexts, such as inter-organizational collaborations for the circular economy or cross-sector partnerships in smart city initiatives.

Another limitation is that our study focused on the initial agreement between focal partners only. While we purposefully chose this focus, it glosses over the many other stakeholder involved in setting up DBMfS (see Section 2.1.) and the demand-side of the business models. Our one-on-one interviews focused exclusively on key pilot leaders due to their central role in the projects, we captured the perspectives of other stakeholders through business modeling workshops. These workshops allowed for broader stakeholder input, though we acknowledge the limitation of not directly interviewing all stakeholders.

Furthermore, we focused on the development phase; the pathways the pilots considered to scale impact were in a planning state. We therefore do not have any observations on the actual impact scaling achieved. Yet, already these plans and the discussions on challenges for impact scaling and how these could be addressed, demonstrated the importance of value capture models.

Lastly, we wish to discuss two points that are not per se limitations but important definitional pointers: First, among the many conceptualizations of scaling adopted in the literature (e.g., Bohan et al., 2024), we centered on impact scaling. This focus led us to conceptualize impact scaling not as the expansion of a single organization (Derks et al., 2022; Han and Shah, 2020), because increasing environmental value creation often requires the collaboration of multiple actors (Derks et al., 2022). Our conceptualization of scaling is also distinct from 'scaling deep', which refers to increasing the use of more sustainable products among existing users (e.g., Jolly et al., 2012). When digital technologies are leveraged to attain sustainability goals, it is paramount that their adoption is diffused among many actors, i.e., producers in the case of the agri-food sector. Second, in this study, we depart from the position that digital technologies have the power to contribute to environmental benefits. We are aware that this 'techno-optimistic' view is critiqued, and scholars point to the importance of carefully considering the unintended consequences and rebound effects that the use of digital technologies can have (e.g., Bohnsack et al., 2022). We support these calls, and believe our study holds interesting points for further exploration in this regard, such as the effects of value capture model choice for power dynamics between actors and the social aspects of sustainability.

5.4. Future research

For future research, our findings point to several interesting avenues. One highly relevant area is the power dynamics between actors, in connection to value capture models. In this study, we paid more attention to the dynamics influencing the choice of a value capture model but it would also be relevant to further explore the consequences of that choice on dynamics between actors. For instance, our findings from the agri-food sector show that producers and groups of producers - provided they have enough resources on their own - prefer to set up DBMfS without involving retailers. When actors choose not to collaborate, however, does it have implications for the pace of impact scaling and maximizing environmental benefits? In turn, if actors collaborate and the value capture model leads to shifts in power dynamics, what are the consequences? For instance, the cases we studied, collaboration with retailers was the only option for producers who wanted to use digital technologies for environmental benefits but lacked the resources. More longitudinal case studies would be needed to trace the consequences of value capture models on the pathways to impact scaling, and the consequences for the partners involved in DBMfS. Research on digital platforms, for instance, has pointed to a 'dark side' of deploying such platforms and argued that, in the long-run, their use might lead to the concentration of power and marginalization of interests of smaller firms (e.g., Asadullah et al., 2023). Are such effects also observable for DBMfS, or do digital technologies help smaller firms to participate in the sustainability-oriented transformation of sectors? Future research can explore these effects, using value capture models as an explanatory factor.

In addition, another promising avenue for future research concerns the reluctance of farmers to adopt digital technologies. While digitalization holds the potential to enhance sustainability in the agri-food sector, its adoption is often met with skepticism from farmers, who may perceive such technologies as costly, complex, or misaligned with traditional practices. Understanding the underlying reasons for this reluctance, whether they stem from trust issues, perceived risks, or lack of digital literacy, would provide valuable insights into how DBMfS can be designed to better address these concerns. Investigating how value capture models might influence farmers' willingness to engage with digital solutions could help identify mechanisms to encourage broader adoption and enhance the scalability of sustainability-oriented innovations.

A better understanding of the link between value capture models and impact scaling is also highly relevant for practitioners and policy-makers. Our findings indicate that actions aimed at maximizing the environmental benefits generated by digital technologies need to closely consider the value capture models that partners set up. Seeing value capture models as an important antecedent or barriers that can emerge in the scaling process helps practitioners and policy-makers to develop more targeted interventions and instruments for scaling the impact of DBMfS. For instance, policy interventions could play a key role in supporting the use certain value capture models over others, the experimentation with different value capture models, and in the facilitation of the collaboration between partners involved.

6. Conclusion

In conclusion, our study sheds light on the value capture models that exist for DBMfS in the agri-food sector. We propose a typology that enriches the understanding of value capture models and discuss the factors influencing the choice for or against a certain model. Our findings underscore the significance of considering the agreements partners make about investments and revenues in DBMfS, offering insights for both research and practice. Recognizing the differences in value capture models helps to better navigate the complexities of adopting digital technologies in pursuit of sustainability goals. This is relevant not only in light of fostering the adoption of digital technologies that enable environmental benefits, but also for discussing the implications of increasing use of digital technologies for the interaction between market participants.

CRediT authorship contribution statement

Andrea Kerstens: Methodology, Investigation, Formal analysis, Data curation, Conceptualization, Writing – review & editing, Writing – original draft. **Rick A.M. Gilsing:** Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization, Writing – review & editing, Writing – original draft. **Christina M. Bidmon:** Methodology, Investigation, Formal analysis, Conceptualization, Writing – review & editing, Writing – original draft. **Francesca Ciulli:** Methodology, Investigation, Formal analysis, Conceptualization, Writing – review & editing, Writing – original draft. **Frank T.H.M. Berkers:** Resources, Methodology, Funding acquisition, Data curation, Conceptualization.

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Appendix

A. Pilot cases

Pilot	Country	Description
Pilot 1	Greece	Pilot 1's smart farming solution advises farmers to optimize their practices and reduce resource use, based on data from sensors, farm calendars, and agronomist observations. The data is fed into a traceability solution to certify product sustainability. The solution generates data-driven insights on farming practices and enables digitalization, offered through an annual subscription. The traceability solution drives organizational innovation for retailers to communicate product quality and sell at a premium price, acquiring certificates to target different markets.
Pilot 2	Italy	Pilot 2 offers durum wheat farmers a decision support system (DSS) that provides insights and advice on farming operations, plant protection, and yield improvement. By periodically inputting farming data, the DSS generates model-based analysis that can reduce fertilizer and pesticide use, resulting in higher quality and production. The DSS is coupled with a parametric insurance service that compensates farmers for yield loss due to adverse weather conditions. The end-users are farmers, while a large retailer in Italy is the customer purchasing the solution to strengthen its relationships with its farmers and ensure a predictable durum wheat supply. Farmers access the insurance service, but pay for it themselves.
Pilot 3	France	Pilot 3 is a consumer platform that empowers communities to collectively decide on the characteristics of new products, which are then made available for purchase at associated retailers. The platform shows how the product price is built up and how each actor in the value chain receives a fair part of it. This enables consumers to deliberately make choices that fit their preferences or needs, driving production towards more sustainable practices, such as reducing CO2 emissions or ensuring appropriate remuneration for local farmers. Crowdsourcing technologies and applications give power to the consumers and the connected traceability solutions bring information from farm to fork. The connection to data from Smart Farming and farm logs will help feed the control process, increasing trust.
Pilot 4	Spain	Pilot 4 uses IoT technology to address traceability disconnection and lack of integrated data control in the greenhouse horticulture value chain in Spain. The pilot implements sensors within greenhouses to enable Smart Farming and Industry 4.0 processes, improving productivity, reducing costs, and increasing traceability data while avoiding human error. The solution is introduced to greenhouse farmers associated with a farmer's cooperative, who receive technical advice and data-driven insights from a technology provider. The collected data on soil quality, temperature, moisture, conductivity, and soil temperature enables tailored advice for sustainable farming practices, resulting in premium-quality produce sold to retailers. Certifiers verify that the product has been produced sustainably, allowing retailers to sell the product for a higher price while reducing costs and increasing predictability. This pilot demonstrates the benefits of IoT technology for the greenhouse horticulture value chain and promotes sustainable farming practices.
Pilot 5	Ireland	Pilot 5 focuses on providing a data-driven solution to farmers in Dingle, Ireland, by using sensors to collect data on farming practices. This data is then used to create a dashboard that generates insights on sustainability and efficiency of farming practices. With this solution, farmers can improve their decision-making processes and reduce water and fertilizer use. The dashboard also allows for increased transparency in farming practices, which can help farmers access new value chains and satisfy different consumers. The ambassador farms are the starting point for data collection, which is then aggregated at the dashboard level.
Pilot 6	Slovenia	Pilot 6 aims to increase soil health and treatment efficiency in Slovenia. The pilot will introduce precision farming techniques. The solution involves modern robotic platforms, drones, and Smart Farming sensor machinery, combined with an advanced advisory e-service for farmers. This technology will provide data-driven insights to support optimal fertilization and spraying applications, leading to improved soil health and productivity.
Pilot 7	Cyprus	Pilot 7 in Cyprus uses smart farming technology to help wine grape producers improve their efficiency and sustainability while also potentially accessing premium prices at retailers. Data on grape cultivation conditions is collected to provide advice to grape producers and communicate sustainability claims to retailers and consumers through digital labelling. The smart farming solution also generates learnings to be shared with other farmers in the region to promote improved sustainability for the climate and landscape of Cyprus.
Pilot 8	The Netherlands	Pilot 8 is focused on developing a technology-based solution to support a compensation system for farmers who optimize carbon sequestration on their land. The platform-based service provides data-driven insights to farmers, allowing them to improve their soil management and store carbon. The tool leverages model-based analysis to calculate carbon storage, which significantly reduces the costs of the service while providing reliable indicators and advice. The solution also enables farmers to earn validated carbon credits based on their carbon farming activities, which can be sold on open markets or to dedicated suppliers. The process involves generating machine data, applying compost, storing carbon, and collecting satellite data on soil performance, which is periodically verified by a third-party partner. A Dutch farmers' association connects farmers to end-users of carbon credits.
Pilot 9	Spain	Pilot 9 focuses on increasing digitalization in the agri-food sector through IoT technology to improve the sustainability and profitability of farm management. The solution provides data-driven insights to farmers and the tourism sector to create synergies and highlight the importance of agriculture for tourism. Additionally, the use of data can lead to internationally recognized certificates for compliancy and value creation.

B. Empirical details

Aspect	Actor	Case characterization	Exemplary data evidence
Willingness	Retailer	Retailer demonstrates significant willingness to achieve environmental impact by following GLOBALG.A.P standards, which aim to minimize environmental pollution, pesticide use, and improve flora and fauna in production areas.	"Description of the current problem: There is a need to improve the GLOBALG.A.P certification process… Certification is based on auditing the applied farming practices. Currently, farming practices are recorded manually… prone to errors and manipulations." (Interview notes Pilot 1, 17/02/2021)
Willingness	Producers	Producers recognize the importance of environmental impact by using technology to monitor sustainability and communicate their efforts to the public, thus aligning business and environmental goals.	"Sensors are placed at ambassador farms which collect data on the sustainability of farming practices. This data is aggregated at the dashboard level to support decision making or help communication of farming practices for agro-tourist services." (Pilot 5, Deliverable 3.11)
Willingness	Producers	Producers recognize the importance of environmental impact by optimizing their machinery to reduce fertilizer usage, leading to both environmental and financial benefits.	"Lots of farmers do have machinery that they do not use to its full potential… for the pilot, the farmers are very aware of the benefits for less fertilizing of this machinery. They also have already achieved cost savings." (Interview notes Pilot 6, 24/02/2021)
Willingness	Retailer	Retailers representing small scall producers are incentivized to work towards sustainability through digital solutions.	"Wineries on Cyprus are striving to be environmentally friendly, and wish to measure this impact and communicate and demonstrate it as well to consumers (and to comply to ongoing regulations)" … "digital technologies such as smart farming solutions and a knowledge sharing platform provide the evidence and information to do so" (Workshop notes Pilot 7, 13/7/2023).

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Aspect	Actor	Case characterization	Exemplary data evidence
Willingness	Retailer and producer	Both the retailer and producer exhibit significant willingness to achieve environmental impact, with the retailer's corporate social responsibility focusing on climate neutrality and producers adhering to strict sustainability guidelines.	"The retailer is part of a chain of organic food supermarkets and they only work with producers who follow sustainability guidelines." (Pilot 8, Deliverable 3.11).
Willingness	Producer	Producers are willing to support sustainability through digital solutions and adopt such solutions in practice.	"Farmers are keen to connect sustainable farming to service propositions based on agritourism, providing a different customer experience … such propositions can be enabled by the smart farming services deployed" (Workshop notes Pilot 9, 18/7/2022).
Ability	Producer	Individual producers have limited abilities to invest in advanced technologies due to financial constraints, reflecting a barrier to implementing environmental technologies.	"Almeria greenhouses are not very modern, the farmers don't have many finances." (Workshop notes Pilot 4, 4/4/2022)
Ability	Producers	Producers, particularly medium and large-scale farmers, have the ability to invest in advanced technologies, indicating stronger financial capability for modernizing farming practices.	"The solution central to SIP 6 is a combination of modern robotic platforms, modern in-situ sensors, IT supporting systems and Smart Farming machinery, wrapped up in an advanced advisory e-service to medium and large-scale farmers." (Pilot 6, Deliverable 3.11)
Investments	Retailer	The retailer (Barilla) makes the initial investment in technology, purchasing the solution for its farmers, representing retailer-driven investments.	"In this SIP, the farmers are the end-user of the solution package rather than the customer… Barilla, a large pasta producer in Italy, is considered the customer and intends to purchase the solution and provide this to its farmers." (Pilot 2, Deliverable 3.11)
Investments	Cooperative	UNICA, a cooperative, makes the investment in technology (sensors) and shares data insights with producers. These cooperative-driven investments centralizes technology acquisition and use for collective farming improvements.	"Hispatec advises UNICA on which sensors to buy. UNICA then buys the sensors and they will be installed… and send it to a cloud-server… UNICA permits access to this data to Hispatec." (Pilot 4, Deliverable 3.11)
Investments	Producer and retailer	Given its ability in terms of resources access and power to do so, the retailer can make the (initial) investments to support the deployment of a digital solutions (smart farming and knowledge sharing systems).	"Given its scale and access to resources, the large scale winery (OenouYi) can make investments for a digital knowledge sharing system, to enable knowledge sharing between farmers and wineries for the region" (Workshop notes Pilot 7, 13/7/2023).
Investments	Producer and retailer	Producers make the initial investment in carbon measurement technology, while the retailer provides financial compensation afterward, indicating shared investment.	"Efforts have been made to reduce carbon emissions… Farmers have to first put effort to acquire/invest in technology to measure carbon storage… the retailer compensates financially." (Pilot 8, Deliverable 3.11)
Investments	Producer	Producers make investments for the digital solutions.	"The agrifood cooperative (e.g., AgroMallorca or COOPBAL) part of the island supports the purchase of and access to the digital solutions such as sensors and smart farming systems" (Workshop notes Pilot 9, 18/7/2022).
Return on investment	Producer	Producers receive a fixed and agreed-upon percentage of the value captured by the retailer, ensuring stable financial returns and support for sustainable practices.	"Fair remuneration… helps producers to live with dignity from their work… adjusted according to their needs… Guaranteed minimum price does not fluctuate according to the market." (Pilot 3 website)
Return on investment	Producer	Cooperative generates return on investment through sales of produce cultivated through digital solutions which is shared among producers involved.	"Locally produced goods are sold to interested value chain partners (for example retailer Mercadona), for which the profits are shared among farmers involved". (Workshop notes Pilot 9, 12/9/2022)
Power Dynamics	Retailer	Power differences exist between the retailer and producer, for which the retailer can exert influence and control.	"The winery (OenouYi) has the scale and access to financial resources to exert influence over winegrowers in the region, with vineyard farmers sometimes becoming dependent or part of the operations of the winery" (Workshop notes Pilot 7, 10/1/2023).

Data availability

Data will be made available on request.

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