ISSN 1831-9424

European Commission

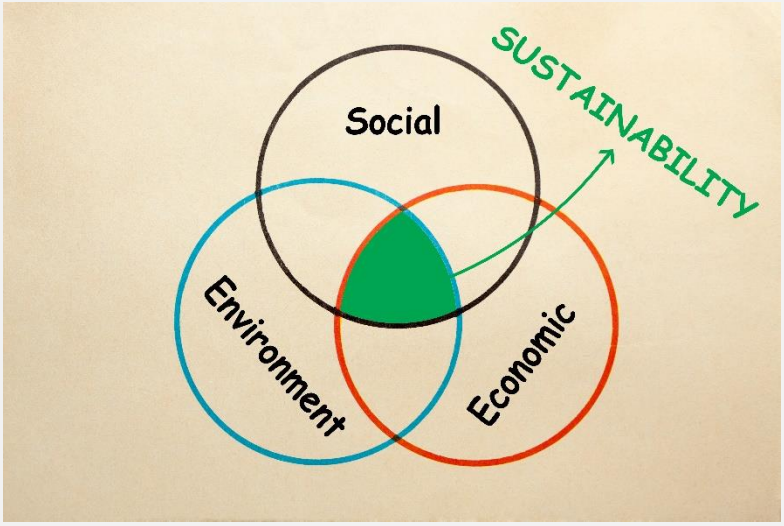
JRC SCIENCE FOR POLICY REPORT

Adoption of innovation and innovative sustainability initiatives by private operators in the EU food chain

Analysis based on semi-structured interviews

Solano Hermosilla, G., Antonioli, F., Ciaian, P., Pinedo Gil, J., Fernández Casal, L.

2023



Joint Research Centre

EUR 31228 EN

Contact information
Name: Pavel Ciaian
Address: C/Inca Garcilaso 3, 41092 Seville (Spain)
Email: pavel.ciaian@ec.europa.eu

EU Science Hub
https://joint-research-centre.ec.europa.eu

JRC129894

EUR 31228 EN

PDF ISBN 978-92-76-57031-8 ISSN 1831-9424 doi:10.2760/04819 KJ-NA-31-228-EN-N

Luxembourg: Publications Office of the European Union, 2023

How to cite this report: Solano Hermosilla, G., Antonioli, F., Ciaian, P., Pinedo Gil, J. and Fernández Casal, L., *Adoption of innovation and innovative sustainability initiatives by private operators in the EU food chain*, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/04819, JRC129894.

Contents

Abstract

The European Green Deal and its farm-to-fork (F2F) strategy have made sustainability in the food system an EU policy priority. It aims to help the EU's current food system transition towards a fairer, healthier and environmentally friendlier one while maintaining its economic viability. The F2F strategy signals action areas to the operators of the food chain, giving rise to opportunities and challenges. The adoption of sustainability-enhancing innovations plays an increasingly important role in this transition. It creates value for companies as they increase their competitive advantage, but also for society as a whole. However, there is limited information on operator-level sustainability initiatives across the food chain. To understand how regulations can effectively support the transition, it is important for policymakers to know which factors and barriers lie behind innovative sustainability initiatives, how they happen, and their expected implications and trade-offs across sustainability dimensions (economic, social/health and environmental) and stages of the food chain. For the purposes of this study, we have interviewed food operators, associations and related organisations to address this gap. Overall, 314 sustainability initiatives were identified, revealing that operators, to different extents, are introducing innovative sustainability initiatives to foster more sustainable food production and consumption processes. The identified initiatives emphasise, with some variation according to the stage of the food chain in question, the pivotal role of the economic dimension, followed by that of the environmental dimension, and the weaker coverage of the social/health dimension. The interviews also revealed that the market's supply and demand requirements are the main driving factors for adopting sustainable initiatives. Interviewees consistently indicated that the lack of recognition of the sustainability efforts by consumers prevents the adoption of sustainable initiatives. Additionally, public support, clarity and harmonisation in the regulatory framework, funding for improved sustainable solutions and government technical support (i.e. for micro-businesses such as farmers) appear to be also essential catalysts for the adoption of sustainability initiatives in the private sector. Finally, the results also highlight the importance of collaboration and knowledge exchange between operators in the food system and with third-party institutions for sustainability innovation to happen. Collaboration with external third parties and vertical collaboration are more common and more acceptable for operators, from a strategic choice point of view, compared to horizontal collaboration. Horizontal collaboration seems to be more relevant to certain stages of the food chain (e.g. the farming sector, where innovating on an individual basis is more challenging) and to the promotion of sustainability issues that are not directly related to the core business activities of the operators involved. The findings of this report are important to operators and policymakers concerned with innovation on sustainability in the food system.

Acknowledgements

The authors are grateful to Giampiero Genovese, Head of the Economics of Agriculture Unit at the Joint Research Centre of the European Commission, for the support and insightful suggestion for the report. We would also like to acknowledge the support of Alexander Stein and Fabien Santini from Directorate-General for Agriculture and Rural Development and Adrian Leip from the Directorate-General for Research and Innovation for their guiding comments during the conception of the project. Finally, the authors would like to thank all the participants in the interviews, without whom this work could not have been carried out.

Authors

Gloria Solano-Hermosilla, European Commission, Joint Research Centre (JRC), Seville, Spain, at the time when this research was conducted; currently working at Pablo de Olavide University, Seville, Spain

Federico Antonioli, European Commission, Joint Research Centre (JRC), Seville, Spain

Pavel Ciaian, European Commission, Joint Research Centre (JRC), Seville, Spain

Julia Pinedo Gil, CARTIF – Technology Centre, Boecillo (Valladolid), Spain

Laura Fernández Casal, CARTIF – Technology Centre, Boecillo (Valladolid), Spain

Executive summary

The European Green Deal and its farm-to-fork (F2F) strategy have made sustainability in the food system a policy priority in the EU, aiming to help the current EU food system transition towards a fairer, healthier and environmentally friendlier one. The F2F strategy signals different areas of action to the operators of the food chain, giving rise to both opportunities and challenges in switching towards more sustainable food production and consumption. Innovation plays an increasingly important role in this transition. Companies and businesses in the food sector are expected to embed the concept of sustainability in their decision-making process and operations via sustainability-enhancing initiatives. The goal of these initiatives is to innovate products and practices, creating value for the company as it increases its competitive advantage, but also for society as a whole. However, there is limited information on operator-level sustainability initiatives across the food chain. To better understand how regulations can effectively support the transition, it is important for policymakers to know which factors and barriers lie behind innovative sustainability initiatives, how innovation happens and the expected implications and trade-offs across different sustainability dimensions (economic, social/health, and environmental) and stages of the food chain.

This report attempts to bring evidence on and provide a comparative assessment of sustainability innovation and innovative initiatives adopted by private operators in the EU food chain, based on data collected through semi-structured interviews with 37 representatives of food chain operators, associations and other related organisations. Overall, 314 sustainability initiatives were identified from the responses provided by respondents. The results reveal that operators from the food chain are introducing, to different extents, innovative sustainability initiatives to foster more sustainable food production and consumption processes. The identified sustainability initiatives emphasise the pivotal role of the economic dimension, followed by that of the environmental dimension, and the weaker coverage of the social/health dimension. Concerning sustainability performance, on average, the initiatives target 22 % of benefits out of a total of 12 identified benefits as represented by the sustainability impact indicators (SIIs). Results also shed light on the main drivers, barriers and financial and policy incentives involved in the adoption of sustainable initiatives, suggesting the presence of demand and supply related factors as a necessary condition for the uptake of sustainable initiatives by operators. Recognition of sustainability efforts on the consumer market, collaboration with other actors in the food chain and third-party institutions, public support, clarity and harmonisation in the regulatory framework, incentives and funding for improved sustainable solutions and government technical support (i.e. for micro-businesses such as farmers) are notably seen as essential catalysts for the adoption of the sustainability initiatives in the private sector. Finally, the results from the interviews also highlight the importance of collaboration and knowledge exchange for the sustainability innovations to happen. Collaboration with external third parties (e.g. universities, research centres) and vertical collaboration (between operators at different stages of the food chain) are more common and more acceptable from a strategic choice point of view for operators compared to horizontal collaboration (between operators from the same stage of the food chain). Horizontal collaboration seems to be more relevant for certain stages of the food chain (e.g. the farming sector) and to the promotion of sustainability issues that are not directly related to the core business activities of involved operators.

Policy context

The European Green Deal has brought renewed attention to the sustainability of the food chain. European food is known for its high safety and nutritional and quality standards. Now it should also become a standard of sustainability (COM, 2019). The F2F strategy, a key component of the European Green Deal, aims to transform EU food systems by supporting 'sustainable food along the whole value chain', considering the three pillars of sustainability – competitiveness, climate and health, i.e. the economic, environmental and social dimensions. The F2F strategy signals different action areas to the operators of the food chain, giving rise to both opportunities and challenges in switching to more sustainable food production and consumption. Innovation plays an increasingly important role in this transition. Individual actors of the food chain can contribute to the sustainability of the final product or business process with their own independent, innovative practices. However, including multiple actors of the food chain in the innovation process may contribute to achieving higher improvements, thus pointing to the need to take a holistic, system-wide approach in the analysis of innovative sustainability initiatives in the food chain. It is important that this approach take into account all stages of the food chain, the interactions between food chain actors, and the trade-offs between the economic, social and environmental contexts in which these actors operate. In this context, policymakers need to know what factors promote or constrain sustainability innovation along the food chain and understand what policies can help and how.

Key conclusions

Overall, the report concludes from the interviews that operators link the idea of achieving sustainability in its various facets in food production and consumption with the introduction of different types of innovations. Accordingly, various initiatives aiming at innovating products, processes, organisational aspects and marketing activities and introducing technological/digital improvements to move towards more sustainable production and consumption dynamics have been adopted by different operators of the EU food system. For most operators, sustainability innovation is a way to improve their competitiveness either by creating value through product differentiation or improving efficiency, while at the same time trying to minimise environmental impacts and/or positively affect social/health aspects.

The economic dimension of sustainability seems the most important pillar for private operators when adopting sustainable initiatives, followed by the environmental dimension, whereas the social (including health) dimension is covered to a much lesser extent.

The most important driver that needs to be present for the private sector to adopt sustainable initiatives is favourable supply and demand conditions, but the lack of recognition of the sustainability efforts by consumers prevents the adoption of sustainable initiatives. This requires increasing awareness of consumers and the whole food chain about products and processes' environmental and social/health aspects. It appears essential to inform, motivate and raise consumer awareness with transparency and clarity so that consumers can value sustainable products and accept to pay the higher price they represent. Some important drivers stimulating the adoption of sustainability initiatives of many operators are also the reputational effect and operators' intrinsic motivation to be sustainable.

On the other hand, the main barrier seems the lack of public support and/or lack of clarity in the current policies regarding sustainability, pointing to the need for government guidance, i.e. a more comprehensive food system vision with an adequate regulatory framework that is harmonised and inclusive of all stages of the food chain and clear legislation across EU Member States. Beyond increasing consumer awareness, some other important catalysts for the adoption of the sustainability initiatives, particularly for smaller operators, are additional incentives and funding for improved sustainable solutions and government technical support.

Main findings

The quantitative analyses of the interviews show that the vast majority of initiatives identified by respondents (86 %) are expected to generate economic benefits; environmental benefits were reported to be generated by 64 % of initiatives and social benefits by around 33 % of initiatives. The fact that no negative impacts on the sustainability dimensions are reported suggests that operators adopt only those initiatives that are expected to generate primarily positive sustainability benefits (particular economic ones) without compromising any sustainability aspects or giving rise to any under-estimated negative sustainability impacts.

The sustainability performance of the studied initiatives indicates that, on average, the analysed sustainability initiatives are expected to generate 22 % of benefits out of the total identified benefits (as represented by SIIs). In other words, on average, each initiative generates approximately at least two benefits out of the total 12 benefits (as given by SIIs) across the three dimensions of sustainability.

The economic pillar shows the highest scores (33 %), followed by the environmental pillar (23 %) and the social pillar (9 %). However, when looking at the stages in the food chain, the packaging and retailer and wholesale sectors seem to have similar scores for the economic and environmental pillars. The social objective seems to be less important for all food chain stages, but some stages such as retail and wholesale and manufacturing have higher social scores than the rest. We also observe that higher scores for sustainability performance are associated with product and process innovation, whereas technological innovation is associated with lower scores.

Related and future Joint Research Centre work

Previous work at the Joint Research Centre has analysed technologies and practices aiming at addressing certain sustainability aspects (e.g. mitigating greenhouse gas emissions from agriculture, biodiversity) or incentives affecting R & D and the adoption of innovations. The focus was particularly on specific technologies – such as precision agriculture, cover crops and other food sector related technologies – and how they impact different sustainability aspects, productivity and economic performance (e.g. Fellmann et al., 2021; Garzon Delvaux et al., 2018; Smit et al., 2019; Soto et al., 2019). The present study extends the scope to operators along the entire food chain, focusing on technological and non-technological innovations in products, processes,

marketing and business models, and expected sustainability performance in economic, social/health and environmental terms. Furthermore, this study also served as a basis for designing an online survey for food operators with the purpose of collecting more representative information on sustainability initiatives adopted in the entire food chain. The online survey was carried out between 22 November 2021 and 15 April 2022. The subsequent analysis of the online survey will provide robustness to the results obtained and shed more light on the current state of sustainability innovations at the operator level, at all stages of the food chain, and their expected sustainability performance in the three dimensions of sustainability.

Quick guide

Section 1 provides an introduction, giving some details on the policy context and a concise up-to-date review of the relevant literature regarding innovation and sustainability. Section 2 details the methodology, particularly regarding the interviews' structure and the rationale of the coding strategy. Section 3 gives the reader a general but useful profiling of the respondents in terms of geographical coverage, sectors and agents of the EU food system. Sections 4, 5 and 6 provide a deeper analysis of the results, particularly in terms of sustainability initiatives adopted by respondents, their nature in terms of sustainability pillars, the drivers, barriers and policies affecting them, and, finally, to what extent the food systems' operators are aware of existing sustainability-related policies, the degree of collaboration in the food system and the measurement of sustainability. Section 7 provides an indicator of the sustainability performance for the adopted innovations. Finally, Section 8 concludes on the results presented in the previous sections.

1 Introduction

The European Green Deal and its farm-to-fork (F2F) strategy have made sustainability in the food a policy priority in the European Union (EU), aiming to transform the EU food system to make it fairer, healthier and environmentally friendlier. Recent estimates place the worldwide food system responsible for one-third of greenhouse gas emissions (Crippa et al., 2021) ([1]) and agro-biodiversity, forest, ecosystems and soil fertility losses, while unhealthy diets are leading to obesity and non-communicable diseases (Afshin et al., 2019; Leach et al., 2020). The F2F strategy signals different areas of action to the actors of the food chain, giving rise to opportunities but also challenges in the transition towards more sustainable food production and consumption. It includes, among other things, the promotion of sustainable agricultural practices – for example precision farming, agro-ecology (including organic farming), stricter animal welfare standards and innovative ways to protect harvests from pests and diseases. It is also about reducing the environmental impact of the food processing and retail sectors (e.g. transport, storage, packaging and reducing food waste) and stimulating a more sustainable and healthier food consumption (e.g. by exploring new ways to inform and empower consumers to make healthy choices, with private and public standards and labelling). Innovation plays an increasingly important role in this transition (Herrero et al., 2020). Companies and businesses in the food sector are expected to embed the concept of sustainability in their decision-making and operations by taking sustainability initiatives. The aim of these initiatives is to innovate on products and practices, as a way to create value for the company and society and increase their competitive advantage in terms of cost and offer, through differentiation (Porter, 1985). As such, opportunities for sustainability innovation (technological and non-technological) are described as commercially viable initiatives, for example introducing new or improved products, processes, marketing strategies, organisational practices and business models, which also advance environmental and social sustainability (Adams et al., 2016; Jenkins, 2009). Most importantly, innovation may help overcome drawbacks such as the sustainability–affordability dilemma (e.g. higher food prices to reduce the environmental impact of food production may also generate social losses as food becomes less affordable) by targeting one or more sustainability dimensions without damaging the others (i.e. 'Pareto improvements') (Barrett et al., 2022). Companies and businesses implicitly or explicitly make a cost–benefit analysis to weigh the costs of implementing innovative sustainability initiatives against the costs of being unsustainable – e.g. from outdated and inefficient production processes, high waste or unused by-products and public or private penalties – also taking into account gained efficiencies (Bocken & Short, 2021) or the benefits from premium prices (Ross et al., 2015).

Empirical literature usually investigates innovative sustainability-oriented practices at different stages of the European food chain (e.g. agricultural sector, food industry) (Balafoutis et al., 2017). However, less is known about innovative sustainability initiatives across the entire food chain (i.e. input providers, famers, manufacturers, wholesalers and retailers, packaging, transport and logistics) and their overall sustainability performance (Meynard et al., 2017). Policymakers need to know the factors behind innovative sustainability initiatives and the main barriers that food operators encounter along the way, as well as the expected implications and trade-offs for sustainability in economic, social and environmental terms and across the different stages of the food chain. This is relevant to our purpose of better understanding how regulation can support the transition, which policies are needed and whether factors, implications and policy needs differ across countries and stages in the food chain.

In this context, this report aims to present a brief but comprehensive comparative assessment of sustainability innovation and innovative initiatives adopted by private operators in the EU food chains in selected Member States. In other words, this report covers private actions undertaken by operators along the food chain to pursue sustainability, their drivers and barriers, including financial and policy factors, collaboration approaches and their expected sustainability performance. This approach is in line with the application of a holistic system approach to respond to the challenge of understanding the complexity of sustainability in the entire food sector. Sustainability innovation decisions are made mainly at the company level, but impacts can affect different system components (e.g. food system actors, environment and society) and lead to enhanced sustainability innovation at the system level (Adams et al., 2016). Accordingly, analysing the food system entails examining the relationship between certain activities in the food chain (i.e. agricultural production, food processing, distribution and consumption), the actors involved and the environmental and socioeconomic outcomes of these actors, while determining the relevant drivers (i.e. economic, political, social) (Fanzo et al., 2017; Galli et al., 2020). Our focus is on innovative sustainability activities.

([1]) According to Crippa et al. (2021), in 2015, food-system emissions amounted to 18 gigatonnes of CO_2 equivalent per year globally, representing 34 % of total greenhouse gas emissions.

In the literature, the study of innovation and drivers is often framed within the debate between technology-push (knowledge-induced), market-pull (demand-induced) or a mix of both, and regulatory-push/pull innovation theories (Horbach et al., 2012; Mowery & Rosenberg, 1979; Schmookler, 1966). The literature on sustainability innovation stresses the role of demand in sustainability innovation (i.e. eco-innovations). It considers that market incentives are essential to create favourable investment conditions for operators to partake (Horbach et al., 2012; Schmookler, 1966). However, the literature also recognises the role of policies (Arfaoui, 2018; Rogge & Reichardt, 2016), research and development (R & D) spending and factors related to the operator's characteristics and the competitive environment, suggesting that different policy incentives may be needed for different operator types and innovation types with sustainability impacts (Traill & Meulenberg, 2002). Operator-level innovative sustainability initiatives are mainly considered to be driven by sustainability awareness and the entrepreneurial opportunity it brings, suggesting that introducing innovations such as new products and services, new processes or new technologies is feasible at prices that exceed their production costs (Shane & Venkataraman, 2000). Moreover, the literature suggests several forces influencing companies' decision to become sustainable: complying with regulatory requirements (or pre-empting mandatory regulations), cost factors, stakeholder pressures, competitive requirements (Berry & Rondinelli, 1998), social and environmental ethics and responsibility, company reputation (Bansal & Roth, 2000) and creating 'shared value' (i.e. simultaneously enhancing business success and social benefits) through value chain innovation (X. Chen et al., 2022; Porter & Kramer, 2011; Ross et al., 2015). Furthermore, sustainability innovation requires having appropriate resources and adapting food operators' capabilities and skills (Cagliano et al., 2016). Operator size, (well-managed) organisational slack and access to finance are related to the adoption of sustainability practices, fostering a long-term vision and the development of dynamic capabilities that promote business adaptation and resilience in changing environments (Shu et al., 2020; Teece, 2009). In contrast, economic uncertainty, insufficient resources, the lack of a formal innovation strategy, excessive administrative regulations and the lack of or inefficient regulations are found to be important barriers to innovation success, as well as constraints in technology access and insufficient knowledge and skills (Fortuin & Omta, 2009; Mehmood et al., 2021). However, to be innovative, companies do not need to rely only on internal competencies and resources. They can absorb and use knowledge and resources from outside through different forms of cooperation (Kühne et al., 2015) with suppliers and buyers (vertically), sometimes with competitors (horizontally) (Fortuin & Omta, 2009) and external institutions (third party) such as international institutions, universities and research centres. The latter may facilitate the flow of knowledge and technology between science and businesses, leading to more efficient innovation systems (Daniluk, 2017). Thus, innovation is increasingly seen as the outcome of a collaborative process involving various stakeholders within and outside the company (Krishnan et al., 2021), which highlights the need for a holistic approach in the analysis of the food chain. Moreover, the entrepreneurial orientation of food operators (or their propensity to undertake uncertain, risky and innovative initiatives) drives the knowledge-acquisition process and the collaboration performance (Dung et al., 2020).

Policies and the right policy mix can play an essential role in promoting the food system transition by pushing or pulling sustainability innovation (Gault, 2018; Rogge & Reichardt, 2016). At the same time, the literature identifies policy gaps and misalignments in sustainable food production, distribution and consumption and sustainable food environments (Galli et al., 2020). Lastly, an important factor for a successful sustainability innovation is measuring, monitoring and managing the innovation performance in economic, environmental and social/health terms (Fortuin & Omta, 2009). For this, generally-accepted indicators, frameworks and guidelines such as the Global Reporting Initiative (GRI) indicators can be helpful, despite the well-known issue that defining the right indicators and measuring them can be difficult for companies (Nikolaou et al., 2019). The literature suggests both monetary and non-monetary indicators (i.e. not measured in monetary terms) to measure business, environmental and social benefits from sustainability management (also referred to as corporate social responsibility) (Weber, 2008). Examples of indicators for measuring operator- or chain-level sustainability performance from the business perspective are efficiency gains, cost reduction, differentiation, improved competitiveness, improved relations with stakeholders, improved reputation and employee attraction/motivation/retention (Weber, 2008). From the environmental and social perspective, there are indicators such as the carbon footprint (efficiency strategies), tonnes of non-natural materials / product units, the degree and time of product biodegradability, the percentage of renewable energies, the number of fair-trade products (substitution strategies) and the number of reduced products (sufficiency strategies) (Schaltegger & Burritt, 2014). Remarkably, fewer indicators can be found for the social aspects (Latruffe et al., 2016).

Building on this literature, this report analyses data on adopted sustainability innovation and innovative initiatives collected through semi-structured interviews with 37 representatives of food chain operators or associations and other organisations that represent their interests or provide them with services. The structured

interviews were carried out within the Joint Research Centre financed IN-PACT ([2]) project between 10 May 2021 and 22 November 2021 ([3]). Overall, the project covers 314 innovation and innovative sustainability initiatives from 13 EU Member States. Some respondents are EU-level associations or multinational companies, implying a wider coverage of the entire EU or a group of Member States. The report presents a brief but comprehensive assessment of the following aspects concerning the detected 314 sustainability initiatives ([4]):

- innovation types and sustainability orientation of the covered sustainability initiatives;
- drivers and barriers affecting the adoption of sustainability initiatives;
- financial factors and policy incentives affecting the adoption of sustainability initiatives;
- awareness and innovation capabilities, collaborative approaches to sustainability initiatives and performance indicators by operators;
- sustainability performance of the covered initiatives.

Overall, this report contributes to the understanding on how the private sector in the EU food system is undertaking the transition towards sustainability. It does so by identifying operators' sustainability initiatives, their expected performance considering the three dimensions of sustainability and the factors and tools that policymakers should use and emphasise to encourage the behavioural change needed for a smooth and rapid move towards a more sustainable food sector. Prior research has often explored the innovation impact only from one particular dimension of sustainability, with the majority of efforts devoted to the economic and environmental dimensions, while far less attention has been paid to the social/health dimension (L. Chen et al., 2017). Moreover, this report looks beyond technological innovation and digitalisation in the food sector (Miranda et al., 2019; Reinhardt, 2022) by analysing the overall contribution of changes in practices and processes, thereby enabling a better understanding of how technological change is connected to changes in all areas in the quest for sustainability (Klerkx & Rose, 2020).

([2]) Sustainable innovation and innovative practices in the agri-food supply chain (IN-PACT), https://www.cartif.es/en/in-pact-en/?msclkid=f4ddb77ab1cd11ecb35f1b5e54847fb3.

([3]) Interviews were conducted by the CARTIF Technology Centre, a horizontal, private and non-profit research institution whose main mission is to provide innovative solutions to various industries to enhance their processes, systems and products, improve competitiveness and create new business opportunities (www.cartif.es).

([4]) To complement the analysis, the information obtained from the interviews was used to design and launch an online survey targeting operators from the EU food chain. The online survey results will be provided in a separate report.

2 Methodology

2.1 Structured interviews

The structured interviews were conducted between 10 May 2021 and 22 November 2021. The interviews aimed to obtain in-depth information about the extent to which operators in the food chain are innovating products and practices to move toward more sustainable food production and marketing. How this is happening? What are the drivers and barriers? To what extent is regulation needed? The aim was to bring empirical evidence to policymakers, but also to understand the benefits expected by operators in the different dimensions of sustainability (economic, environmental and social).

For the purpose of the interviews, sustainability innovation and innovative initiatives were defined as the introduction of new or improved products, processes (production, marketing and organisational) and technologies/digitalisation related to improving the economic, environmental and social (including health and nutrition) dimensions of sustainability, which impact not only the company but also society as a whole (Adams et al., 2016).

The structured interviews consisted of 21 questions (see questionnaire in Annex 1) divided into four sections: (i) general information about the respondent and the business or organisation they represent; (ii) questions about innovative sustainability initiatives; (iii) questions about the innovation strategy and about drivers, barriers and sustainability implications; and (iv) questions about EU and regional policies supporting sustainability innovation and what is needed in that regard. The list of innovative sustainability-oriented initiatives was then extracted from the interviews and categorised. Information on drivers, barriers and financial and policy incentives, along with interviewees' expected benefits in terms of the sustainability dimensions and how innovation happens, was also extracted from the interviews.

In total, around 166 operators or associations representing their interests were contacted to participate in the structured interview. A total of 37 respondents accepted the invitation and were interviewed: 25 were companies based in the EU (operators) operating at different stages of the food chain (i.e. famers, manufacturers, wholesalers and retailers, and providers of services such as packaging, transport and logistics) and 12 were European associations and other organisations representing the interests of or serving these companies ([5]). Interviews were conducted online via a videoconference platform, and interviews were always recorded with the consent of the interviewee. The associations and other organisations (e.g. farmers' associations, trade associations, associations of food processing firms, retail associations, technology and research centres and innovation clusters) participating in the structured interviews were expected to provide the targeted information based on their knowledge of the sector. Given that several respondents were multinational companies or EU-level associations, they were also expected to represent wider regional coverage than the Member State where they were located (e.g. EU-level for the EU-level associations).

The data of the structured interviews is based on convenience samples and are not representative of the underlying population. The operators were selected to provide a mix of large, medium-sized and small companies and to cover of a range of product sectors, food chain stages and countries of different EU regions. The positions of the people interviewed varied by operator and organisation, but generally included the managing director, president, owner, R & D director, innovation manager or the sustainability director, i.e. people who can provide relevant insights on innovation, sustainability strategies and related activities in the represented businesses. Finally, while we acknowledge the selection bias of only interviewing operators who innovate for sustainability, one can argue that those who engage in sustainability-oriented innovation can give more relevant insights into the driving and constraining factors and expected sustainability impacts.

2.2 Interview coding methodology

After conducting the interviews, the transcription of collected information was processed and coded, which facilitated a more effective analysis. Qualitative coding allows us to categorise information, which in turn allows us find themes and patterns in a systematic manner. In practice, this study uses a mixed deductive–inductive coding method; keywords and codes are defined before and during the data-collection phase. The classification of sustainability innovative initiatives into innovation categories relies on the classification provided by the Oslo Manual ([6]) (i.e. product, process, organisational and marketing innovations) (OECD/Eurostat, 2005, 2018).

([5]) This implies an approximate response rate of 22 %.

([6]) The latest version of the Oslo Manual distinguishes between product innovation (new or improved good or service introduced in the market significantly different from the firm's previous goods or services) and business process innovation (new or improved business

Furthermore, the digitalisation megatrend is becoming progressively more relevant to food systems nowadays and promises to be disruptive (Ehlers et al., 2022; Prause et al., 2021; Trendov et al., 2019); therefore it deserves special attention. Indeed, scholars agreed that digitalisation is the most effective and rapid (and probably unique) process to help the agricultural sector transition towards sustainability (Basso & Antle, 2020; Davies, 2020; Reinhardt, 2022). Accordingly, the F2F strategy expects that digital tools will support the sustainability of the EU food sector (European Commission, 2020). So far, the academic literature has primarily focused on the farming sector (Basso & Antle, 2020), while digitalisation is occurring at every step of the food chain, embracing the entire food system (Prause et al., 2021; Trendov et al., 2019).

Accordingly, the technological/digital innovation category was added to identify those product or process/practice innovations concerning technological or digital solutions, hence providing an additional piece of information to explore to what extent the food system relies upon digital tools. The latest version of the Oslo Manual (OECD/Eurostat, 2018) also recognises the importance of understanding digitalisation in the context of innovation. The classification of the sustainability initiatives into categories and the expected economic, environmental and social impact is derived from the GRI indicators (Global Reporting Initiative, 2021). Finally, the review of the relevant literature together with the recurrence of information collected during the interviews have contributed to the final list of sustainability initiatives, types of expected impacts and the categories of drivers, constraints and collaborative approaches. To ensure inter-rating reliability, interviews were codified independently by four researchers; when differences arose between assigned codes, one additional expert was consulted to agree on the final coding structure.

In the first step, based on interviews, a total of **314 initiatives** (see Annex 2) were identified and classified into **65 types of sustainability initiatives** and, as explained above, organised into the following **five innovation categories** (see Annex 3 for further details):

- product innovation (e.g. development/introduction of improved or new product and services to meet demand for more healthy and sustainable products, development/introduction of improved or new and more sustainable inputs for production, development/introduction of new/smart packaging material);
- process innovation (e.g. development/introduction of improved or new production, delivery – including logistics and distribution – and business models for more efficient and sustainable production and commercialisation);
- organisational innovation (e.g. reorganisation of the supply chain relationships, the acquisition of firms to acquire new sustainable technology or products and the establishment of business alliances to develop/introduce more sustainable technology/products);
- marketing innovation (e.g. development/introduction of new marketing, sales and after-sales support methods involving significant changes in packaging design, product placement – i.e. marketing channels, product promotion or pricing; development/introduction of improved or new sustainability labelling/information and private standards/certification); and
- technological/digital innovation (e.g. development/introduction of improved or new technology/digital solutions for more sustainable farm and manufacturing production, distribution and consumption).

In a second step, for each initiative reported by the respondent, operators identified what they expected from its application, namely economic, environmental or social benefits (or costs). In turn, different sustainability impact indicator (SIIs) were generated based on GRI indicators and the literature review previously performed. Overall, for each dimension of sustainability – economic, social and environmental – 4 SIIs were assigned, for a total of 12 SIIs. The SIIs were further divided into sub-indicators (Table 1), with the aim of providing more detailed information about their impact.

The impacts concerning the economic dimension mainly refer to the improvement of the economic situation at both the operator (i.e. its financial performance and competitiveness) and system levels (i.e. local, national and international levels), besides the need to comply with legal regulations. From the environmental perspective, impacts refer to the reduction of negative externalities for the natural system, particularly concerning the use (and re-use) of resources and compliance with environmental regulations. Finally, social impacts refer to improving labour practices at both the operator and supply-chain levels, ameliorating product responsibility (i.e. healthier and safer products), contributing to societal issues (e.g. preventing emigration from marginal areas,

process for one or more business functions – production of goods or services, distribution and logistics, marketing and sales, information and communication systems, administration and management, product and business process development – brought to use in the firm and significantly different from the firm's previous business processes) (OECD/Eurostat, 2018).

supporting the employment of weaker worker categories or donating to food banks or other) and complying with societal regulations (Table 1).

For each initiative a series of factors that define sustainability impact indicators (SSI) were collected from the interviews (see Annex 4) and were evaluated based on the respondents' responses. We assign a score of 1 if they are mentioned by the interviewee as having an expected positive impact, a score of -1 if they are expected to produce a negative impact, and 0 otherwise.

Relying on the approach followed to define SIIs, we also identify drivers, barriers, financial and policy factors and policy incentives, along with different implementation and collaborative approaches affecting the adoption of sustainability initiatives (see Annex 5). Each category of drivers, barriers, the financial and policy factors and implementation and collaborative approaches is assessed based on interviewees' responses, getting a score of 1 if they are mentioned and 0 otherwise.

Table 1. Sustainability impact indicators

Categories of sustainability		
Economic	**Environmental**	**Social**
Direct economic performance – Increasing sales – Improving efficiency	**Reducing negative externalities** – Renewable energy – Biodiversity – Animal welfare – Emissions – Land use – Inputs/materials	**Labour practices (*in situ*, along the food chain)** – Labour/management relationships – Occupational health and safety – Training and education – Diversity and equal opportunity (incl. women, disadvantaged) – Fair conditions along the chain
Competitiveness and growth – Company/product differentiation – Market growth	**More efficient use of resources** – Water – Energy – Chemicals – Other inputs	**Product responsibility** – Costumer health and safety – Product labelling – Marketing communications
Indirect economic impacts (external) – Support the local economy – Focus fair chain	**Waste management** – Minimising and diverting loss/waste from disposal – Recycling, recycled materials	**Society** – Promoting food security (e.g. donation to food banks), solidarity/social programmes
Compliance (public or private)	**Compliance (public or private)**	**Compliance (public or private)**

Source: based on GRI Indicators List, GRI Index G3, G4 – 2021.

In the third and final step, the **sustainability score** is calculated at two different levels.

- At the specific economic-, social- and environmental-pillar levels. The score is calculated for each sustainability pillar as the share of the interviewee's expected benefits (or costs) in any of the SIIs considered, over the total number of SIIs (four SIIs per pillar) (Table 1). A score of 1 represents the maximum value of the score and indicates that for a given initiative, the interviewee expects benefits from all 4 considered SIIs (e.g. direct economic performance, competitiveness and growth, indirect economic impacts and compliance, in the case of the economic pillar). In contrast, a score value of 0 indicates that, for that initiative, the interviewee did not expect any benefits from the given sustainability pillar.

- **At the global level, considering the three pillars together.** The global sustainability score is calculated as an average of the three sustainability pillars (economic, environmental and social). As above, a score of 1 represents the maximum value of the score – if the global score is 1, this means that for a given initiative, the interviewee expected benefits to occur for all considered SIIs across all the three pillars. In contrast, a score of 0 indicates that for a given initiative, the interviewee did not expect any benefits across any SIIs and pillars.

Note that the sustainability score does not measure the absolute sustainability performance of the considered initiative. It only attempts to evaluate the relative sustainability performance of a given initiative as compared to all the remaining initiatives. Furthermore, the score measures the presence of expected sustainability benefits (or costs) of initiatives as suggested by interviewees and does not provide an actual measurement or quantification of the magnitude of the benefits (or costs). Finally, the specific benefits (costs) considered within the sustainability score are not exhaustive as they only include those indicated spontaneously by interviewees for the initiatives considered.

3 Respondents' profiles

This section describes characteristics of respondents who participated in the structured interviews. The analysis focuses on describing the distribution of respondents in terms of geographic coverage, stage in the food chain, sector and business size.

Figure 1 shows the profile of respondents with respect to the country of origin. The 37 respondents come from 13 EU Member States, with more than one-third being based in Spain, followed by Belgium and France with 4 respondents each ([7]). The rest of the Member States represented have less than 4 respondents per country. Though 37 is above the range of 15–30 interviewees suggested in the literature for case studies (Marshall et al., 2013), the sample is not representative across different Member States, given that some Member States (in terms of size of the food sector) are over-represented, while some bigger ones are under- or not represented at all. Also, some respondents are EU-level associations or multinational companies, meaning they indirectly cover several Member States or the entire EU.

Figure 1. Respondents by Member State and by stage of the food chain (% of all respondents; number of all respondents)

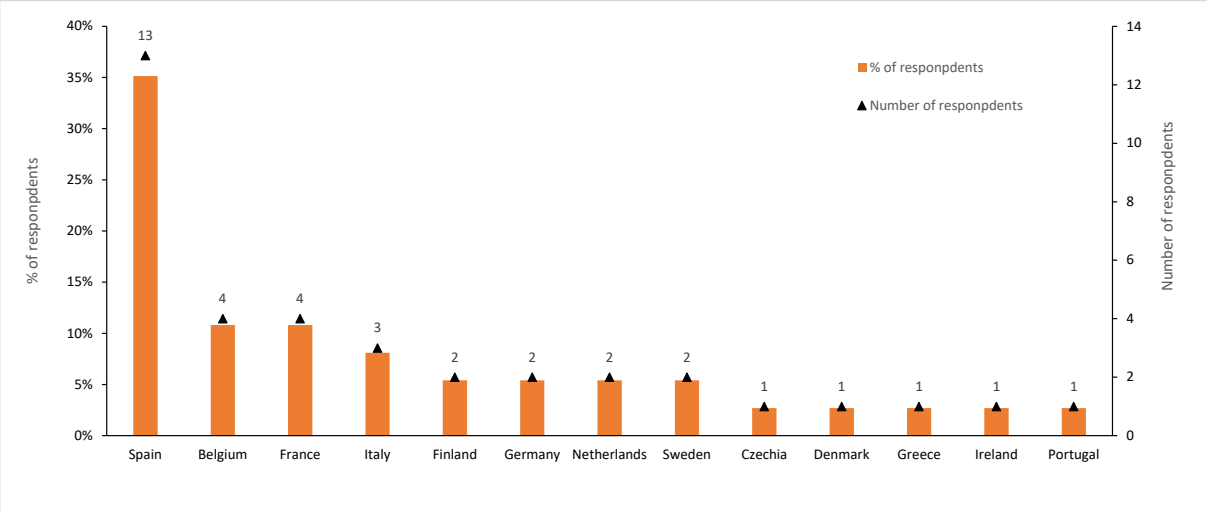


Figure 2 illustrates the main stages of the food chain represented in the survey, where manufacturers are the most represented group, accounting for more than one-third of the sample. Farmers follow with 24 %. Together, these two first groups constitute more than half of the sample. Packaging, retail and wholesale, and transport and logistics represent 11 %, 8 % and 5 % of the sample respectively. A sizeable portion of the sample corresponds to other respondents (19 %). The 'Other' category refers to those agents that mainly offer research-related services to the food chain. Almost 70 % of respondents are operators of the food chain, while the remaining 32 % are associations or other organisations (referred to as 'non-operators' or 'not an operator').

([7]) The higher representation of Spanish respondents is due to their higher acceptance to participate at the interview. This could be because respondents were contacted and interviewed by a Spanish company (i.e. CARTIF Technology Centre).

Figure 2. Respondents by food chain stage (% of all respondents, Number of all respondents)

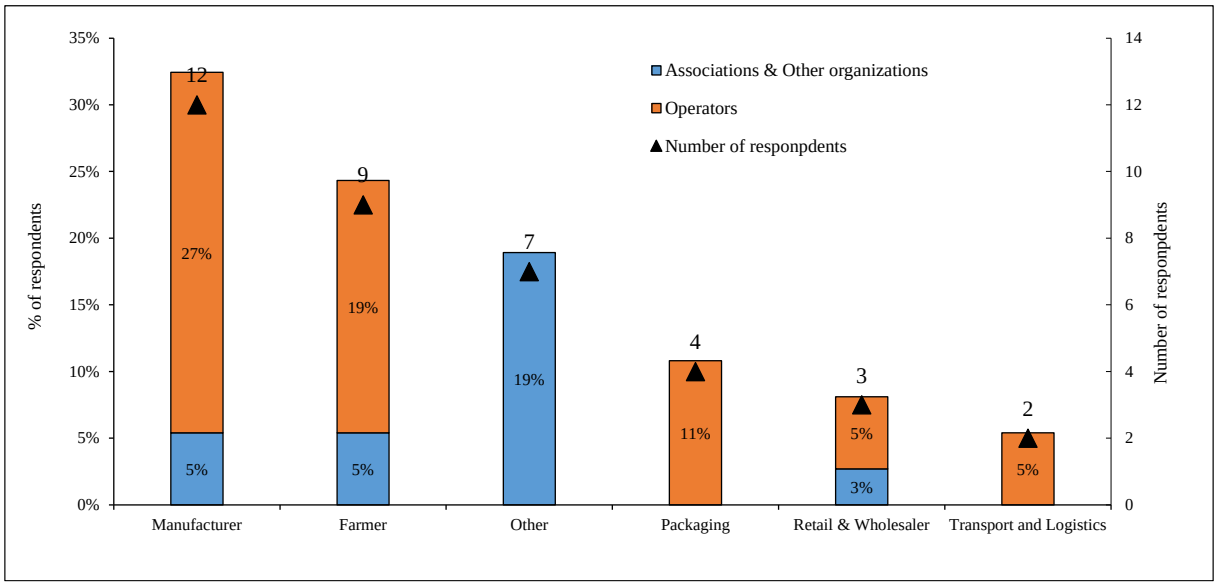


Figure 3 details respondents' distribution by product sector. The 'various food products' category includes those respondents whose activities embrace more than one specific sector (e.g. associations or operators producing different types of products) and clearly represents the main share of the total sample (46 % of total respondents), followed by the dairy sector (22 %) and fruits and vegetables (16 %). The beverage sector is the least represented (3 %), followed by meat-related operators (5 %) and cereals (8 %).

Figure 3. Respondents by product sector (% of total respondents)

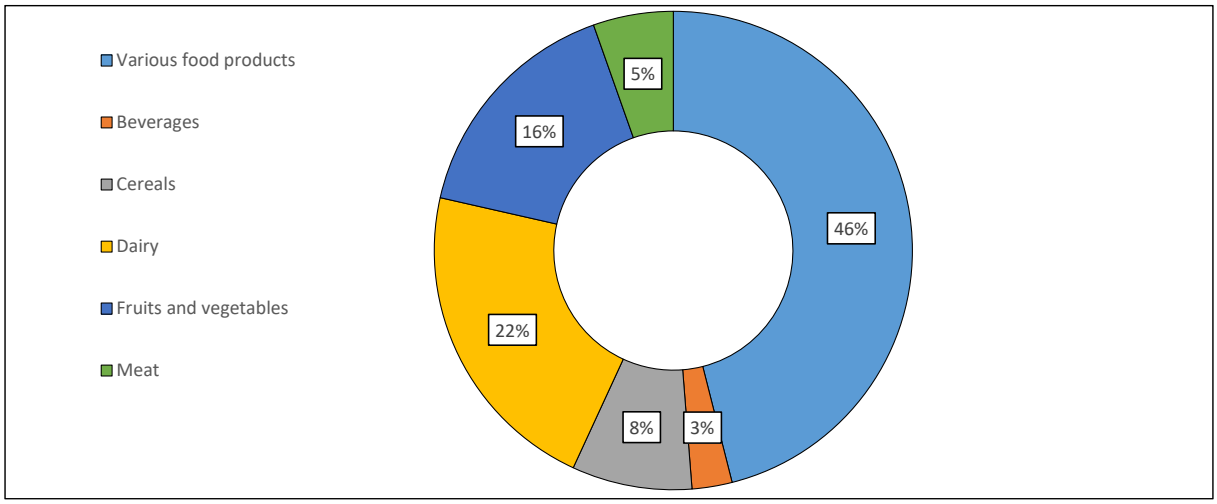
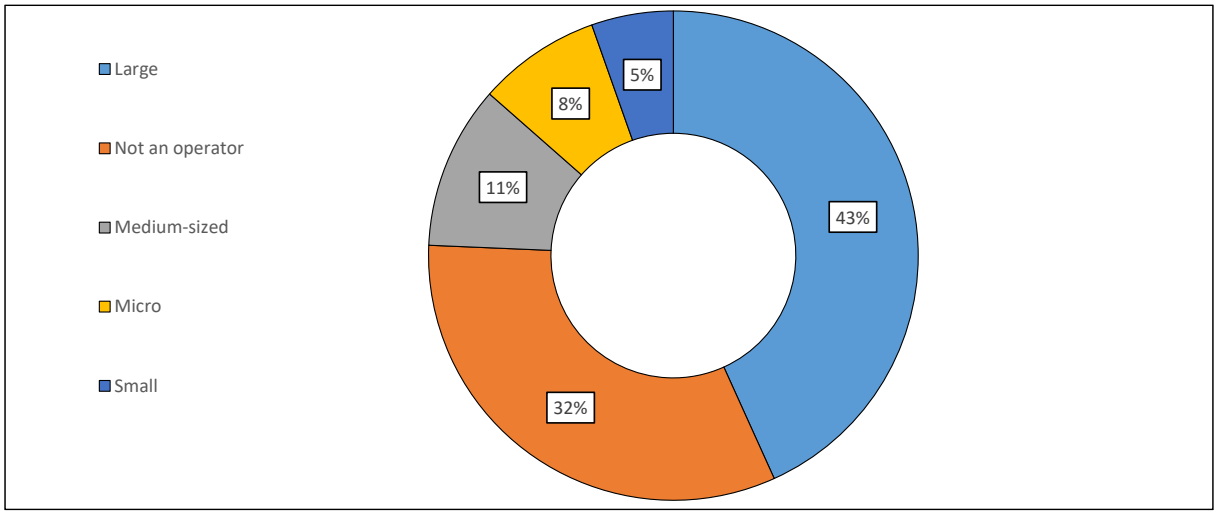


Figure 4 depicts the distribution of respondents according to operators' size in terms of number of employees. The majority of respondents are large companies (43 %), followed by medium-sized (11 %), micro (8 %) and small companies (5 %). Considering the operator's size in the analysis is essential, as it has been associated with the operator's propensity to innovate. However, the literature findings are conflicting on the relationship between firm size and innovation activity. Some notably argue that in the food sector small and medium-sized firms may be better at invention and development, while larger firms have more advantages when introducing and diffusing innovations on the market (Grunert et al., 1997; Traill & Meulenberg, 2002). Others argue that smaller firms face more limitations in conducting R & D activities that may lead to innovation compared to large operators (Finco et al., 2018). However, some companies innovate without carrying out R & D (Gault, 2018).

Figure 4. Respondents by company size in terms of the number of employees (% of total respondents, excludes respondents that are not operators)



4 Inventory of sustainability initiatives

4.1 Innovation types

As indicated above, the 37 interviewees have reported a total of 314 innovations or innovative initiatives oriented towards one or more aspects of sustainability, classified into five categories of innovation and 65 types of initiatives.

In terms of categories of innovation, defined according to the nature of the initiative (i.e. product, process, marketing, organisational and technological/digital), process innovations represent the most undertaken type of sustainability initiative, followed by organisational innovations and product innovations (Figure 5). Considering the food chain stage, manufacturers and packaging tend to focus more on product, process and organisational innovations and less on marketing or technological innovations. Farmers seem to focus mainly on both process and organisational practices. In contrast, retailers and wholesalers innovate more in marketing, product and organisational practices than in process or technological practices. Finally, transport companies innovate in technology, processes and organisational practices (Figure 6). As expected, the interviews show that downstream operators are more oriented towards marketing innovation than upstream operators. Yet, downstream operators are expected to pass on requirements upstream, which may translate into innovation on products and processes, among other things. We also find that most interviewees engage in three or more innovation types of innovation. Previous research has found that different types of innovation (e.g. product, process and organisational) and related competencies complement each other, enhancing their impact. Therefore, facilitating this interaction between different areas of competence and innovation types may lead to synergies and developing long-lasting competitive advantages (Hullova et al., 2019). Furthermore, encouraging this interaction across the food system can enhance the sustainability impact (Meynard et al., 2017). Finally, Figure 7 shows the innovations by innovation category, comparing operators and non-operators. Associations and other organisations notably reported more marketing and technological innovations than operators of the food chain, which makes sense as they cover a variety of operator types.

Figure 5. Interviewees' reported innovations by innovation category (% share of initiatives, number of initiatives)

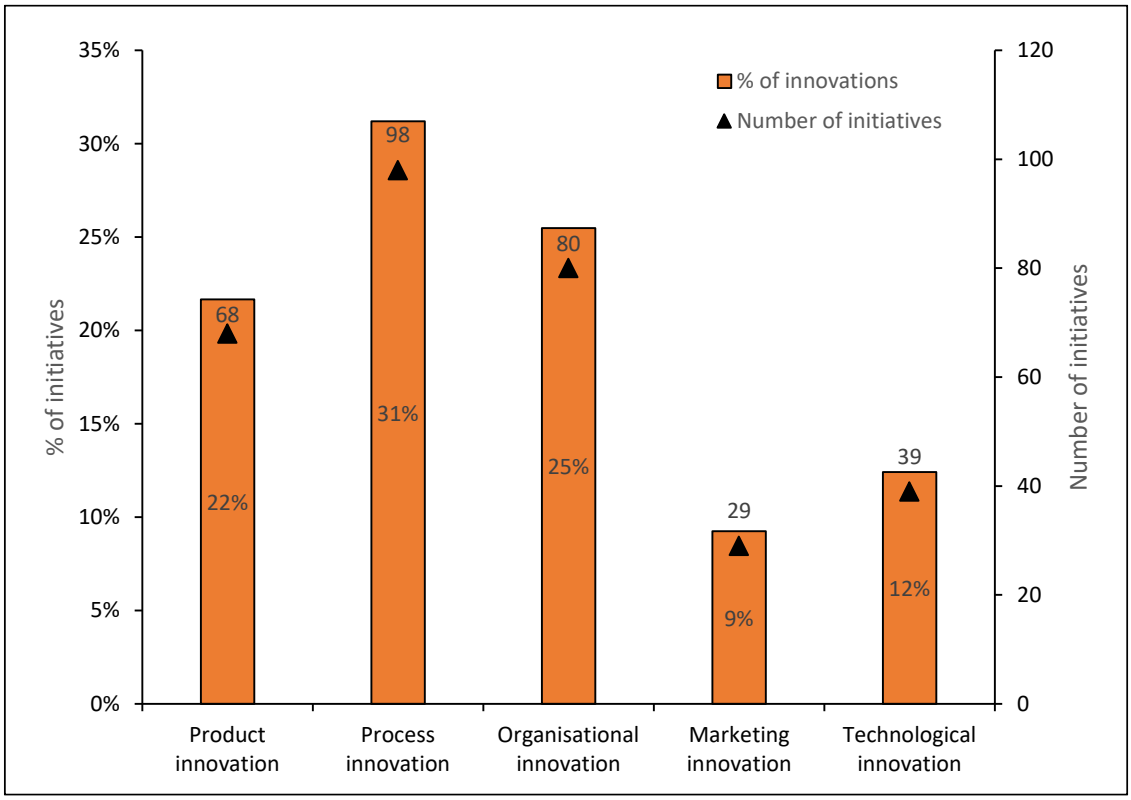


Figure 6. Distribution of interviewees' reported innovations by innovation category and stage of the food chain (% share of initiatives)

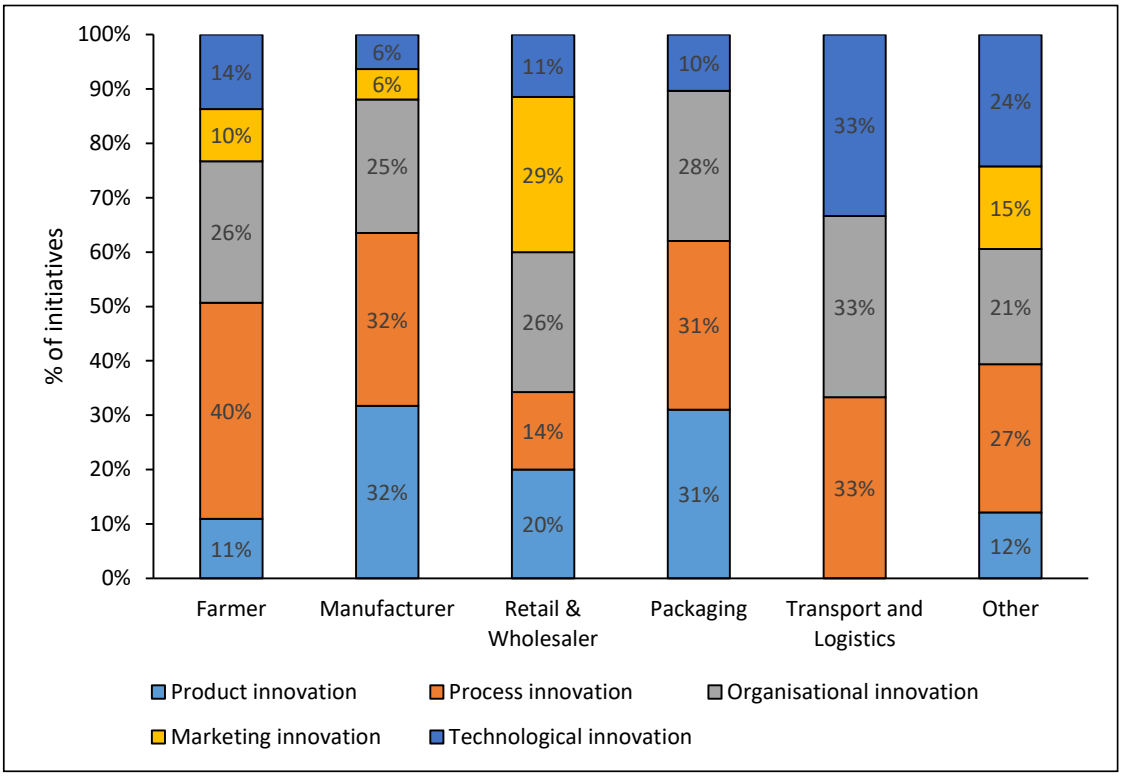


Figure 7. Distribution of interviewees' reported innovations by innovation category and respondent type (operator vs non-operator) (% share of initiatives)

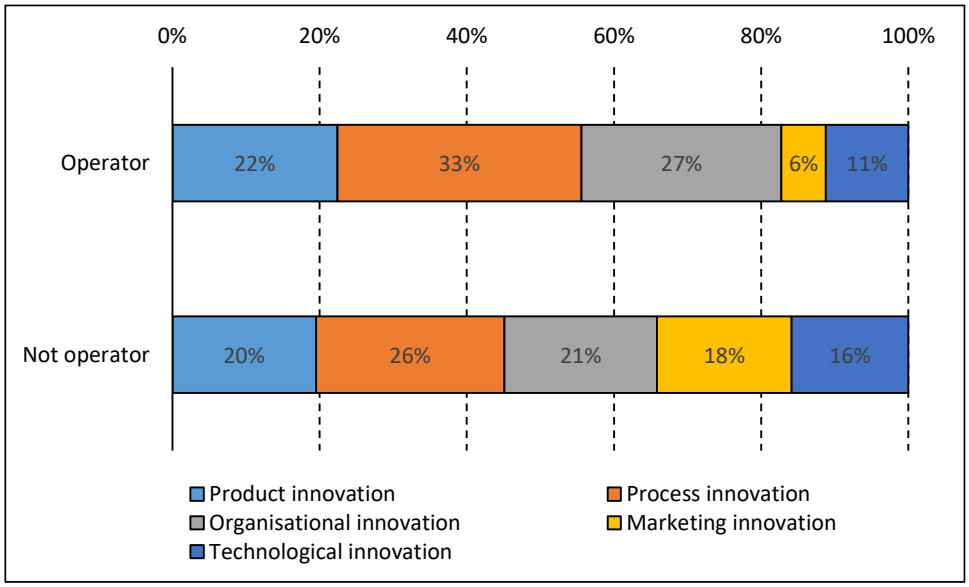
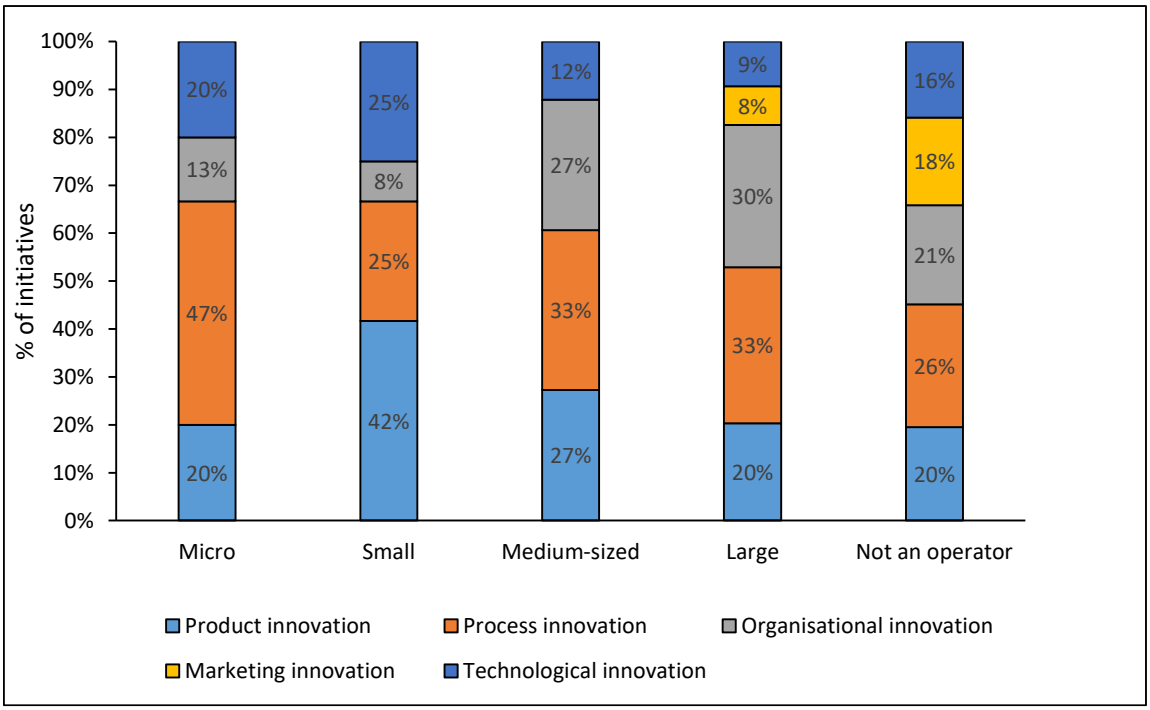


Figure 8 shows innovations by innovation category considering the operator's size. We can observe that the micro and small operators focused more on process innovation and product innovation, respectively, followed by technological innovations, while relying less on organisational innovation; they didn't carry out any marketing innovation. Medium-sized operators did not mention marketing innovation either; they focused evenly on product, process and organisational innovation, whereas they showed less interest in technological innovation. In contrast, large operators carried out marketing and technological innovations, although their main focus remained on process, organisational and product innovations, with a similar emphasis on each of them. The

lack of marketing innovation in micro, small and medium-sized operators may be because those interviewed respondents were mainly farmers, as well as certain processors to which downstream operators generally impose specifications linked to products or processes, as mentioned above. This underlines the importance of a system-wide approach in studying innovation in the food sector, suggesting that different incentive packages may be needed for different types of operators and innovations. Non-operators reported a relatively balanced distribution across all categories of innovation; again, this makes sense because they respond to what is happening across various operator types.

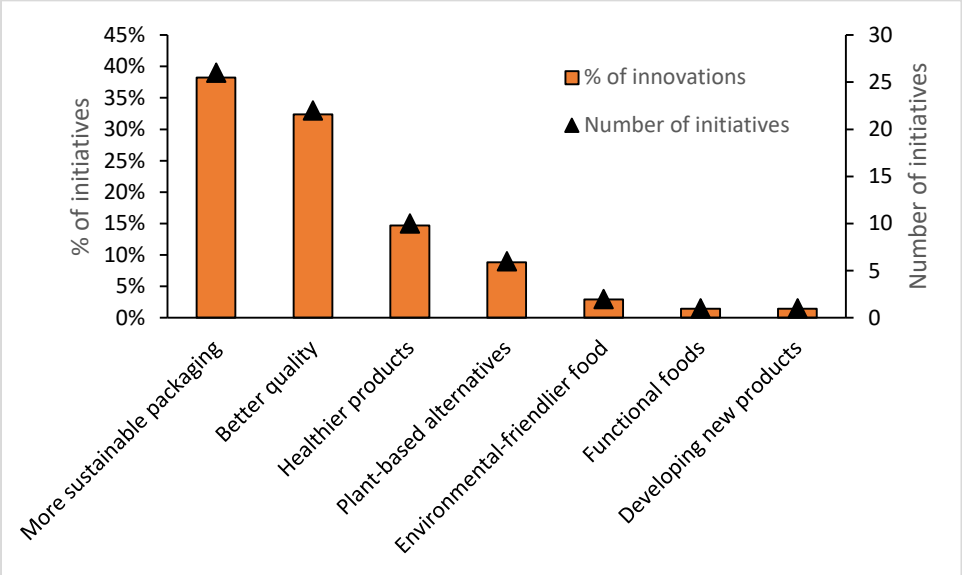
Figure 8. Distribution of interviewees' reported innovations by innovation category and operator size (% share of initiatives)



In the interviews, the respondents provided details on the implemented sustainability initiatives, which were then classified into types of sustainability initiatives within the categories of innovation. The results for the five innovation categories are shown below.

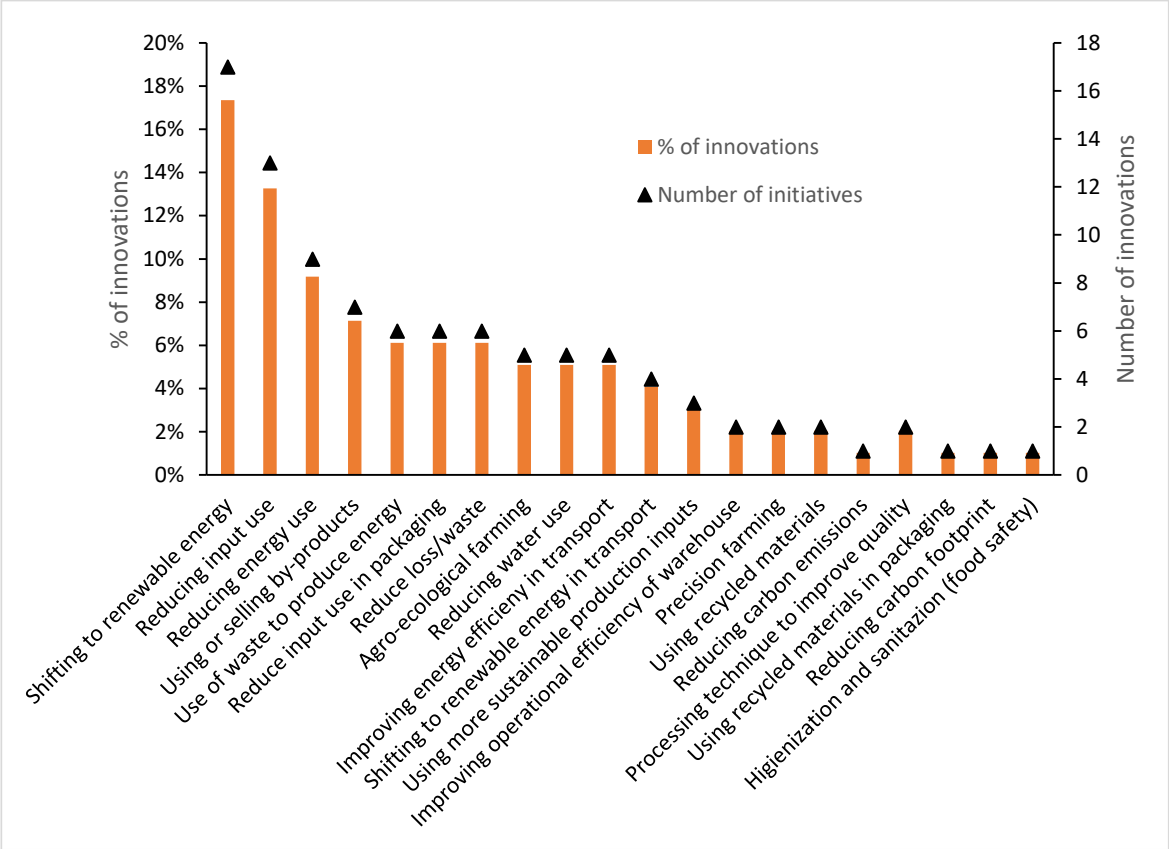
Regarding **product innovations**, the respondents reported a higher number of innovations in more sustainable packaging (38 % of initiatives that were reported to include product innovation), followed by better-quality products (32 %), healthier products (15 %) and the development of plant-based alternatives (9 %) (Figure 9). Using more sustainable packaging entails initiatives that rely, for instance, on using compostable, easy-to-recycle or bioplastic materials, or reducing the amount of plastic and consuming less energy in the production process of packaging. When referring to 'better quality products', respondents refer, for example, to new varieties or new formulations, enriched products or products whose shelf-life has been extended (aiming at a lower food waste). The rest of the product innovations are less represented among the sampled initiatives; they were present in less than 5 % of initiatives that were reported to include product innovation.

Figure 9. Interviewees' reported product innovations by type (% share of initiatives that were reported to include product innovation, number of initiatives)



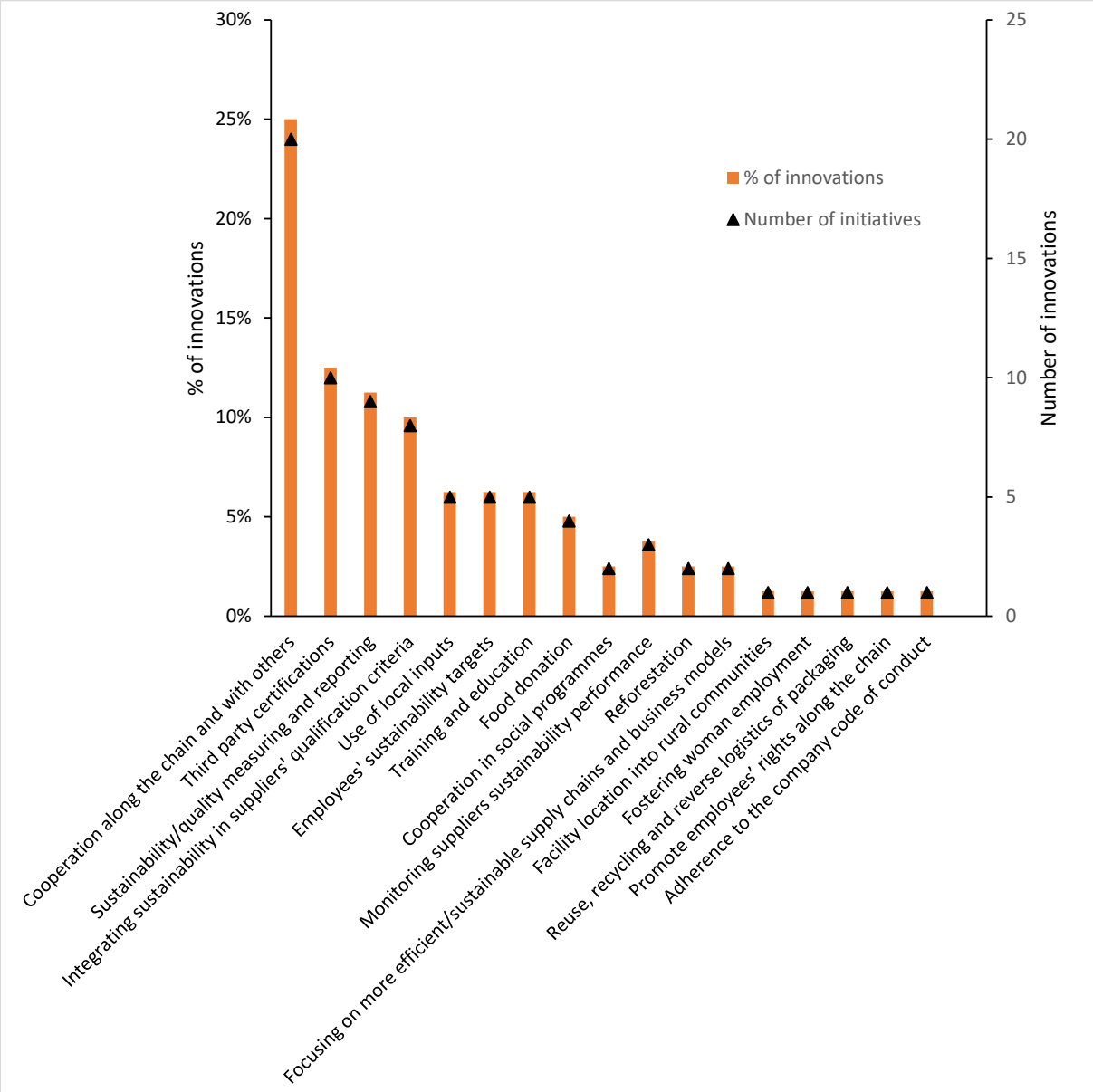
According to interviewees' responses, a fifth of **process innovations** converge towards relying more on renewable energy sources (17 % in production/selling facilities plus 4 % in transport), followed by reducing the use of inputs (13 % accounting for reducing chemicals such as fertilisers, pesticides, antibiotics and other inputs and 6 % for reducing the amount of plastic in the packaging), reducing energy use (9 %) and using or selling by-products (7 %). It bears noting that although agro-ecological or precision farming practices (7 %) appear to a lesser extent, these are applicable only to a specific subset of respondents (i.e. farmers). The rest of the process innovations were reported to be present in less than 7 % of initiatives that were reported to include process innovation (Figure 10).

Figure 10. Interviewees' reported process innovations by type (% share of initiatives that were reported to include process innovation, number of initiatives)



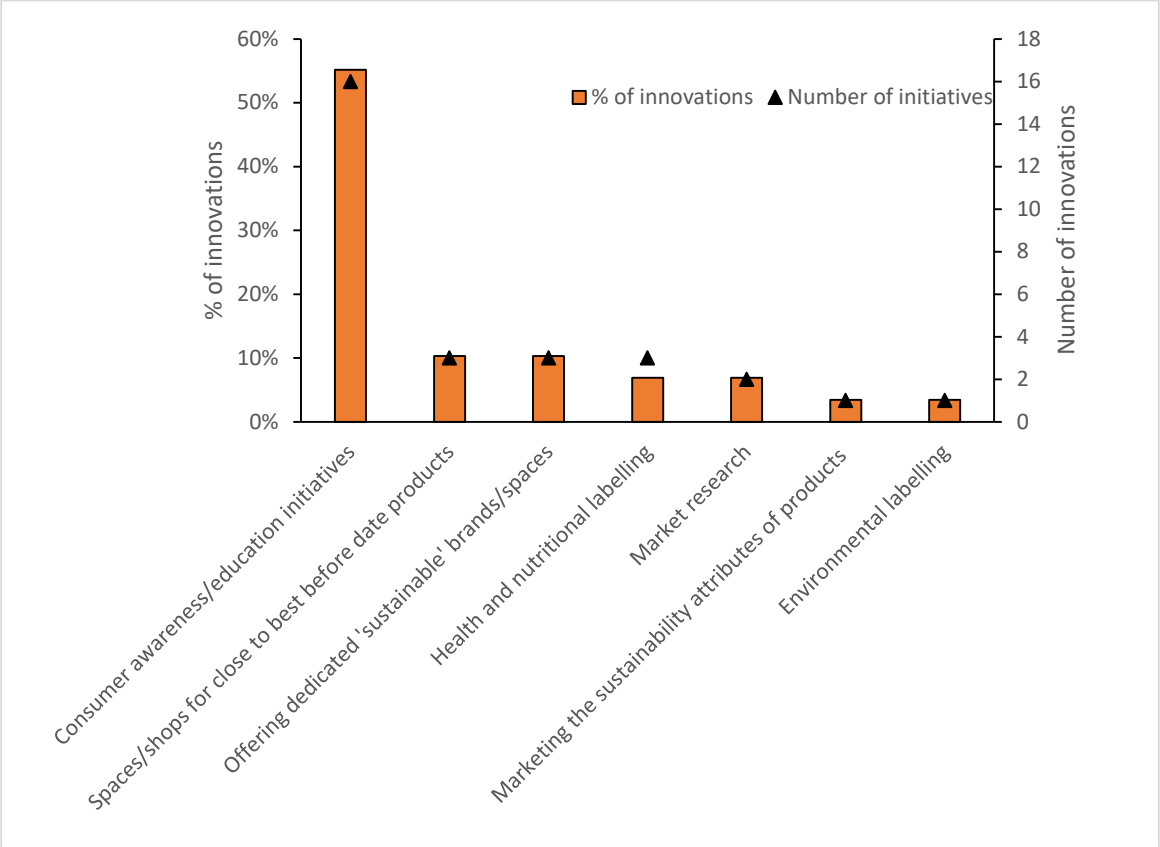
Concerning **organisational innovations**, one quarter of the reported initiatives refers to cooperation with other agents along the food chain or with other public/private institutions. 13 % of the initiatives correspond to third-party certifications that are used to certify some sustainable aspect of the operator's own products, or that the operator requires from its suppliers to allow its products to be eventually certified. A further 11 % and 10 % of initiatives correspond to measuring, acting and reporting on different sustainability aspects and integrating sustainability in suppliers' qualification criteria, respectively. Other organisational innovations were reported to be present in less than 7 % of initiatives that were reported to include organisational innovation (Figure 11).

Figure 11. Interviewees' reported organisational innovations by type (% share of initiatives that were reported to include organisational innovation, number of initiatives)



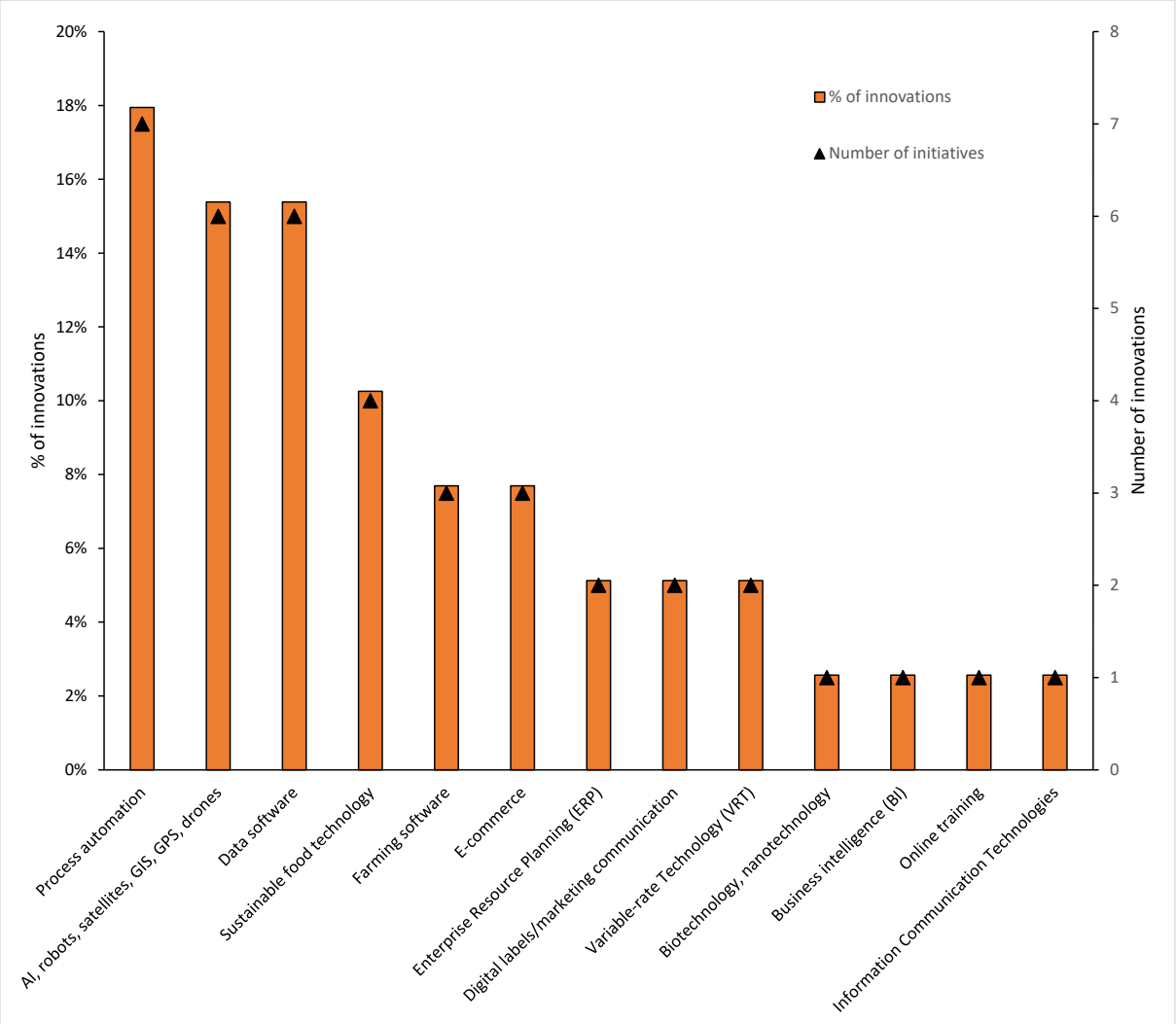
The **marketing innovation** that was applied the most as reported by respondents is the enhancement of consumers' awareness regarding sustainability (i.e. consumer awareness / education initiatives), accounting for more than 50 % of initiatives that were reported to include marketing innovation. By 'Consumer awareness / education initiatives', respondents refer, for instance, to providing online information about nutritional properties, nutrients, packaging, waste reduction (e.g. anti-waste recipes) and packaging disposal and the promotion of healthy eating through their website and social media. 10 % of the initiatives refer to providing dedicated spaces/shops for close to best before date products. A further 10 % of initiatives correspond to offering dedicated 'sustainable' brands/spaces. The rest of the marketing innovations were reported to be present in less than 7 % of initiatives that were reported to include marketing innovation (Figure 12).

Figure 12. Interviewees' reported marketing innovations by type (% share of initiatives that were reported to include marketing innovation, number of initiatives)



Finally, the category of **technological/digital innovations** includes process automation (18 %), followed by the use of robots, satellites, geographic information systems (GIS), the Global Positioning System (GPS) and drones (15 %), application of data software (15 %), sustainable food technology (10 %), farming software (8 %) and e-commerce (8 %). Other technological innovations were reported to be present in less than 7 % of initiatives that were reported to include technological innovation (Figure 13).

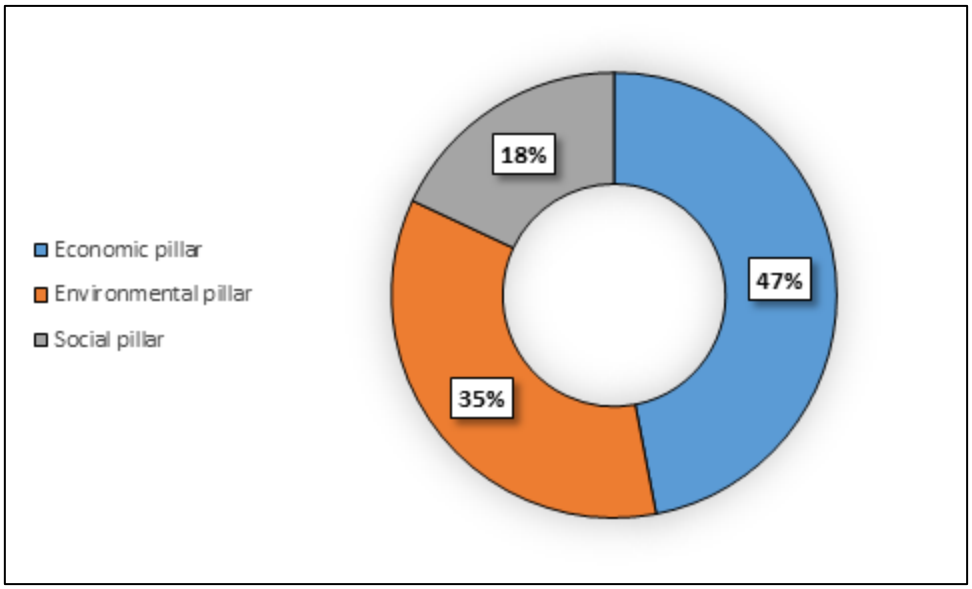
Figure 13. Interviewees' reported technological/digital innovations by type (% share of initiatives that were reported to include technological innovation, number of initiatives)



4.2 Sustainability orientation

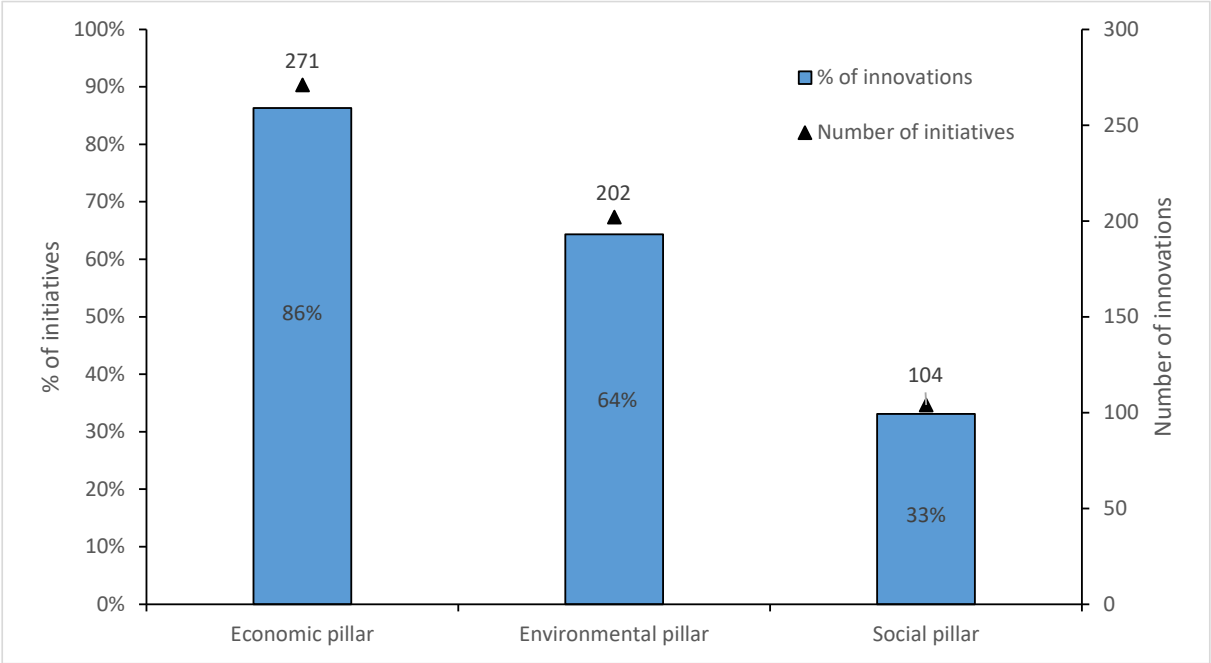
In the interviews, respondents were asked about the expected impacts (net benefits) of the sustainability initiatives in terms of the three dimensions of sustainability (i.e. economic, environmental and social/health). Figure 14 shows the reported expected sustainability benefits by respondents across the three sustainability pillars for the 314 initiatives as measured by SIIs. The economic pillar represents the most reported dimension of sustainability from which respondents expect benefits (47 % of all benefits), followed by the environmental (35 %) and social dimensions (18 %) (Figure 14). No negative impacts on the sustainability dimensions were reported, which suggests that operators only adopt those initiatives that are expected to generate primarily positive sustainability benefits (particularly economic ones) without compromising any sustainability aspects or alternatively under-estimating negative sustainability impacts.

Figure 14. Overall interviewees' reported expected sustainability benefits (% share of reported benefits)



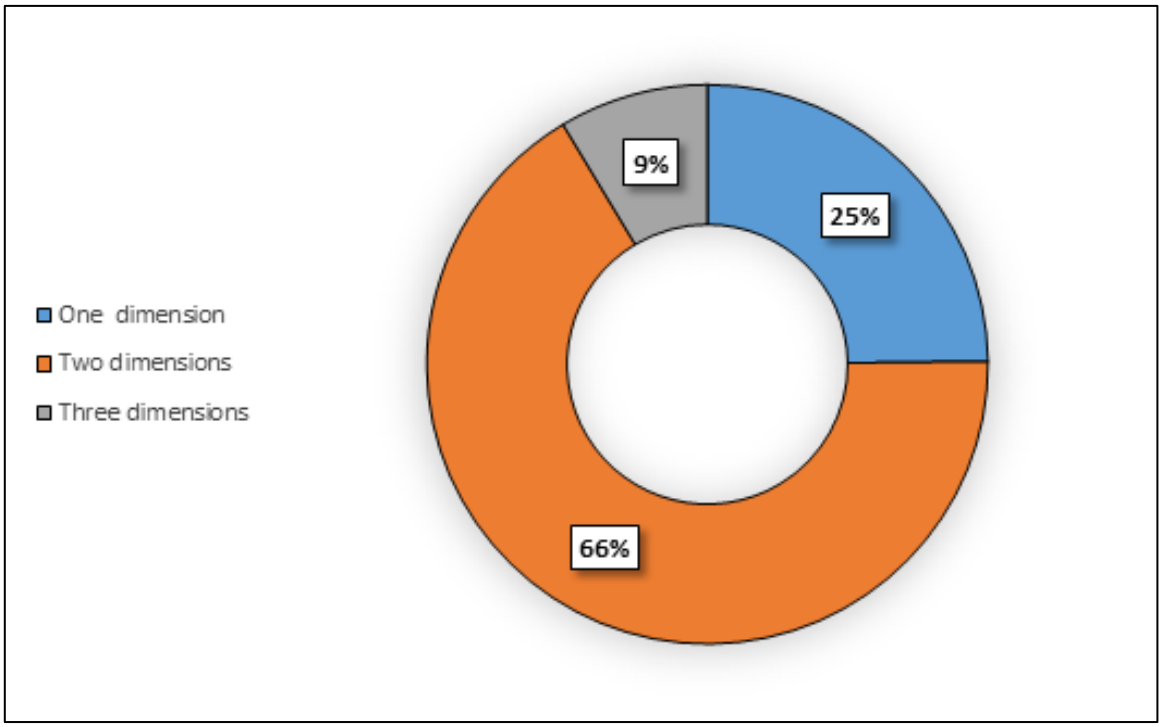
When looking at respondents' expected benefits across initiatives, the majority of initiatives were reported to generate economic benefits (86 %), followed by environmental ones (64 %). Social benefits are expected to occur for around 33 % of initiatives (Figure 15). According to the interviews, operators often seem to ignore or to not consider social innovation when discussing or pursuing innovation for sustainability. Overall, economic gains seem to represent the key factor affecting the adoption of sustainability initiatives.

Figure 15. Interviewees' expected sustainability benefits by initiative (% share of reported initiatives, number of initiatives)



Most of the initiatives are expected to generate benefits for more than one dimension of sustainability: at least two dimensions for nearly two-thirds of initiatives (66 % of initiatives), with only a minority of initiatives covering all three sustainability dimensions (9 %). The remaining initiatives (25 %) cover only one sustainability dimension (Figure 16).

Figure 16. Interviewees' overall expected sustainability benefits (% share of initiatives)



There seems not to be a clear pattern observed across all stages of the food chain and operator sizes in terms of the respondents' expected sustainability benefits for the considered initiatives. The exceptions are retailers and wholesalers, manufacturers, other organisations (mainly non-operators) and larger operators, who seem to report expected social benefits more often than other operators. This seems to also be true for associations and other organisations. Also, environmental benefits are reported more often by the packaging sector, the transport and logistic sector and small operators (Figure 17, Figure 18).

Figure 17. Interviewees' expected sustainability benefits by stage in the food chain (% share of reported initiatives by stage in the food chain)

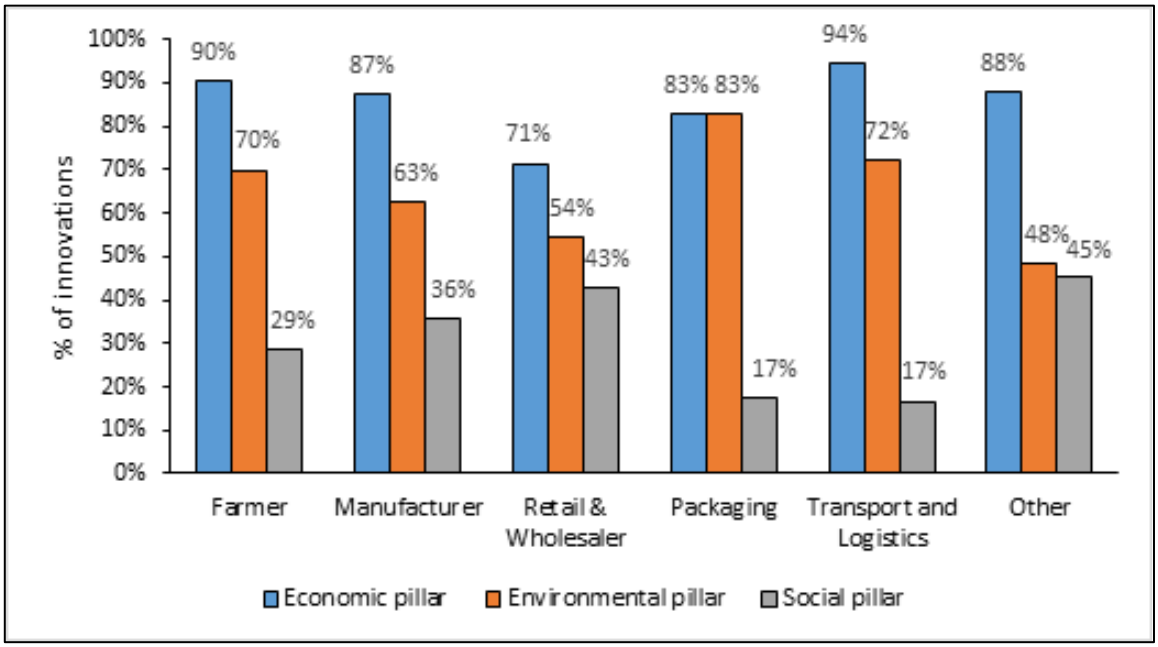
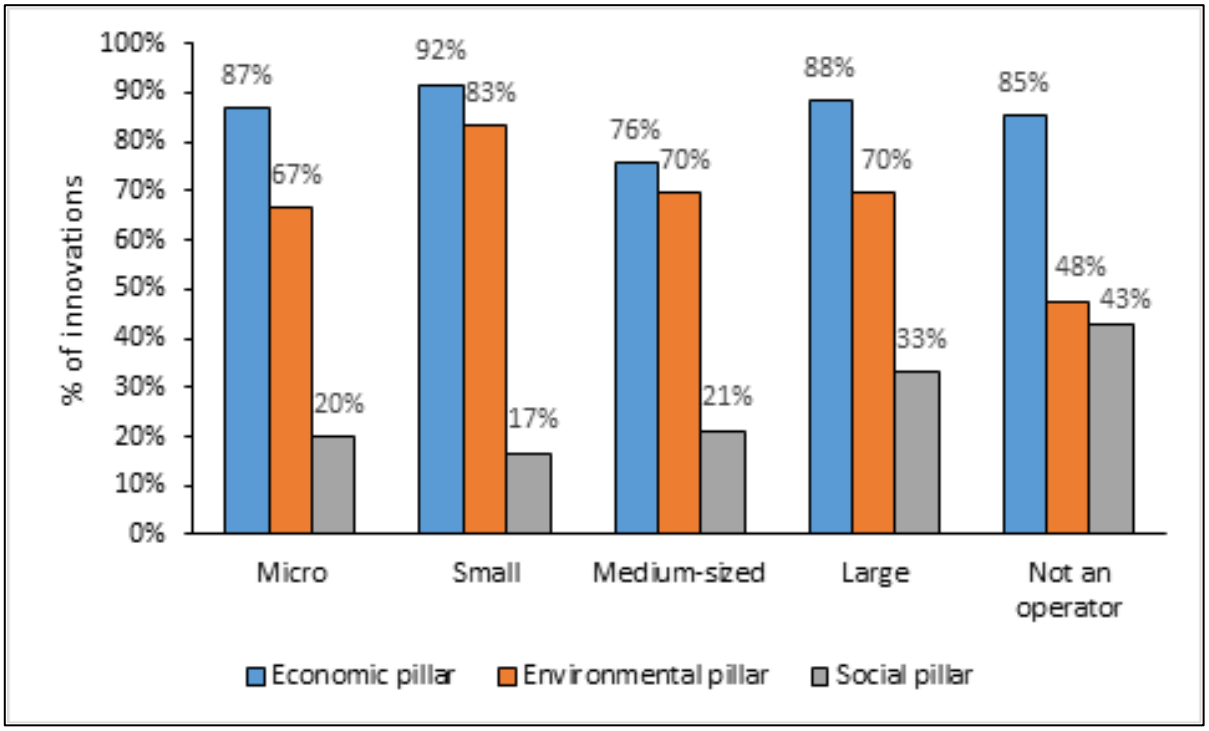
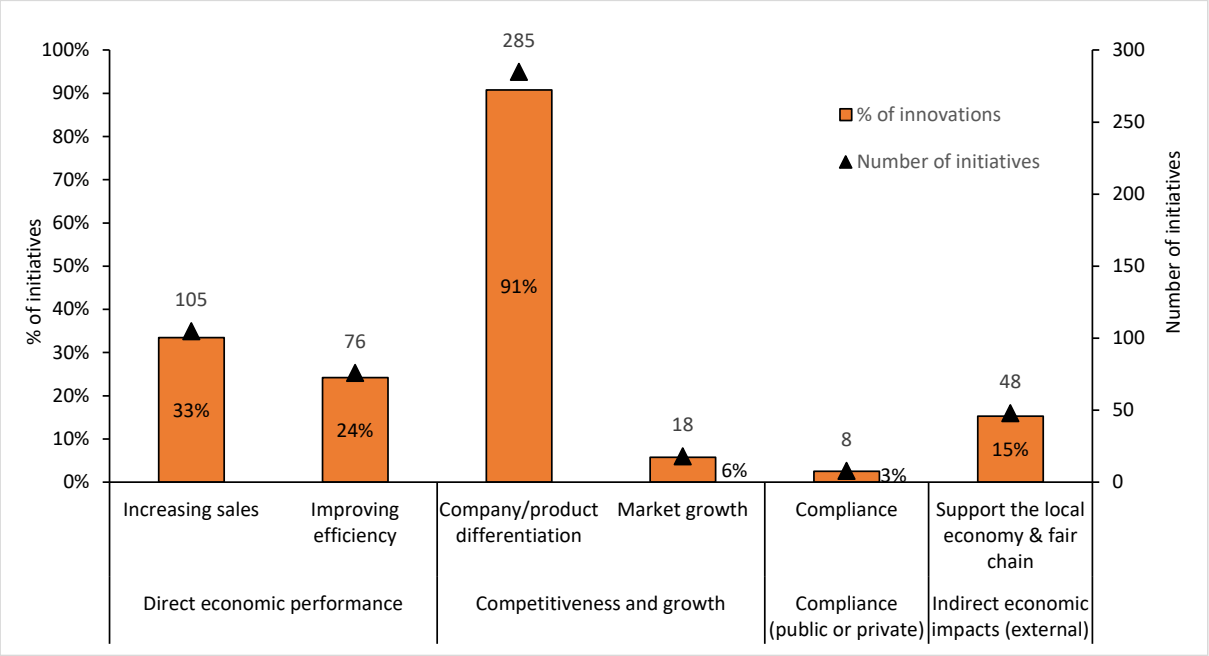


Figure 18. Interviewees' expected sustainability benefits by operator size (% share of reported initiatives by operator size)



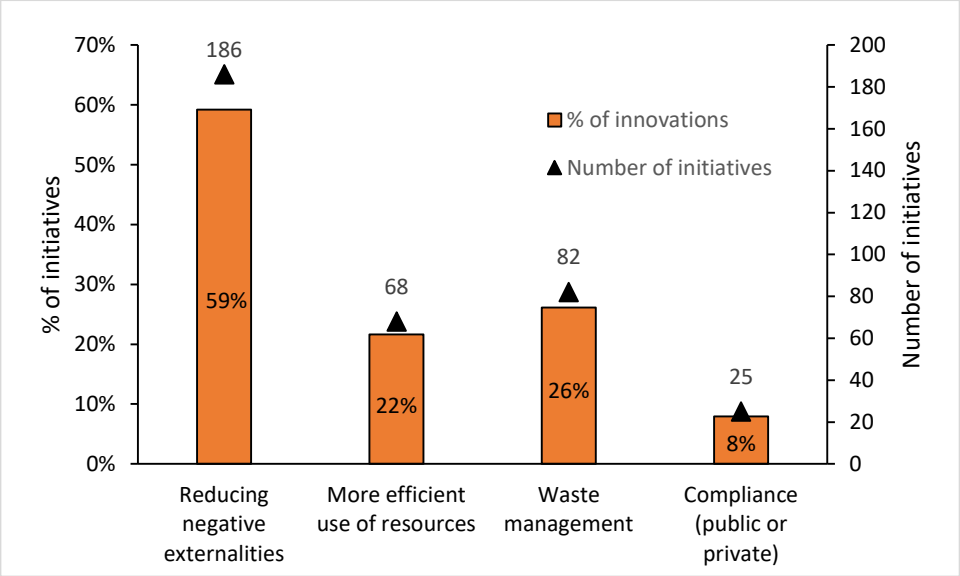
Increasing competitiveness is the main economic benefit indicated by most operators to adopt sustainability innovative initiatives, as it allows to achieve company and product differentiation (differentiation strategy) (91 % of reported initiatives). To a lesser extent they seek to enhance their economic performance by increasing sales and by improving efficiency (cost leadership strategy) (33 % and 24 %, respectively). Other economic benefits seem to be significantly less frequently reported by respondents – especially compliance with public and private standards and regulations (Figure 19).

Figure 19. Interviewees' expected <u>economic</u> benefits by initiative and operator size (% share of initiatives, number of initiatives)



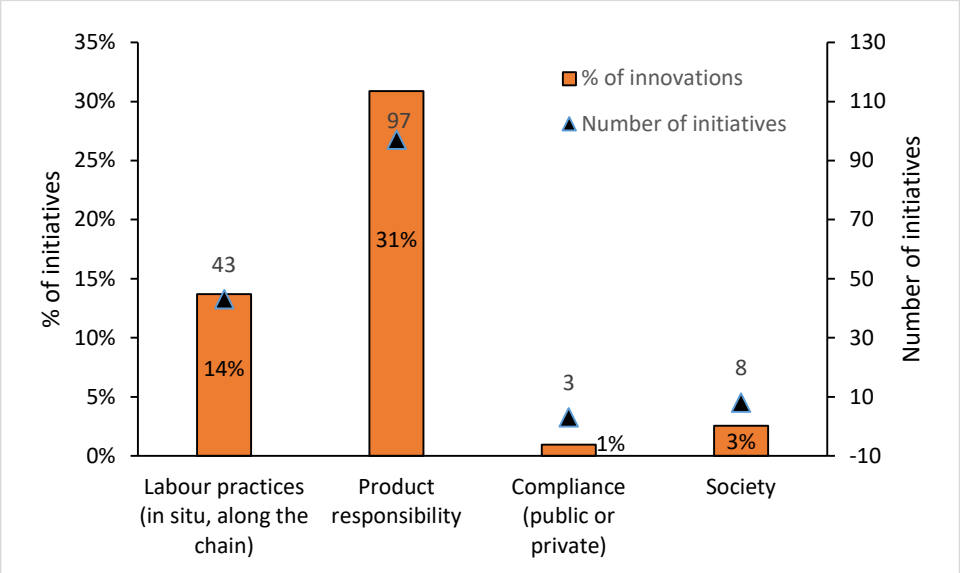
Regarding environmental benefits, operators expect to reduce negative externalities (59 % of initiatives) (e.g. reduce greenhouse gas emissions), improve waste management (26 %) and make more efficient use of resources (22 %) (Figure 20).

Figure 20. Interviewees' expected environmental benefits by initiative and operator size (% share of reported initiatives, number of initiatives)



Finally, expected social benefits from adopting innovative sustainability initiatives are mainly represented by product responsibility (31 % of initiatives) (e.g. supporting the consumption and production of healthier products) and the improvement of labour practices (14 %) (e.g. support employment of young people, workers' training and education). Societal benefits and especially compliance with public and private social standards and regulations were not commonly present among sustainable initiatives (3 % and 1 % of initiatives, respectively) (Figure 21).

Figure 21. Interviewees' expected environmental benefits by initiative and operator size (% share of reported initiatives, number of initiatives)



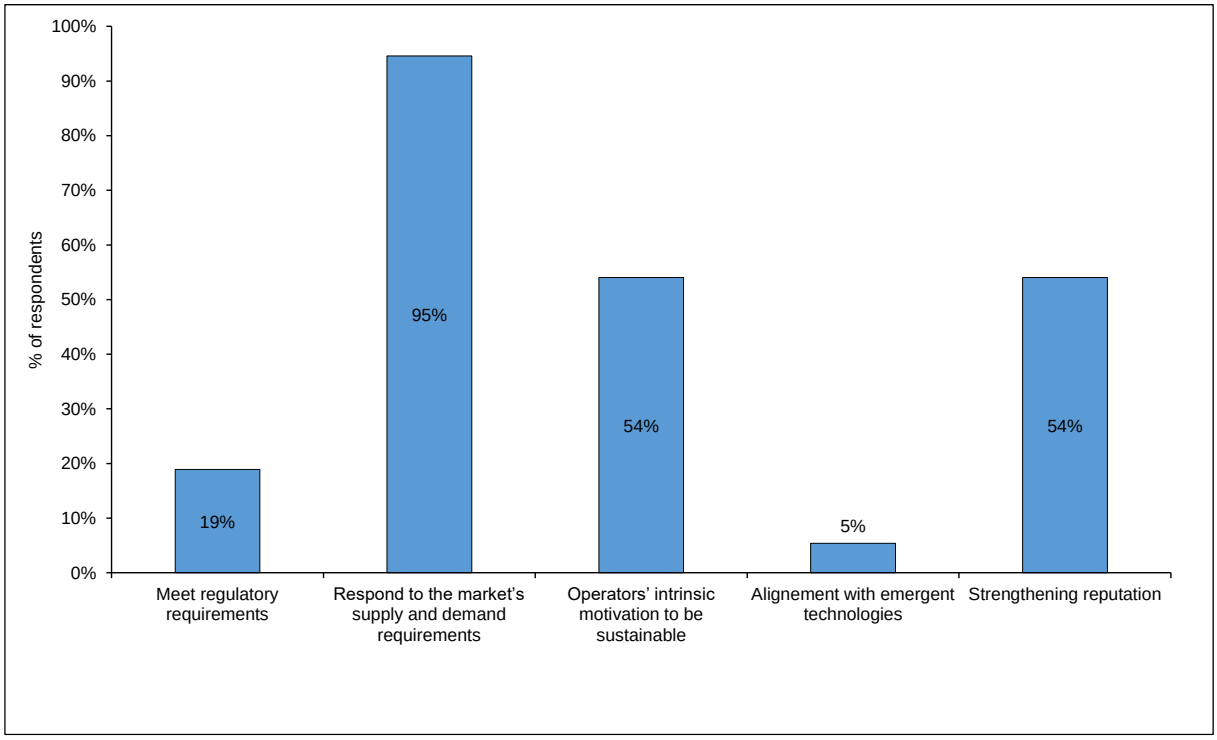
5 Drivers, barriers and policies affecting the adoption of sustainability initiatives

5.1 Drivers

In order to identify the factors that motivate operators to make sustainability innovations, respondents were asked about the drivers. Then, insights from the theories of technology-push and market-pull innovation and regulatory pull/push effects are used to analyse them. Generally, these theories help to understand businesses' innovation adoption factors and behaviours and how to influence them. Notably, the technology-push theory generally considers innovation driven by science and knowledge and emphasises the importance of R & D capabilities and competencies. By contrast, the market-pull theory considers consumers' demand and needs as the primary force guiding innovation and emphasises the need to pay more attention to market needs for innovation than maintaining technical and R & D competencies. Similarly, regulation can have push and pull effects on sustainability innovations (Arfaoui, 2018). The policy effects are discussed below, combining the information obtained on drivers, barriers and policy incentives. Awareness of sustainability-related opportunities is a key driver for innovation (Jenkins, 2009). In general, respondents to the interview were well aware of the European Green Deal and the F2F strategy, except for two respondents who were not aware of them and one respondent who said that they only had general knowledge about them.

Figure 22 shows the main drivers identified by respondents. Consistent with market-pull theories, results clearly depict how responding to market' supply and demand requirements is the main element driving the choice of implementing sustainability initiatives (95 % of respondents). Also, strengthening reputation together with the intrinsic operators' motivation for adopting more sustainability initiatives are also important in driving the adoption of sustainability initiatives (54 % of respondents each). This is, for instance, reflected in the following statements from respondents: 'In Sweden, if you do not work in sustainability, you cannot survive in the market'; '[Sustainability] it is an internal thing, we know we have a responsibility because of the size of the company, a responsibility to produce food in a more sustainable way'. Meeting regulatory requirements and alignment with emergent technologies are mentioned to be drivers for the adoption of sustainability initiatives for the minority of the respondents (19 % and 5 %, respectively).

Figure 22. Main drivers identified by respondents (% share of respondents)

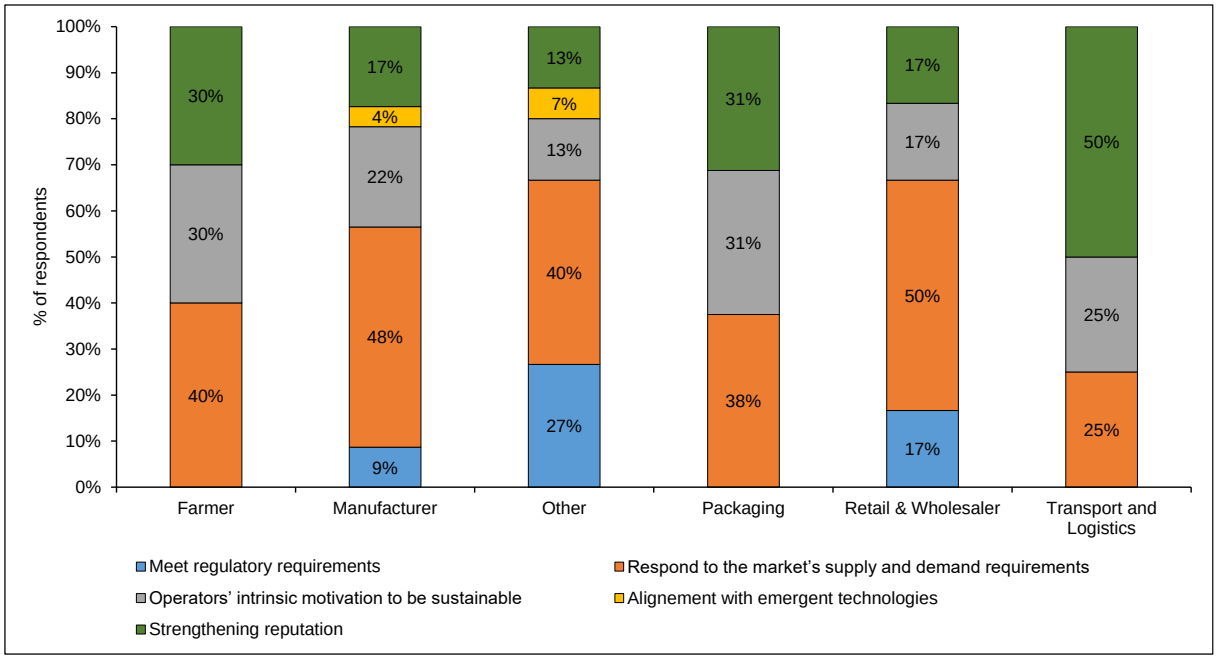


It is worth mentioning that these results must be understood in the context of the food sector, which has traditionally been viewed as a low-tech sector with slow rates of innovation. Interviewees may consider the

market as the primary stimulus for innovation in sustainability because the interviewed operators mainly adopt or integrate innovations (innovation diffusion) from the market and are not necessarily inventors and first movers, which may lead to the technology-push effect on innovation being underestimated. The interviews did not explore the degree of novelty of innovations (e.g. new to the market versus new to the operator and radical innovations versus improvements). Furthermore, this study considers not only product, process and digital technology innovation but also marketing and organisational innovation, which may also lead the technology-push effect being underestimated.

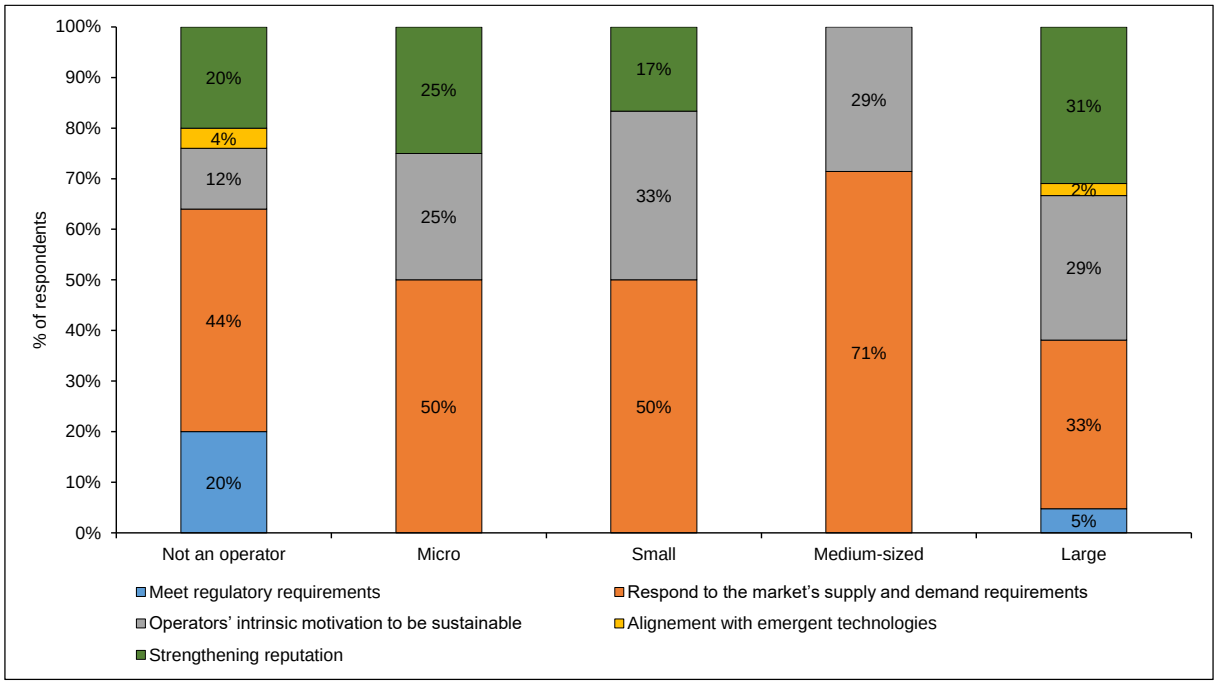
Respondents from all stages of the food chain often reported responding to market's supply and demand requirements as a driver for the adoption of sustainability initiatives, especially those representing retailers and wholesalers, and manufacturers. The intrinsic operators' sustainability motivation and strengthening reputation mostly adhere to respondents representing transport and logistics, packaging and farmers. The driver referring to meeting regulatory requirements is mentioned primarily by retailers and wholesalers, manufacturers and other organisations. Perhaps because larger manufacturers and wholesalers/retailers often impose the regulatory requirements through private standards on their suppliers, this driver may be underestimated by other stages of the food chain. Finally, alignment with emergent technologies is a driver identified only by a minor proportion of manufacturers and other organisations (Figure 23), indicating that it is for them that technology-push effects could play a more important role than for respondents from other food chain stages.

Figure 23. Main driver by respondents' stage of the food chain stage (% share of respondents that provided an answer)



Looking at the drivers by size of operators, large operators and non-operators (associations and other organisations) report all the five drivers identified in the survey, although responding to market's supply/demand requirements and strengthening reputation seem to be more important than other drivers. Micro and small operators, and especially medium-sized operators, report responding to market's supply/demand requirements as most common driver followed by intrinsic operators' sustainability motivation (Figure 24).

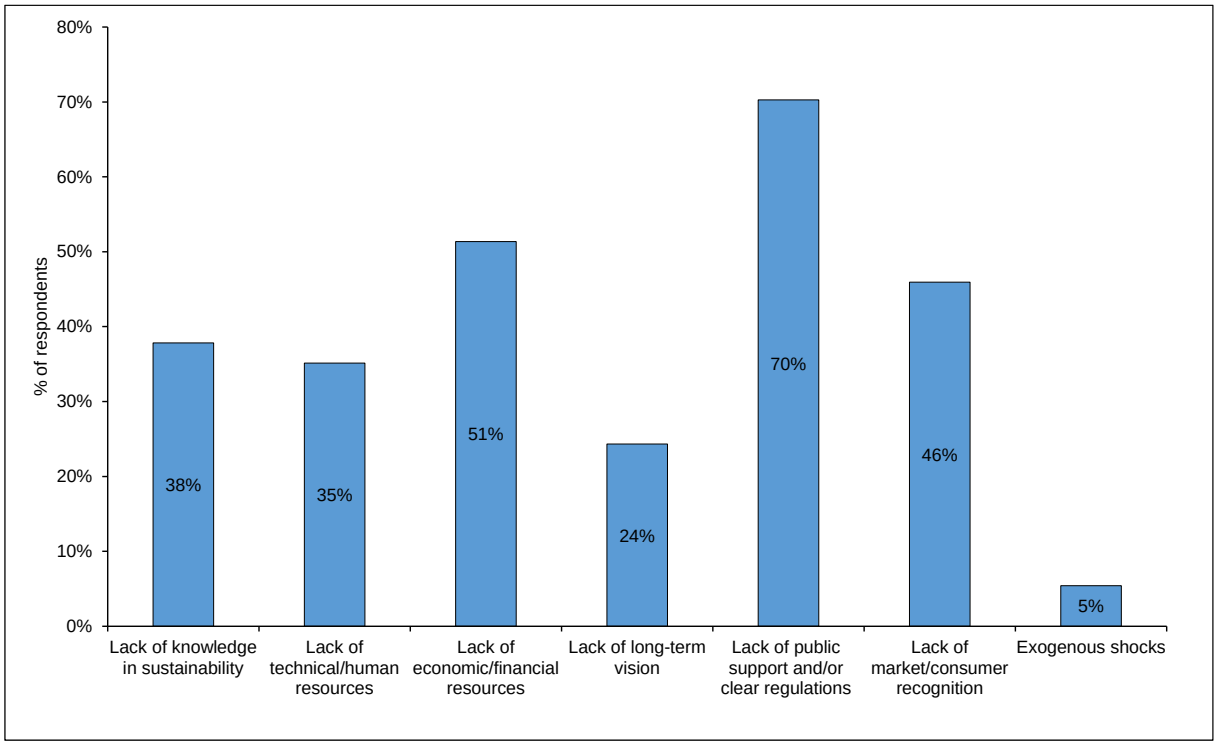
Figure 24. Main drivers by size of the company (% share of respondents that provided answer)



5.2 Barriers

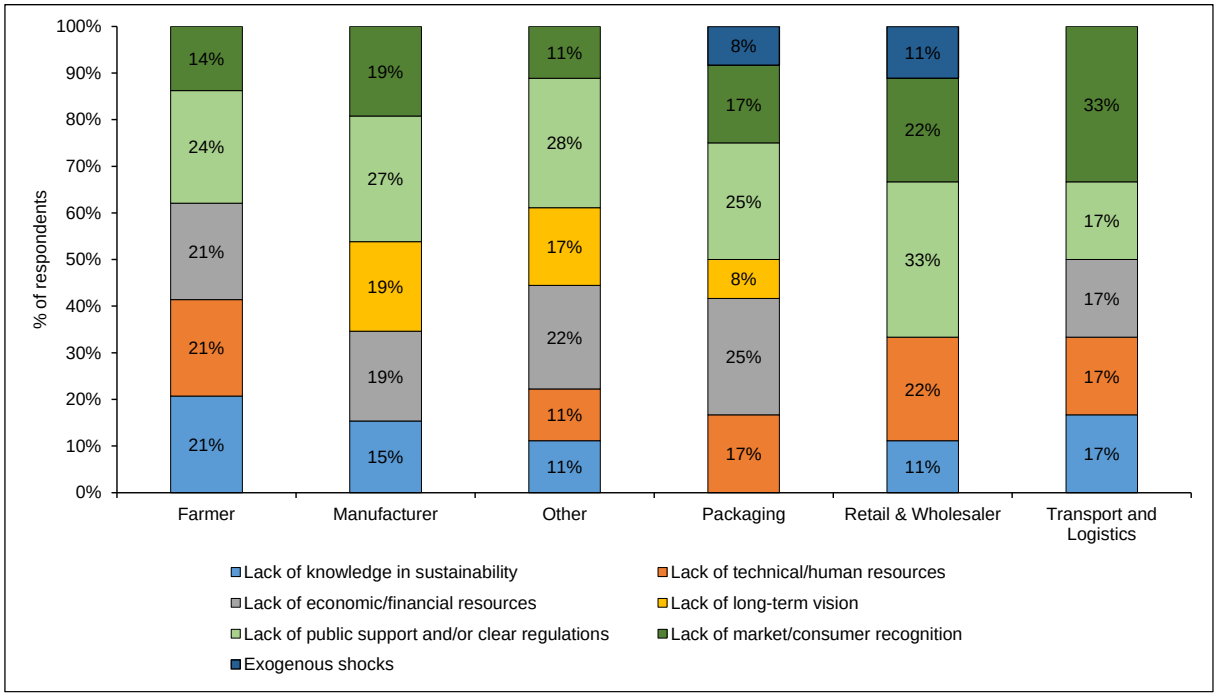
Following the approach applied for drivers analysed in the previous section, several barriers were identified for sustainable innovative practices implementation. Respondents widely agreed on the lack of public support and/or lack of clarity in the current policies regarding sustainability (70 % of respondents) as the main barrier for the adoption of sustainability initiatives. The lack of economic and/or financial resources briefly follows with 51 % of respondents, while the lack of market/consumer recognition accrues for 46 % of respondents. The lack of knowledge, experience and/or culture in sustainable-related solutions also represents a barrier for 38 % of respondents. Lack of technical/human resources to innovate and lack of long-term vision are also reported as barriers by a sizable share of respondents (35 % and 24 %, respectively). Exogenous shocks, like the current pandemic, accounts only for 5 % of respondents (Figure 25).

Figure 25. Main barriers identified by respondents (% share of respondents)



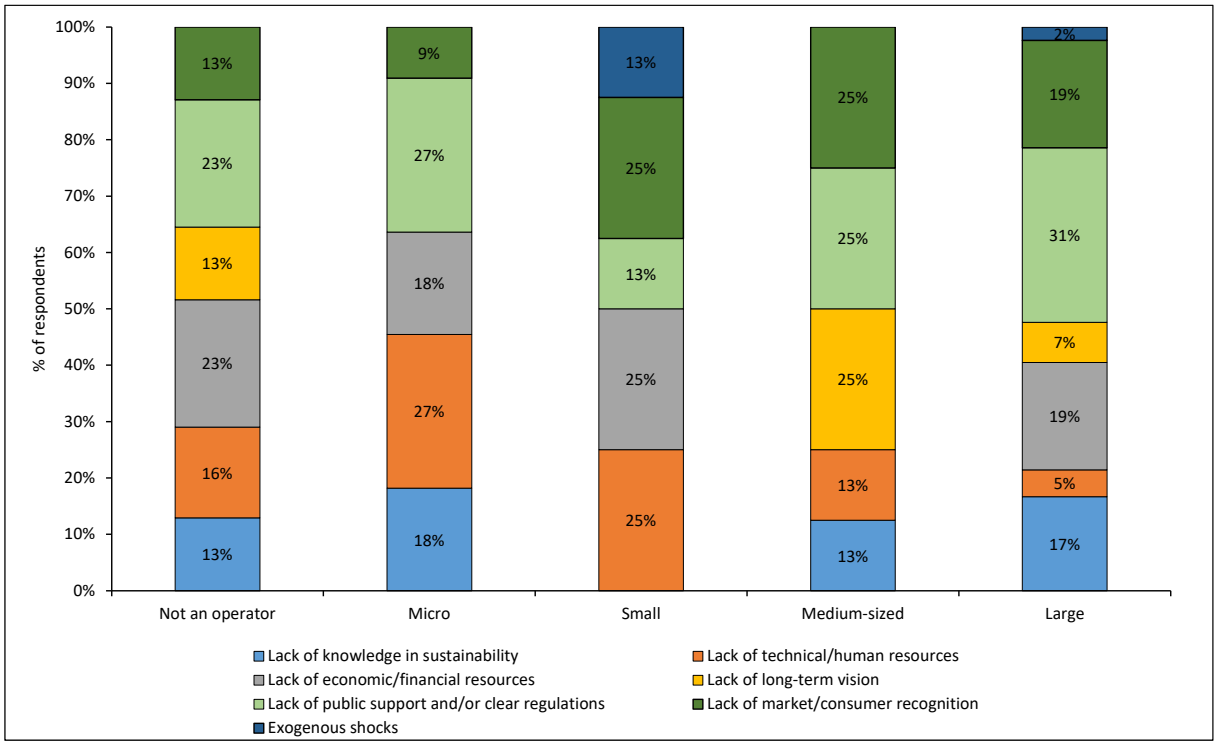
With some exceptions, the different barriers identified in the interviews are fairly represented by all the operators from different stages of the food chain. In line with above figures, the mostly reported barrier for adopting sustainability initiatives among the different operator groups refers to lack of public support and/or clarity in regulations. The exception are respondents from transport and logistics who report the lack of market/consumer recognition as the main barrier. Retailers and wholesalers and packaging operators are the solely recognising the negative role of exogenous shocks. Similarly, only manufacturers, packaging and other organisations report the lack of long-term vision as a barrier (Figure 26), possibly because they face more costly up-front investments to innovate that pay off in the long term.

Figure 26. Main barriers according to the respondents' stage of the food chain stage (% share of respondents that provided answer)



When looking at the operators' size, the lack of public support and/or clarity in regulations were the most reported barriers for micro, medium-sized and large operators and for non-operators (associations and other organisations). Similarly, the lack of market/consumer recognition is rather widely present among small, medium-sized and large operators. For small operators (as compared to other groups), exogenous shocks are more often mentioned as a significant barrier. Also, micro and small operators report the lack of technical/human resources as a barrier more often than other operators. Another important barrier for medium-sized operators and non-operators is the lack of long-term vision (Figure 27).

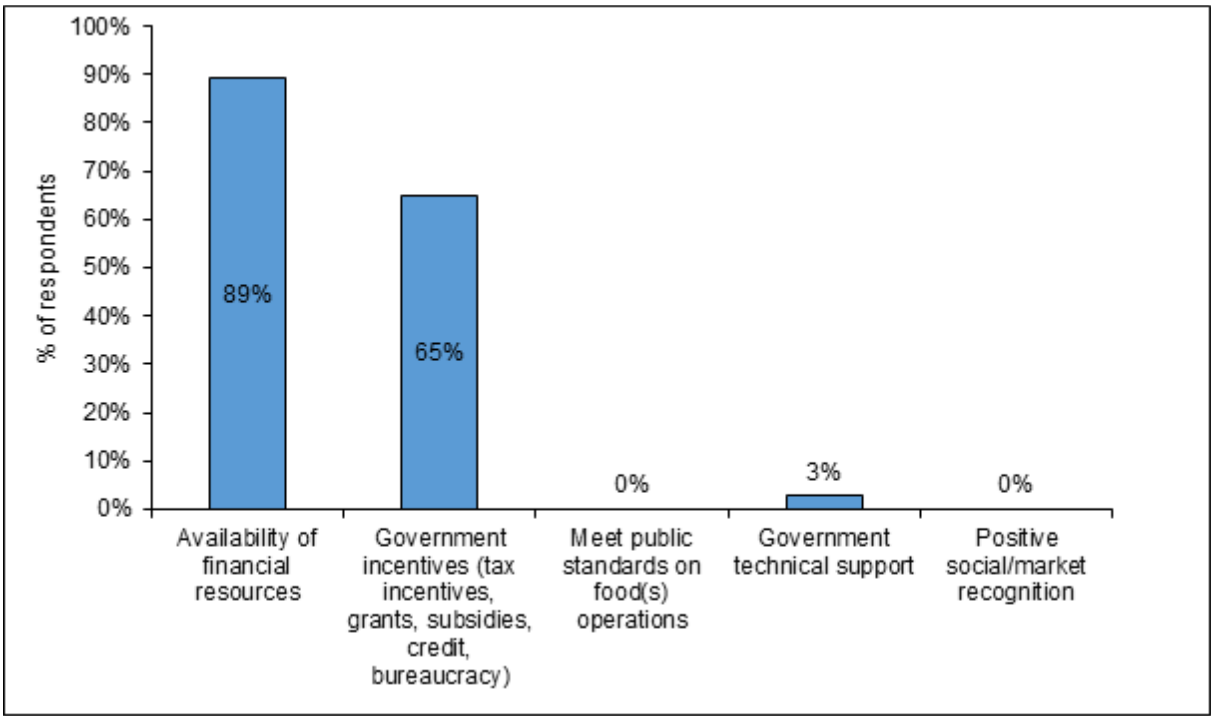
Figure 27. Main barriers by size of the company (% share of respondents that provided answer)



5.3 Financial factors and policy incentives

Beyond market-pull and technology-push factors, the interviews asked about factors such as the availability of financial resources and policies to foster sustainability innovation. The majority of respondents point to two major factors that foster the adoption of innovative sustainability initiatives: the availability of financial resources (i.e. own resources) (89 % of respondents) and governmental incentives (65 %). Around 3 % of respondents also identified technical support from public authorities as a factor that may help boost the adoption of sustainability innovations (Figure 28).

Figure 28. Main financial factors and policy incentives identified by respondents (% share of respondents)

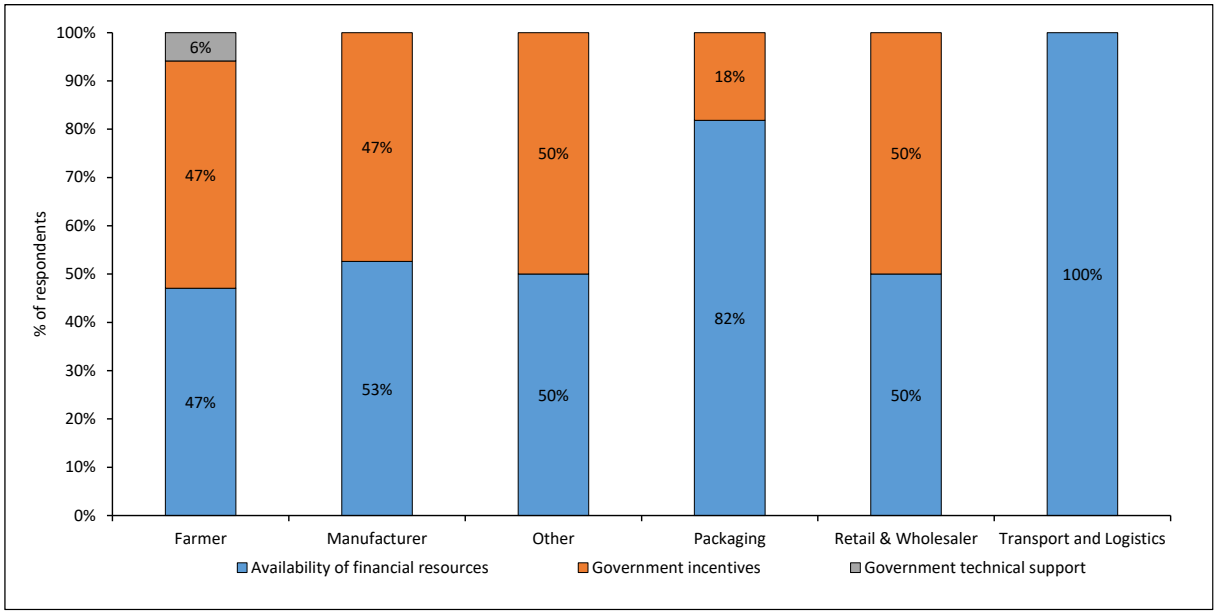


Policies are key to promote innovation by creating incentives and removing barriers. They do so through their influences (i.e. economic, regulatory, informative) in the technology-push and market-pull forces of innovation. Technology-push policies can promote sustainability by reducing the costs of the sustainability innovations (e.g. through R & D grants and loans or tax incentives), by influencing the supply of knowledge (e.g. through professional and entrepreneurship training, scientific workshops, promoting collaboration for knowledge exchange) and by regulation (e.g. patent law and intellectual property rights). Moreover, since consumers are generally not able to assess the sustainability (e.g. in terms of environmental, social or health aspects) of food products and are unwilling to pay more for products whose higher sustainability benefits are not proven, demand-pull policies can help by providing information (e.g. public information campaigns, rating and labelling programs), by subsidising sustainable food (e.g. taxes and levies) and by regulation (e.g. establishing standards, prohibiting or constraining products/practices) (Arfaoui, 2018; Rogge & Reichardt, 2016).

When analysing drivers, barriers and policy incentives of sustainability innovation altogether, market-pull is considered the most critical factor, and lack of customer recognition and willingness to pay is considered a significant barrier. Conversely, mainly economic, technology-push policies (e.g. subsidies and tax credits) are identified as supporting sustainability innovations. However, this factor is in line with the most commonly reported barrier for the adoption of sustainability initiatives, i.e. the lack of public support and/or lack of clarity in the current policies regarding sustainability.

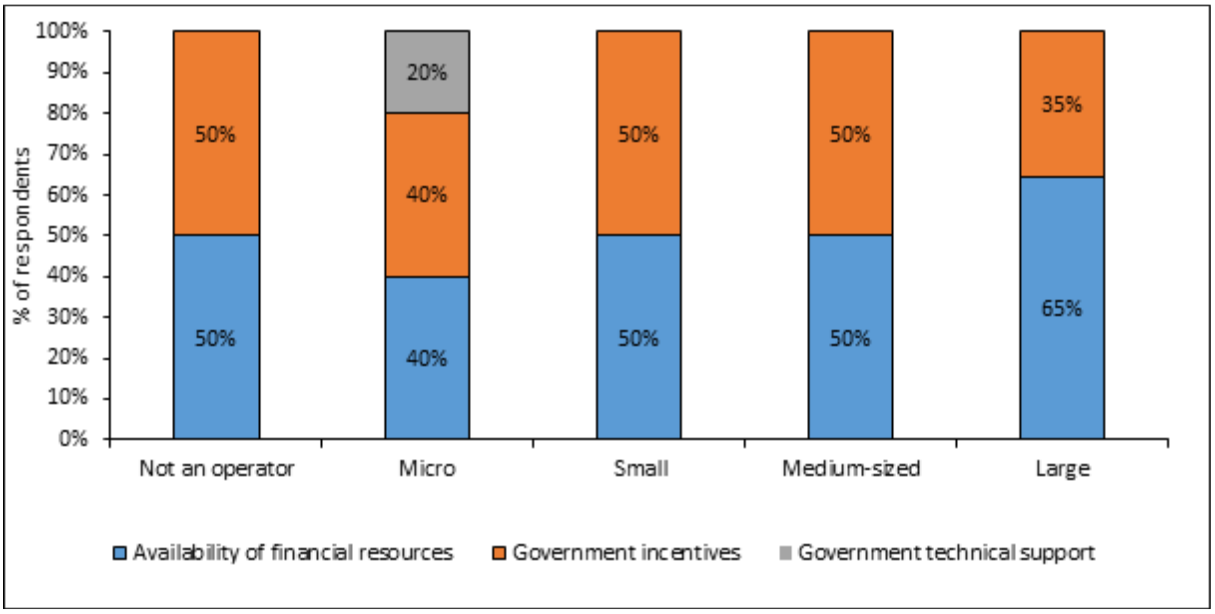
In regard to different stages of the food chain, respondents from all stages consistently identified the availability of financial resources as the primary factor influencing the adoption of sustainability initiatives. Government incentives were also frequently cited as a contributing factor. However, the transport and logistics sector did not report government incentives as a significant driver for sustainability innovation. Interestingly, respondents from the transport and logistics as well as packaging sectors assigned greater importance to the availability of financial resources compared to other respondent groups. Notably, farmers (comprising 6 % of farmer respondents) were the only group that mentioned government technical support as a notable incentive (Figure 29).

Figure 29. Main financial factors and policy incentives by respondents' stage of the food chain (% share of respondents that provided answer)



When considering the operator's size, similarly to the abovementioned results, the availability of financial resources and government incentives are the two main factors affecting the adoption of sustainability initiatives. Also, it is important to highlight that the importance of the availability of financial resources tends to increase with the size of the respondent, indicating that smaller operators tend to rely more on government support. Micro operators (20 %), which in this study are mainly farmers, are the only group that reported government technical support as an incentive for the adoption of sustainability innovations (Figure 30).

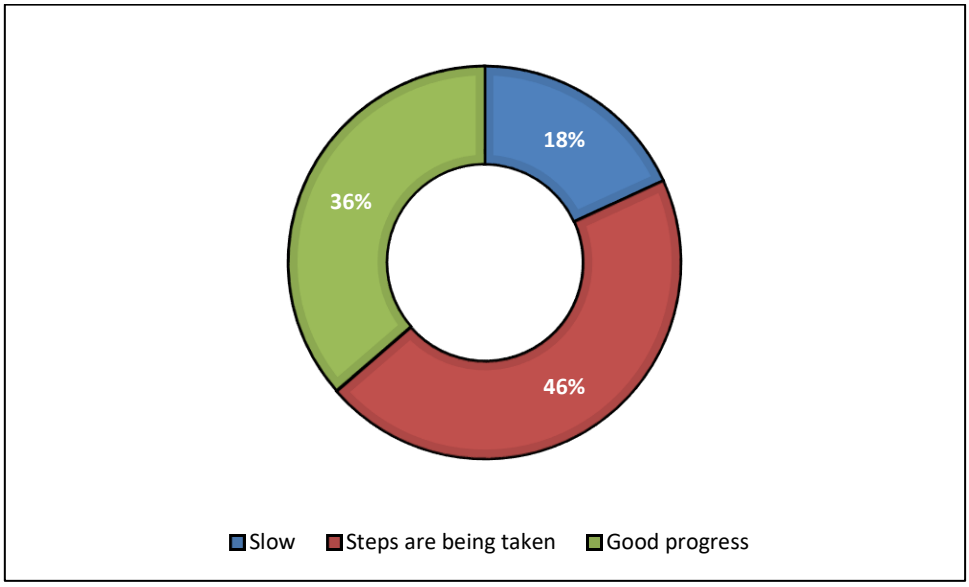
Figure 30. Main financial factors and policy incentives by size of the company (% share of respondents that provided answer)



In the final part of the interviews, interviewees were asked to express their opinion regarding the current state of the transition towards sustainability in the food sector (i.e. slow, steps have been taken, good progress, etc.) and what would be necessary for this transition to happen. Most interviewees agreed that although the

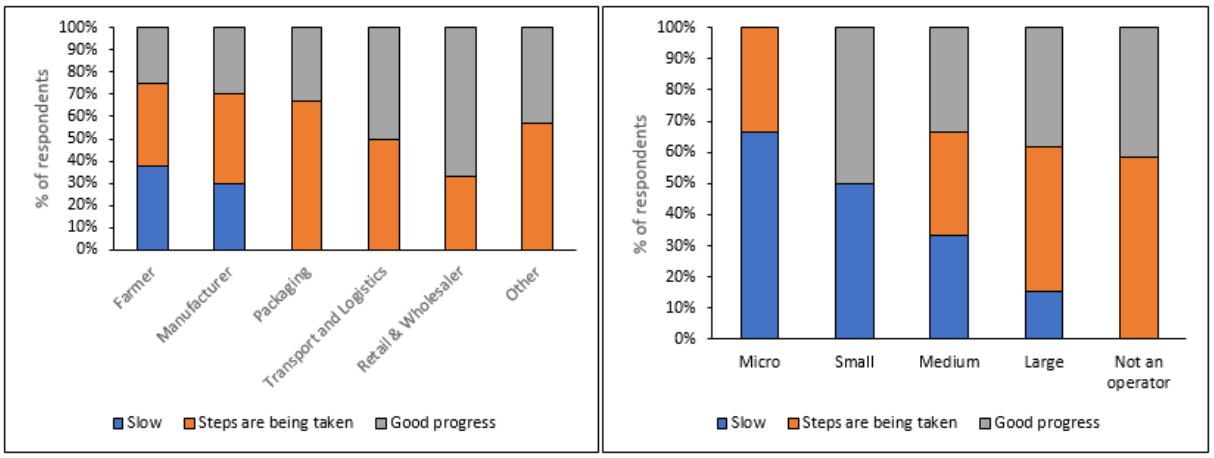
transition process has begun, there is still a long way to go. Around 18 % of interviewees consider that the process is slow because the system is not well organised and that more detailed and effective legislation is needed. Another 46 % of respondents consider that operators are making progress in innovating and making the transition towards sustainability, partly to comply with legislation, but mainly as a part of their competitive strategy. However, they pointed out that the consumer is still a barrier, as purchasing decisions are mainly based on price and, often, they are not willing to pay a higher price for sustainability. They suggest that consumers need more clarity on what sustainability is, particularly regarding its diverse facets, and how to value it. Nevertheless, 36 % consider that the progress made so far is satisfactory, although there are still efforts to be made; they highlighted that front-up costs, financial resources and the need to involve all agents of the food chain, including consumers, still represent the main barriers, and that policies should take this into account (Figure 31).

Figure 31. Current status of transition towards sustainability in the food chain (% share of respondents that provided answer)



Regarding the stage in the food chain and operator size, Figure 32 shows that only some of the interviewed farmers and manufacturers consider the process to be slow, and this perception diminishes as the operator size increases. Non-operators do not consider the transition towards sustainability to be slow.

Figure 32. Current status of transition towards sustainability in the food chain by stage (left) and size (right) of operators (% of respondents that provided answer)



Moreover, interviewees provided details on how current policies support innovation and the transition towards sustainability and what would be needed to foster the transition. About one-fifth of the interviewees consider

that both EU and regional policies significantly support the adoption of innovative practices for sustainability, while, on the other hand, most respondents point out that the adoption of new legislation is needed, particularly to highlight the importance of innovation. Along these lines, 27 % of respondents feel that EU and national or regional policies need to be better aligned, and that there needs to be a greater harmonisation between countries. They find that countries and regions are currently competing with different rules and regulations, which is hindering innovation. Almost 40 % suggest that legislation should be clearer, more robust (e.g. stronger on taxation) and more efficient, considering that understanding and complying with legislation is time- and resource-consuming for operators. The latter is particularly relevant for small operators. Also, more public funding seems important, as it was mentioned before that the lack of funding is a key problem. In addition, it is worth noting that a quarter of respondents indicated that current policies are not successful in promoting change and innovation towards more sustainable products, and a further 11 % indicated that they are not implemented on time. They state that, generally, the food industry is quicker in promoting sustainability, as it bears the risk of acting without a legal framework in place to protect it.

Therefore, more than one quarter of respondents (27 %) indicates that policies should promote sustainability both systematically and structurally, ensuring that all stages, including consumers, come to a global agreement and commitment. This would allow a common and shared strategy to be built and for the economic, environmental and social dimensions of sustainability to be pursued in a viable manner. Again, they stress that sustainability entails costs (one interviewee explicitly advocated for the internalization of externalities in food prices), and it is important to consider how it impacts consumers' willingness and ability to pay (sustainability versus affordability). 41 % of respondents argue that the Green Deal and the F2F strategy therefore have to work on how to communicate the meaning and the value of sustainability to citizens and entrepreneurs and increase public awareness by means of clear and transparent information. And let's not forget that policy measures need a holistic impact analysis embracing all dimensions and trade-offs, particularly economic viability and the impact on prices and consumers (19 % of respondents). The importance of certifications is also highlighted in this respect. Some respondents (16 %) indicate a need for more education, research and scientific information and to promote collaboration and the exchange of knowledge and resources within and between chain operators and external institutions. As for legislation, it should be simple, stable and timely, and should allow for sufficient implementation periods with clear mandatory or optional targets and a high degree of harmonisation between regions and countries (22 % of respondents). Finally, some respondents believe that small businesses and the primary sector need more political, economic and technical support to be involved in the transition, pointing out that it is crucial to foster the digitalisation of the primary sector via a concrete funding strategy.

6 Innovation capabilities, collaborative approaches to sustainability and measuring operators' performance

6.1 Innovation capabilities

Some interviewees said that identifying market opportunities is the starting point for adopting sustainability innovations, and some stressed that sustainability innovation is a part of their integrated strategy and business plans. Concerning the latter, who is in charge of innovation reflects the level of systematisation and organisation of the process and has an influence on whether they carry out R & D activities and what the operator's resources and innovation capabilities are. According to the results (Figure 33) some differences were observed when leading or managing innovation inside the company. Most respondents (84 %) reported that R & D departments, other specific departments (e.g. business development) or specific committees were in charge of innovation within the company. Additionally, Figure 34 reveals that the operator's size seems to have a bigger influence on who is in charge of innovation than the food chain stage: the owner or director is the one in charge of innovation in micro-enterprises, whereas R & D or other specific departments are in charge of innovation in larger operators. This organisation of innovation may restrict micro-companies to specific capabilities by limiting their activities to scan the business environment for opportunities and the capabilities to exploit them.

Figure 33. Responsibility for sustainability innovation in food operators (% share of respondents that provided an answer)

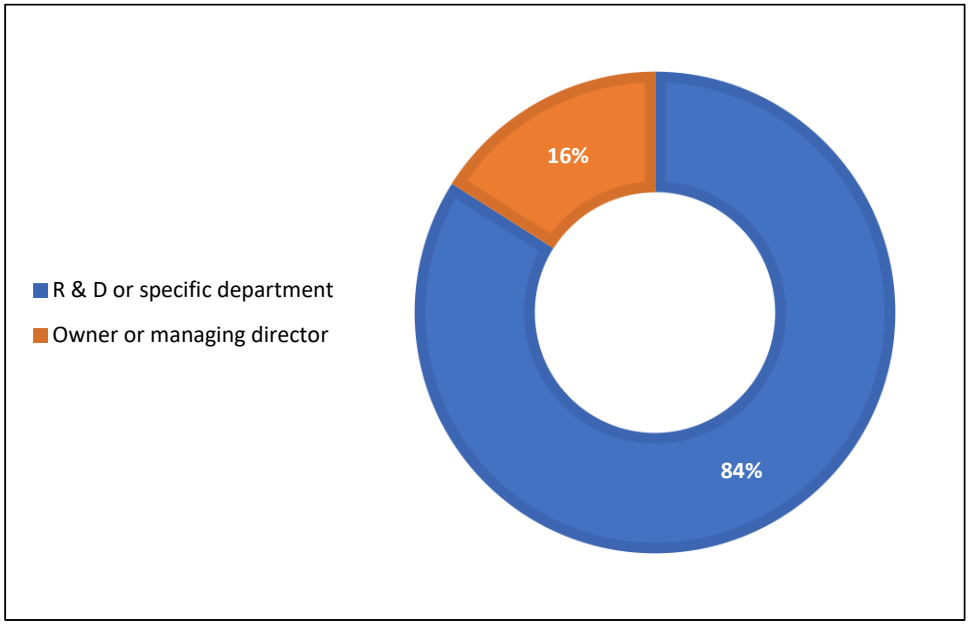
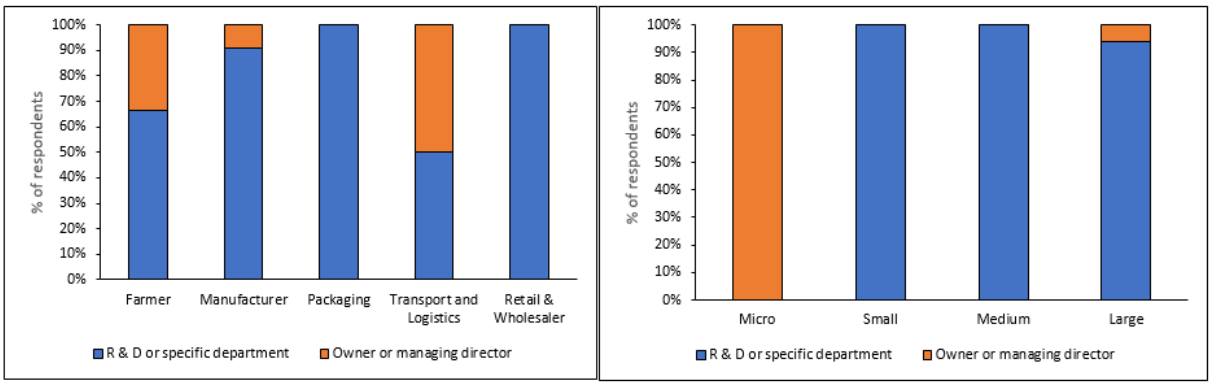


Figure 34. Department in charge of sustainability innovation in food operators by food chain stage an operator's size (% of respondents that provided an answer)



6.2 Collaborative approaches

The results confirm that, currently, innovation processes on sustainability are hardly conducted by a single company, highlighting the importance of considering the innovation process from a food chain and network perspective, taking into account the different types of actors involved. Nearly all interviewees consider that collaboration is fundamental and knowledge exchange is crucial, as long as it is within the legal framework. One respondent indicated that even though exchange of knowledge is important, this should take place through licences and economic exchanges.

While interviewees confirm the importance of collaboration, there are caveats worth considering. For this purpose, as it was explained in the introductory section, collaborative practices are categorised into horizontal collaboration (i.e. between companies operating at the same level of the food chain and therefore competing within the same sector or industry), vertical collaboration (i.e. between operators at different stages of the food chain – e.g. suppliers and customers – and therefore partners within the same chain) (Omta, 2004) and collaboration with external third parties (e.g. universities, research centres). Figure 35 shows that collaboration for sustainability innovation is mainly of vertical nature, involving both chain partners, (57 % of respondents) and third parties (59 %). Collaboration between competitors (i.e. horizontal) is less frequent (24 %) and mainly reported by farmers (Figure 36). Famers traditionally cooperate, for instance through cooperatives or associations, to augment their market power and information sharing as a means to increase prices and decrease production and transaction costs, which allows them to achieve higher-quality products, adopt technologies that would not be available to the individual farmer and enhance efficiency gains resulting from shared knowledge and best practices. Indeed, farmers state that they usually share information on sustainable practices among themselves and within the association to which they belong. Horizontal cooperation also has a sizable representation in transport and logistics. In this sector, cooperation with competitors is mentioned concerning sustainable truck development, which is stressed as not being their core business. Again, this suggests that companies do not collaborate with competitors when it comes to core business activities. Some respondents highlighted that horizontal collaboration should be promoted for sustainability issues and digital transformation, or in pre-competitive phases, but not for product development. On the other hand, other respondents explicitly stated that they do not collaborate with competitors as a strategic choice.

The interviewees believe that cooperating on sustainability innovation enables knowledge sharing, the development of new capabilities (collaboration), coordination on the use and access to resources and technology, and enhances the commitment to sustainability. None of the respondents referred to joint decision-making as a benefit of cooperation on sustainability innovation, however (Figure 35).

.

Figure 35. Type of collaboration declared by respondents (left) and capabilities dimension of cooperative approaches (right) (% of all respondents)

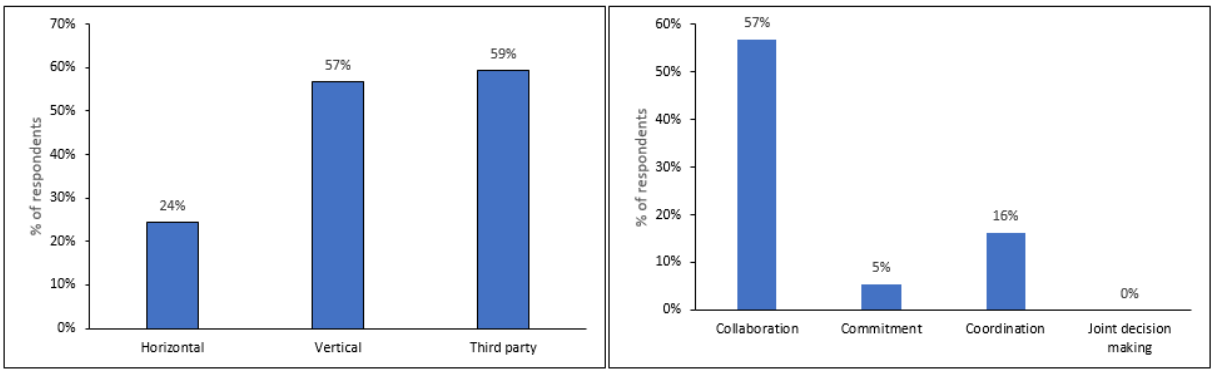
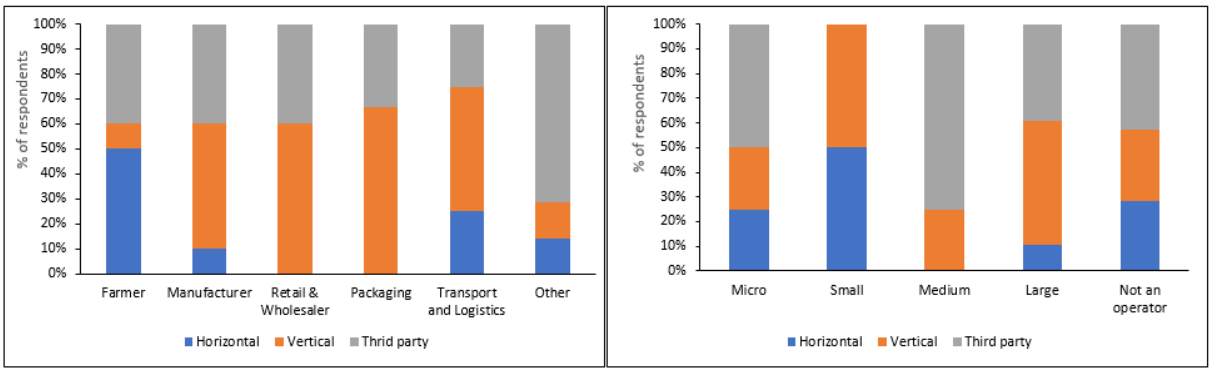


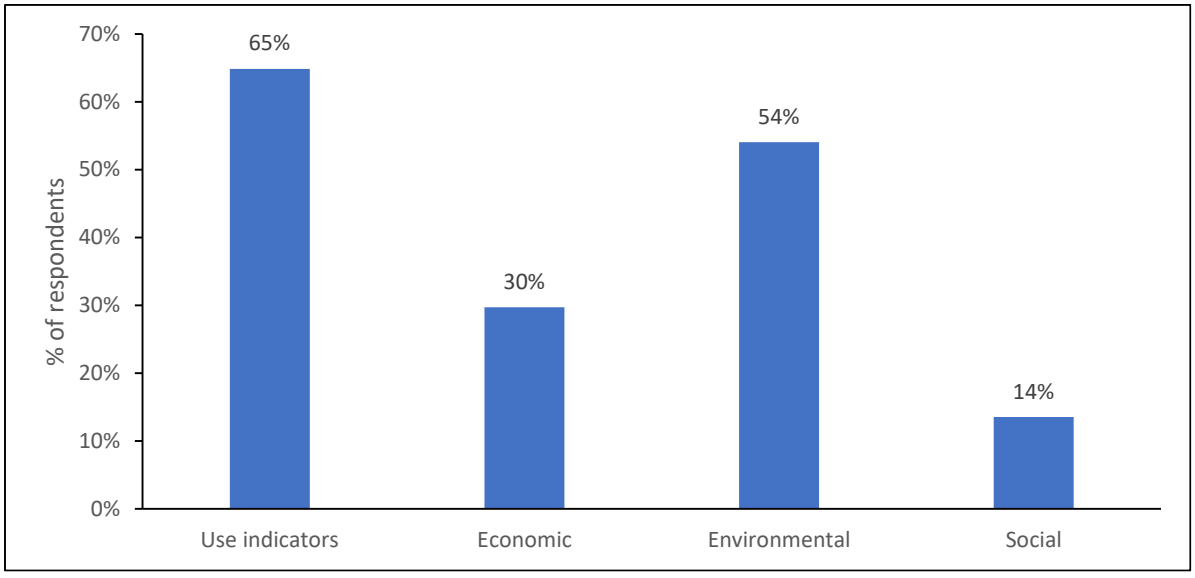
Figure 36. Type of collaboration reported by respondents by stage in the food chain (left) and size (right) (% of all respondents)



6.3 Measuring operators' sustainability innovation performance

One part of the interview was dedicated to the evaluation of operators' sustainability innovation and the indicators used to do so. More than 60 % of the interviewees said that they use indicators to measure sustainability innovation performance (see Table 2 for examples). Nearly 55 % of them use indicators to measure their environmental performance, around 30 % use economic indicators, and only 14 % use social indicators (Figure 37). These results are consistent with the fact that respondents indicated (Section 4.2) that they primarily orient their sustainability innovation towards economic and environmental objectives and less toward social ones, suggesting that social innovation is often neglected in the sustainability debate.

Figure 37. Use of sustainability innovation performance indicators (% of all respondents)



Environmental indicators appear to be more used in all stages of the food chain, except for retailers and wholesalers and other organisations, who use economic indicators just as much. Social indicators are less used in all stages of the food chain and are not applied at all in packaging or transport and logistics. Looking at operators' size, surprisingly, micro-companies focus on measuring environmental performance only, whereas medium-sized and large operators alone measure social performance (Figure 38).

Figure 38. Use of sustainability innovation performance indicators by stage in the food chain (left) and size (right) (% of all respondents)

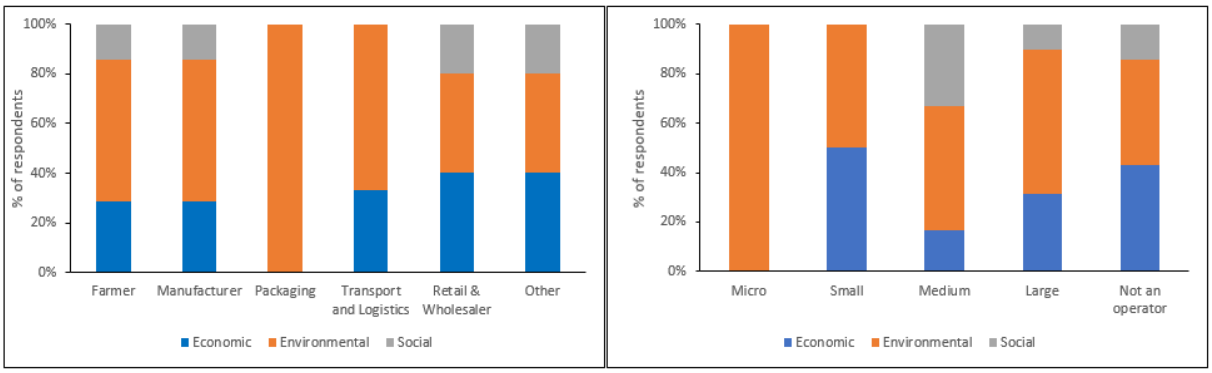


Table 2 gives examples of indicators used by operators to measure sustainability innovation performance as reported by the respondents. However, no consensus on how to evaluate sustainability innovation has emerged from the interviews, probably because operators do not coordinate much in this respect.

Table 2. Example of sustainability indicators as reported by the interviewees

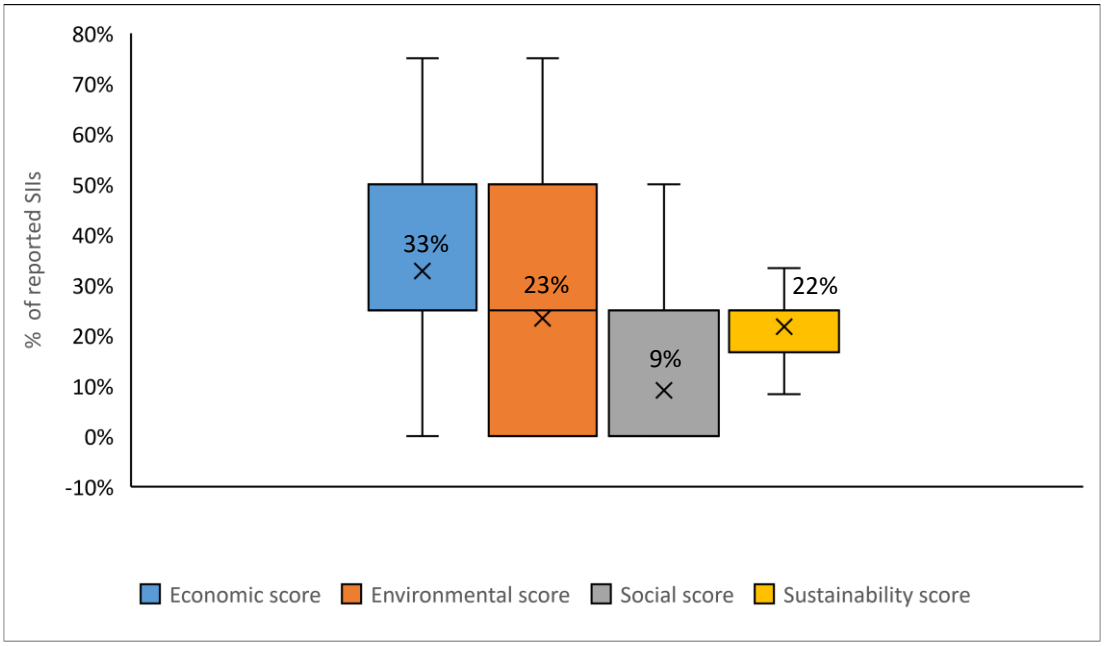
Economic	Environmental	Social
Product quality	Carbon footprint	Creating jobs in rural areas
Growth indicators	Animal welfare (mortality levels on the farm)	Employability and education of people
Number of products on the market	CO_2 emissions	Employees' training hours
Innovation return	Quantification of by-products	Permanent vs temporary contracts
Sales related to products	Sustainable development goal indicators	Vacancy positions covered with internal employees
Level of efficiency	Energy, waste and plastic use	Breakdown by gender and age
Indicators of reputation	Shelf-life	Food donations
Healthy sales compared to total sales	Water footprint	Donations for social help
Cost–benefit ratio of new products	Transport and distribution costs	

7 Sustainability performance of sustainability initiatives

As a way to evaluate or quantify the sustainability performance of sustainability initiatives, the average sustainability score has been calculated. The average sustainability score over the three sustainability pillars (sustainability score) for the considered initiatives is 22 % with a ±9 % deviation for the 95 % confidence interval. This means that on average the 314 sustainability initiatives are expected to generate 22 % of benefits (represented by SIIs) out of the total identified SIIs (i.e. 12 SIIs as indicated in Table 1). In other words, each initiative generates on average approximately at least 2 benefits out of the total 12 benefits (represented by SIIs) (Figure 39).

On average, the economic pillar shows the highest scores (33 %, ±19 %), followed by environmental pillar (23 %, ±21 %) and social pillar (9 %, ±14 %) (Figure 39) ([8]).

Figure 39. Average sustainability scores (% share of reported SIIs)

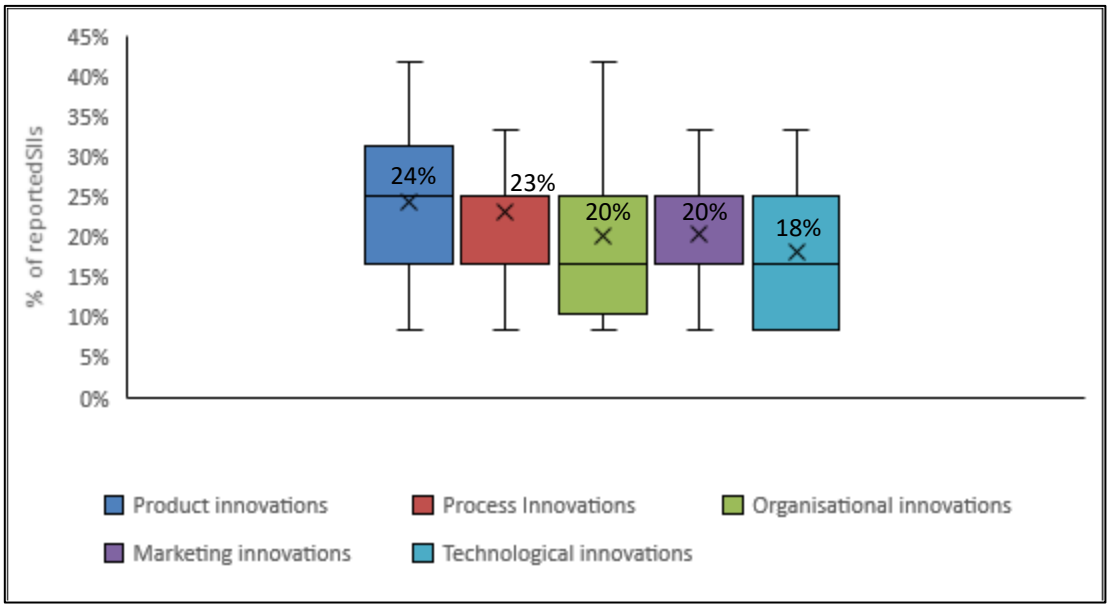


Notes: the cross represents the average score, the top edge of the box is the 75th percentile (Q3), the bottom edge is the 25th percentile (Q1), and the box is the Q3–Q1 interquartile range (IQR). The top whisker, called the 'upper extreme', is Q3 + 1.5*IQR, and the bottom whisker ('lower extreme') is Q1 -1.5*IQR. Any value above the 'upper extreme' or below the 'lower extreme' is considered an outlier.

Although there is high variation across innovation categories, product and process innovations seem to lead with slightly higher average sustainability scores compared to other innovation categories, especially technological/digital innovation, the score of which is the lowest (Figure 40).

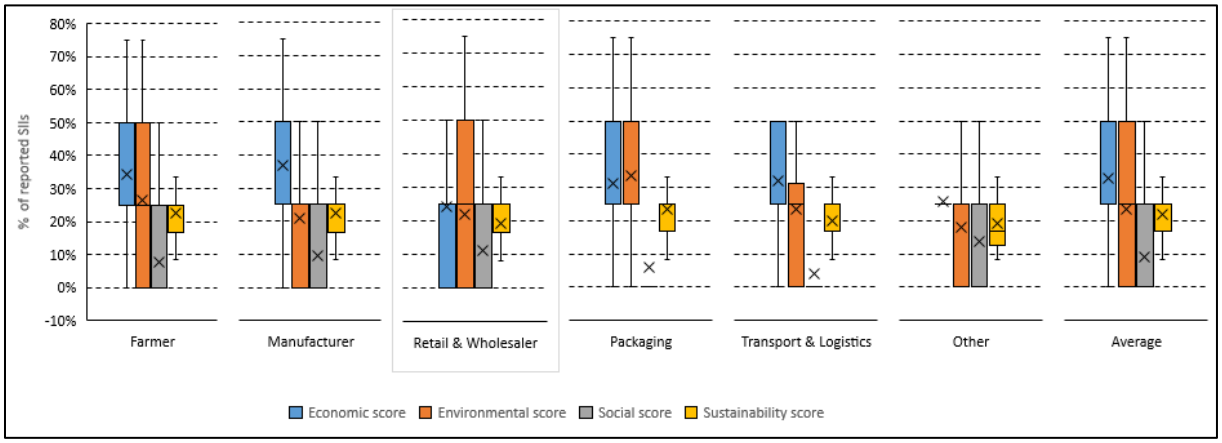
([8]) In addition, the boxplots in Figure 31, Figure 32, and Figure 33 give an indication of how the values in the data are spread out.

Figure 40. Average sustainability scores by innovation category (% share of reported SIIs)



There seems not to be a significant difference in the overall sustainability scores across the different stages of the food chain. In general, the economic pillar score is the highest for all stages of the food chain except for packaging and retailers and wholesalers, where the environmental pillar shows similar average scores. As it was observed above, the social pillar is the lowest ranked among all stages of the food chain (Figure 41).

Figure 41. Average sustainability scores by the stage of the food chain (% share of reported SIIs)



8 Conclusions

This report presents a comparative assessment of sustainability innovation and innovative initiatives adopted by operators in the EU food chain. The analyses in this report are based on data collected through semi-structured interviews with 37 representatives of food chain operators, associations and other organisations that represent their interests or provide them with services. Overall, 314 sustainability initiatives were identified from the responses provided by respondents across the 13 EU Member States covered by the study. It is worth noting that some respondents are EU-level associations or multinational companies, which means that they indirectly cover several Member States or the entire EU (e.g. in the case of EU associations). The results should be cautiously interpreted in terms of representation, given the relatively small sample size.

The results from the interviews reveal that operators from the food chain, to a different extent, have introduced various initiatives aiming to innovate products, processes, organisational aspects, marketing activities and introduce technological/digital improvements to move towards more sustainable production and consumption dynamics. The results place the economic dimension of sustainability as the most important one for private operators when adopting sustainable initiatives, followed by the environmental dimension, whereas the social dimension is covered to a much lesser extent. In other words, the quantitative analyses of the interviews show that most initiatives identified by respondents (86 %) are expected to generate economic benefits; environmental benefits were reported to be generated by 64 % of initiatives and social benefits by around 33 % of initiatives. Indeed, operators stressed that the economic aspects are essential; they usually adopt those sustainability innovations from which they expect positive economic impacts, including improving their competitiveness to ensure the sustainability of their businesses, particularly by adding value to their products through product differentiation, so enhancing their competitive advantage, while achieving positive effects for environmental or social aspects. They also claimed that the economic dimension is often closely related to the environmental one since an essential aspect of the latter is the reduction and more efficient use of resources, indirectly implying economic benefits. Interestingly, no negative impacts on the sustainability dimensions are reported, which suggest that operators adopt only those initiatives that are expected to generate primarily positive sustainability benefits (particular economic ones) without compromising any sustainability aspect or rise the issue of a potential under-estimation of negative sustainability impacts.

The sustainability performance of the studied initiatives indicates that, on average, the analysed sustainability initiatives are expected to generate 22 % of benefits out of the total identified benefits (as represented by SIIs). In other words, on average, each initiative generates approximately at least 2 benefits out of the total 12 benefits (represented by SIIs) across the three dimensions of sustainability. The economic pillar shows the highest scores (33 %), followed by the environmental pillar (23 %) and the social pillar (9 %). Also, we observed that higher scores for sustainability performance are associated with product and process innovations, whereas technological/digital innovations are associated with lower scores. It bears stressing that this sustainability measure does not measure the actual benefits obtained from sustainability initiatives. Instead, it is only an attempt to measure the relative sustainability of an initiative (or types of innovative initiatives) compared to the rest in terms of which dimensions (i.e. economic, environmental and social) and sub-dimensions (e.g. competitiveness, more efficient use of resources, labour practices, product responsibility) of sustainability it tries to encompass. This approach may help operators systematically identify all relevant sustainability impacts and serve as a basis for rational decision-making concerning the operator's sustainability strategy and activities, as it evaluates the strategic relevance of the expected benefits. In addition, the interviews report that most operators use indicators to measure and manage specific aspects of the sustainability performance of their innovations.

In terms of innovation resources and capabilities, the interviews reveal that most operators (84 % of respondents) have R & D or business development departments in charge of sustainability innovations, reflecting the presence of a strategy orientated towards sustainability. For a minority of respondents (16 %) the owner or director is in charge of sustainability innovation, which may place constraints on their time and resources to innovate. This is mainly the case of micro-operators and, in particular, farmers.

Looking at drivers, barriers, financial factors and policy incentives, the interviews further revealed that the most important driver that needs to be present for private sector operators to adopt sustainable initiatives is favourable supply and demand conditions. Interviewees believe that responding to the market supply and demand requirements is the main driving factor behind adopting sustainability initiatives and, therefore, consider that sustainability innovation in the food sector comes more from market-pull factors than from technological-push factors. However, the technology-push effect may be underestimated if operators adopt or integrate innovations from the market and are not the main inventors and first movers. Moreover, interviewees indicated that the lack of recognition of the sustainability efforts by consumers and lack of willingness to pay

the higher costs of sustainable products and processes prevents the adoption of sustainability initiatives. This implies, among other things, that an effective transition towards sustainable production and consumption requires raising awareness among consumers and the whole food chain about the environmental and social aspects of products and processes. It seems essential to inform, motivate and raise consumer awareness with transparency and clarity so that consumers can value sustainable products and accept to pay the higher price they represent. The reputational effect, together with operators' intrinsic motivation for adopting more sustainability initiatives, are also found to be somehow important in driving the adoption of sustainability initiatives for many operators. Further, the interviewed respondents widely agreed on the lack of public support and/or lack of clarity in the current policies regarding sustainability as the main barrier to the adoption of sustainability initiatives. This result points to the need for government guidance, offering a more comprehensive food system vision with an adequate regulatory framework and harmonised, clear legislation across countries which is inclusive of all stages of the food chain. Additional incentives and funding for improved sustainable solutions and government technical support were also identified as important catalysts for the adoption of sustainability initiatives – particularly for micro-operators (e.g. farmers) who need help bridging the lack of financial resources, technical human resources and knowledge about sustainability solutions and their integration into operations. Operators often perceive the adoption or update of relevant regulation on sustainability to be rather slow and lagging behind. The food industry, for example, is often faster in promoting sustainability, but bears the risk of acting without a legal framework in place to protect it.

The results from the interviews also highlight the importance of collaboration and knowledge exchange for the sustainability innovations to happen. Collaboration on sustainability innovations enables knowledge sharing, the development of new capabilities, coordination of the use and access to resources and technology, and enhances the operators' commitment to sustainability. However, results show that operators have established certain boundaries in terms of the types of collaboration they are willing to engage in. Collaboration with external third parties (e.g. universities, research centres) and vertical collaboration (between operators at different stages of the food chain) are more common and more acceptable for operators from a strategic point of view compared to horizontal collaboration (between operators from the same stage of the food chain). In certain cases, horizontal collaboration seems to be more relevant, for example at certain stages of the food chain (e.g. farming sector). Some respondents argued that it can be relevant and useful to promote sustainability issues that are not directly related to the core business activities of the operators involved.

Finally, most interviewees agree that, although the transition towards a more sustainable food system is under way, there is still a long way to go, and that policies can play an essential role in accelerating the transition by encouraging sustainability-oriented innovation in products and business processes, which in turn fosters change in terms of what and how food is produced, distributed, and consumed. In summary, five policy recommendations have emerged from the interviews with food chain operators and related organisations. First, policies supporting consumer valorisation of sustainable food are needed, in order to raise awareness about the importance of sustainable food in all of its facets. Consumers are generally unable to evaluate the sustainability of food products (e.g. in terms of environmental or social/health aspects) and are unwilling to pay more for products with higher sustainability benefits that are not proven. Thus, demand-pull policies can help by providing information with, for example, public information campaigns and rating and labelling programs. The social dimension is significantly under-addressed and requires attention. Moreover, consumers may still be reluctant or unable to pay more for sustainability. Other demand-pull policies may therefore be needed (e.g. tax, subsidies or bans). Second, government guidance is needed in order to have a comprehensive food system vision with a coherent regulatory framework including all stages of the food chain; government guidance is also needed to have clear, timely and harmonised legislation supporting sustainability innovation across countries. Third, more incentives and funding for improved sustainable solutions and government technical support are needed; these would promote innovation by reducing its cost and providing knowledge and training in sustainability, innovation and entrepreneurship. Also, the results show that different operator types and sustainability innovation types may require different incentive mixes. Micro operators, particularly farmers, mainly reported the lack of financial and technical human resources and knowledge about sustainability solutions and their integration in operations as barriers to innovation. Fourth, promoting knowledge exchange and collaboration between operators and third-party institutions is important to foster a commitment to sustainability. Finally, guidance is needed in terms of comprehensive sustainability performance measurement and monitoring frameworks to promote the adoption of sustainability innovations.

One must be aware when drawing conclusions that the findings of this report reflect methodological assumptions and data limitations. First, the information collected through the interviews and used to derive analyses in the report is based on convenience samples and is not representative of the underlying population of stakeholders active in the EU food chain. Analysing the results of the subsequently launched online survey

will help to provide robustness to the results of this study. A second caveat of the analysis is that although statistics are provided on the sustainability performance of the analysed sustainability initiatives, the report does not quantify their actual sustainability impacts due to the qualitative nature of the information collected through the interviews. The report only identifies the impacts as expected by respondents. Further research is needed in this area to provide a comprehensive quantitative impact estimate of the adopted sustainability initiatives in the EU food chain. A third caveat is that the methodology applied in the report did not quantify the direct cost of developing and adopting sustainability initiatives for operators. Instead, the report attempted to collect information on the qualitative assessment of barriers, drivers and financial factors affecting their adoption. Future research should consider these limitations to the current approach. Despite these limitations, the report provides important insights on the implementation of sustainability initiatives in the food system. Its findings are important to operators and policymakers concerned with sustainability innovation in the EU food chain.

References

Adams, R., Jeanrenaud, S., Bessant, J., Denyer, D., & Overy, P. (2016). Sustainability-oriented innovation: A systematic review. *International Journal of Management Reviews*, *18*(2), 180–205.

Afshin, A., Sur, P. J., Fay, K. A., Cornaby, L., Ferrara, G., Salama, J. S., Mullany, E. C., Abate, K. H., Abbafati, C., & Abebe, Z. (2019). Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*, *393*(10184), 1958–1972.

Arfaoui, N. (2018). Eco-innovation and regulatory push/pull effect in the case of REACH regulation: empirical evidence based on survey data. *Applied Economics*, *50*(14), 1536–1554.

Balafoutis, A., Beck, B., Fountas, S., Vangeyte, J., Wal, T. Van der, Soto, I., Gómez-Barbero, M., Barnes, A., & Eory, V. (2017). Precision agriculture technologies positively contributing to GHG emissions mitigation, farm productivity and economics. *Sustainability*, *9*(8), 1339.

Bansal, P., & Roth, K. (2000). Why companies go green: A model of ecological responsiveness. *Academy of Management Journal*, *43*(4), 717–736.

Barrett, C. B., Benton, T., Fanzo, J., Herrero, M., Nelson, R. J., Bageant, E., Buckler, E., Cooper, K., Culotta, I., & Fan, S. (2022). Socio-technical innovation bundles for agri-food systems transformation. In *Socio-Technical Innovation Bundles for Agri-Food Systems Transformation* (pp. 1–20). Springer.

Basso, B., & Antle, J. (2020). Digital agriculture to design sustainable agricultural systems. *Nature Sustainability*, *3*(4), 254–256. https://doi.org/10.1038/s41893-020-0510-0

Berry, M. A., & Rondinelli, D. A. (1998). Proactive corporate environmental management: A new industrial revolution. *Academy of Management Perspectives*, *12*(2), 38–50.

Bocken, N. M. P., & Short, S. W. (2021). Unsustainable business models–Recognising and resolving institutionalised social and environmental harm. *Journal of Cleaner Production*, *312*, 127828.

Cagliano, R., Worley, C. G., & Caniato, F. F. A. (2016). The challenge of sustainable innovation in agri-food supply chains. In *Organizing supply chain processes for sustainable innovation in the agri-food industry*. Emerald Group Publishing Limited.

Chen, L., Zhao, X., Tang, O., Price, L., Zhang, S., & Zhu, W. (2017). Supply chain collaboration for sustainability: A literature review and future research agenda. *International Journal of Production Economics*, *194*, 73–87.

Chen, X., Wang, C., & Li, S. (2022). The impact of supply chain finance on corporate social responsibility and creating shared value: A case from the emerging economy. *Supply Chain Management: An International Journal*.

COM. (2019). *The European Green Deal*. https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., & Leip, A. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. *Nature Food*, *2*(3), 198–209.

Daniluk, A. (2017). Cooperation between business companies and the institutions in the context of innovations implementation. *Procedia Engineering*, *182*, 127–134.

Davies, A. R. (2020). Toward a Sustainable Food System for the European Union: Insights from the Social Sciences. *One Earth*, *3*(1), 27–31. https://doi.org/10.1016/j.oneear.2020.06.008

Dung, T. Q., Bonney, L. B., Adhikari, R. P., & Miles, M. P. (2020). Entrepreneurial orientation, knowledge acquisition and collaborative performance in agri-food value-chains in emerging markets. *Supply Chain Management: An International Journal*.

Ehlers, M.-H., Finger, R., El Benni, N., Gocht, A., Sørensen, C. A. G., Gusset, M., Pfeifer, C., Poppe, K., Regan, Á., Rose, D. C., Wolfert, S., & Huber, R. (2022). Scenarios for European agricultural policymaking in the era of digitalisation. *Agricultural Systems*, *196*, 103318. https://doi.org/10.1016/j.agsy.2021.103318

European Commission. (2020). Farm to Fork Strategy - For a fair, healthy and environmentally-friendly food system. In *DG SANTE/Unit 'Food information and composition, food waste''.'*

Fanzo, J., Arabi, M., Burlingame, B., Haddad, L., Kimenju, S., Miller, G., Nie, F., Recine, E., Serra-Majem, L., & Sinha, D. (2017). Nutrition and food systems. *A Report by the High Level Panel of Experts on Food Security and*

Nutrition of the Committee on World Food Security.

Fellmann, T., Domínguez, I. P., Witzke, P., Weiss, F., Hristov, J., Barreiro-Hurle, J., Leip, A., & Himics, M. (2021). Greenhouse gas mitigation technologies in agriculture: regional circumstances and interactions determine cost-effectiveness. *Journal of Cleaner Production*, *317*, 128406.

Finco, A., Bucci, G., & Bentivoglio, D. (2018). Lessons of innovation in the agrifood sector: Drivers of innovativeness performances. *Economia Agro-Alimentare / Food Economy*, 181–192. https://doi.org/10.3280/ECAG2018-002004

Fortuin, F. T. J. M., & Omta, S. W. F. O. (2009). Innovation drivers and barriers in food processing. *British Food Journal*.

Galli, F., Prosperi, P., Favilli, E., D'Amico, S., Bartolini, F., & Brunori, G. (2020). How can policy processes remove barriers to sustainable food systems in Europe? Contributing to a policy framework for agri-food transitions. *Food Policy*, *96*, 101871.

Garzon Delvaux, P. A., Hockmann, H., Voigt, P., Ciaian, P., & Gomez y Paloma, S. (2018). *The impact of private R&D on the performance of food-processing firms: Evidence from Europe, Japan and North America*. Joint Research Centre (Seville site).

Gault, F. (2018). Defining and measuring innovation in all sectors of the economy. *Research Policy*, *47*(3), 617–622.

Grunert, K. G., Harmsen, H., Meulenberg, M., Kuiper, E., Ottowitz, T., Declerck, F., Traill, B., & Göransson, G. (1997). A framework for analysing innovation in the food sector. In *Products and process innovation in the food industry* (pp. 1–37). Springer.

Herrero, M., Thornton, P. K., Mason-D'Croz, D., Palmer, J., Benton, T. G., Bodirsky, B. L., Bogard, J. R., Hall, A., Lee, B., & Nyborg, K. (2020). Innovation can accelerate the transition towards a sustainable food system. *Nature Food*, *1*(5), 266–272.

Horbach, J., Rammer, C., & Rennings, K. (2012). Determinants of eco-innovations by type of environmental impact—The role of regulatory push/pull, technology push and market pull. *Ecological Economics*, *78*, 112–122.

Hullova, D., Simms, C. D., Trott, P., & Laczko, P. (2019). Critical capabilities for effective management of complementarity between product and process innovation: Cases from the food and drink industry. *Research Policy*, *48*(1), 339–354.

Jenkins, H. (2009). A 'business opportunity'model of corporate social responsibility for small-and medium-sized enterprises. *Business Ethics: A European Review*, *18*(1), 21–36.

Klerkx, L., & Rose, D. (2020). Dealing with the game-changing technologies of Agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways? *Global Food Security*, *24*, 100347.

Krishnan, R., Yen, P., Agarwal, R., Arshinder, K., & Bajada, C. (2021). Collaborative innovation and sustainability in the food supply chain-evidence from farmer producer organisations. *Resources, Conservation and Recycling*, *168*, 105253.

Kühne, B., Gellynck, X., & Weaver, R. D. (2015). Enhancing innovation capacity through vertical, horizontal, and third-party networks for traditional foods. *Agribusiness*, *31*(3), 294–313.

Latruffe, L., Diazabakana, A., Bockstaller, C., Desjeux, Y., Finn, J., Kelly, E., Ryan, M., & Uthes, S. (2016). Measurement of sustainability in agriculture: a review of indicators. *Studies in Agricultural Economics*, *118*(3), 123–130.

Leach, M., Nisbett, N., Cabral, L., Harris, J., Hossain, N., & Thompson, J. (2020). Food politics and development. *World Development*, *134*, 105024.

Marshall, B., Cardon, P., Poddar, A., & Fontenot, R. (2013). Does sample size matter in qualitative research?: A review of qualitative interviews in IS research. *Journal of Computer Information Systems*, *54*(1), 11–22.

Mehmood, A., Ahmed, S., Viza, E., Bogush, A., & Ayyub, R. M. (2021). Drivers and barriers towards circular economy in agri-food supply chain: A review. *Business Strategy & Development*, *4*(4), 465–481.

Meynard, J.-M., Jeuffroy, M.-H., Le Bail, M., Lefèvre, A., Magrini, M.-B., & Michon, C. (2017). Designing coupled

innovations for the sustainability transition of agrifood systems. *Agricultural Systems*, *157*, 330–339.

Miranda, J., Ponce, P., Molina, A., & Wright, P. (2019). Sensing, smart and sustainable technologies for Agri-Food 4.0. *Computers in Industry*, *108*, 21–36.

Mowery, D., & Rosenberg, N. (1979). The influence of market demand upon innovation: a critical review of some recent empirical studies. *Research Policy*, *8*(2), 102–153.

Nikolaou, I. E., Tsalis, T. A., & Evangelinos, K. I. (2019). A framework to measure corporate sustainability performance: A strong sustainability-based view of firm. *Sustainable Production and Consumption*, *18*, 1–18.

OECD/Eurostat. (2005). *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*. OECD.

OECD/Eurostat. (2018). *Oslo manual 2018: Guidelines for collecting, reporting and using data on innovation*. OECD publishing.

Omta, S. (2004). Increasing the innovative potential in chains and networks. In *Journal on Chain and Network Science* (Vol. 4, Issue 2, pp. 75–81). Wageningen Academic Publishers.

Porter, M. E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance. Free Press: N. Y.* New York.

Porter, M. E., & Kramer, M. R. (2011). Creating shared value: Redefining capitalism and the role of the corporation in society. *Harvard Business Review*, *89*(1/2), 62–77.

Prause, L., Hackfort, S., & Lindgren, M. (2021). Digitalization and the third food regime. *Agriculture and Human Values*, *38*(3), 641–655. https://doi.org/10.1007/s10460-020-10161-2

Reinhardt, T. (2022). The farm to fork strategy and the digital transformation of the agrifood sector—An assessment from the perspective of innovation systems. *Applied Economic Perspectives and Policy*.

Rogge, K. S., & Reichardt, K. (2016). Policy mixes for sustainability transitions: An extended concept and framework for analysis. *Research Policy*, *45*(8), 1620–1635.

Ross, R. B., Pandey, V., & Ross, K. L. (2015). Sustainability and strategy in US agri-food firms: An assessment of current practices. *International Food and Agribusiness Management Review*, *18*(1030-2016–83052), 17–47.

Schaltegger, S., & Burritt, R. (2014). Measuring and managing sustainability performance of supply chains: Review and sustainability supply chain management framework. *Supply Chain Management: An International Journal*.

Schmookler, J. (1966). Invention and economic growth. In *Invention and Economic Growth*. Harvard University Press.

Shane, S., & Venkataraman, S. (2000). The promise of entrepreneurship as a field of research. *Academy of Management Review*, *25*(1), 217–226.

Shu, C., Zhao, M., Liu, J., & Lindsay, W. (2020). Why firms go green and how green impacts financial and innovation performance differently: An awareness-motivation-capability perspective. *Asia Pacific Journal of Management*, *37*(3), 795–821.

Smit, B., Janssens, B., Haagsma, W., Hennen, W., Adrados, J. L., Kathage, J., & Domínguez, I. P. (2019). Adoption of cover crops for climate change mitigation in the EU. *Publications Office of the European Union, Luxembourg*.

Soto, I., Barnes, A., Balafoutis, A., Beck, B., Sánchez, B., Vangeyte, J., Fountas, S., Van der Wal, T., Eory, V., & Gómez-Barbero, M. (2019). *The contribution of precision agriculture technologies to farm productivity and the mitigation of greenhouse gas emissions in the EU*. Publications Office of the European Union Luxembourg, Luxembourg.

Teece, D. J. (2009). *Dynamic capabilities and strategic management: Organizing for innovation and growth*. Oxford University Press on Demand.

Traill, W. B., & Meulenberg, M. (2002). Innovation in the food industry. *Agribusiness: An International Journal*, *18*(1), 1–21.

Trendov, N., Varas, S. and, & Meng, S. (2019). Digital technologies in agriculture and rural areas - Status report

(FAO). In *Food and Agriculture Organization of the United Nations*.

Weber, M. (2008). The business case for corporate social responsibility: A company-level measurement approach for CSR. *European Management Journal*, *26*(4), 247–261.

List of abbreviations and definitions

AI	Artificial intelligence
ERP	Enterprise resource planning
EU	European Union
F2F	Farm to fork
GIS	Geographic information system
GPS	Global Positioning System
GRI	Global Reporting Initiative
ICT	Information and communications technology
R & D	Research and development
SII	Sustainability impact indicator

List of figures

List of tables

Annexes

Annex 1. Semi-structured interview questionnaire guide

General questions

Q1. Could you please describe the business or organisation that you represent? Please tell us about your main activity and products, the size of the company or organisation in terms of employees and turnover, country coverage, etc. If you are an association, which types of members do you have?

Q2. In which stage of the food chain does the business or the organisation that you represent operate? Who is the buyer in the next steps of the food chain?

- Farmer.
- Processor/manufacturer.
- Wholesaler/distributor.
- Retailer.
- Inputs provider.
- Provider of other materials (e.g. packaging), equipment and services.

Q3. What is your role in the business or organisation that you represent?

Questions on innovative practices for sustainability

Q4. Are you aware of the European Green Deal and the Farm to Fork (F2F) strategy?

Q5. What are the innovations oriented towards sustainability that were recently (in the last 3 years) implemented, in the process of being developed or implemented, or planned in the business or organisation that you represent?

Q6. Are there innovations for sustainability that you are aware of but that the company or business that you represent is not planning to implement? Which ones are these and why aren't they implemented?

Questions about the innovation strategy

Q7. What is the value of the development of an innovation strategy in the company?

Q8. How is the innovation strategy materialised in the company?

- The company lacks an explicit innovation strategy.
- Innovation arises as a need derived from products or services that the company provides, but the company does not spend any resources planning innovation.
- The company management knows that they need to plan innovation methodologically, but they have a lack of human and material resources to do so.
- Innovation is managed and planned from an integrated perspective (technological, commercial and organisational), with different teams and people participating.

(The next questions should be answered for each of the innovation mentioned – product, process, organisational, market and packaging innovation).

Q9. What are the drivers that compel the company to innovate or implement innovations?

- Economic/profits.
- Policy/regulation.
- Consumer demand.
- Environment.
- Reputation.

Q10. What are the risks and constraints/barriers encountered in the development of this innovation? E.g. workforce, lack of right skills, lack of right solutions, lack of awareness of available solutions, lack of knowledge on how to use / integrate them, lack of time, lack of budget.

Q11. What are the expected benefits for the company or business that you represent, namely in terms of the three dimensions of sustainability (economic, environmental and social – including trade-offs)?
E.g. product expansion replacing phase-out products, novelty, differentiation, market expansion, improving product characteristics, improving safety, environmental aspects, meeting buyers' standards / requirements.

Q12. How are innovative decisions taken? Who is in charge? Is there a R & D department, business development department or something similar? How does innovation happen?

- Internal development (significant adaptation or completely new development).
- Adopting innovations from the market (licensing, copying products/processes).
- Receiving support from advisory services.

Q13. What do you think about collaborating on sustainability innovation, e.g. collaborating with other business/companies up and down the food chain, with packaging and equipment suppliers, or with public organisations (public–private collaboration)?

Q14. What do you think of knowledge sharing to stimulate innovations (e.g. sharing with other companies of the sector, with stakeholders, with other stages of the food chain)?

Q15. What would you consider to be the average spending in innovation for sustainability in the business or company that you represent as a percentage of the annual revenue?

Q16. How is innovation funded in the business or company that you represent?

- Internal financial resources.
- R & D tax credits.
- Government grants.
- Governmental financing support.
- Governmental/public research facilities.
- Government-supported training programs.
- Export development support.

Q17. Which indicators do you use to measure innovations in sustainability?

- Economic indicators: level of investment in innovation, sustainable objectives included in the production plan, number of new products, certifications, productivity and company's profitability.
- Environmental indicators: measurement and reduction of food waste; energy, water and land indicators; CO_2 and greenhouse gas emissions; life cycle assessments.
- Social indicators: degree of employment, social life cycle assessment, social return on investment.

Q18. On average, in the last 3 years, what percentage of sales came from innovative products oriented towards sustainability introduced during this period? Are the margins from innovative products/practices in general higher than those from traditional products?

Questions about EU and regional policies supporting sustainability innovation and what is needed

Q19. Do you think that EU and regional policies support or motivate innovation in sustainability? What policies are needed?

Q20. How would you describe the current status of the transition towards sustainability in the food system?

- Little movement.
- Starting.
- Good progress.
- Advanced stage.
- The vast majority of operators have made the transition to sustainable practices.

What is needed for this transition towards sustainable production and consumption to happen?

Q 21. Do you have any innovations in mind for the next few years? In which field?

Annex 2. Sustainability initiatives by private operators

Innovation category	Type of sustainability initiative	No.	Sustainability initiative
New product	Better quality products (e.g. new varieties, enriched products)	1	New cheese snack to reach children segments
New product	Better quality products (e.g. new varieties, enriched products)	2	New packaging oriented to extend the shelf life of cheese sticks
New product	Better quality products (e.g. new varieties, enriched products)	3	New formulas with whey powder to add nutritional and functional value to the product
New product	Better quality products (e.g. new varieties, enriched products)	4	New cheese ripening technology
New product	Better quality products (e.g. new varieties, enriched products)	5	New sizes and formats for business-to-business products
New product	Better quality products (e.g. new varieties, enriched products)	6	Substitution of an ingredient
New product	Better quality products (e.g. new varieties, enriched products)	7	Products for intolerant and elderly adults with A2 and/or standard milk, exosomes, microRNA and galacto-oligosaccharides
New product	Better quality products (e.g. new varieties, enriched products)	8	Range of dairy products with high protein content
New product	Better quality products (e.g. new varieties, enriched products)	9	Lactose-free baby formulas with lactose-derived prebiotics (galacto-oligosaccharides)
New product	Better quality products (e.g. new varieties, enriched products)	10	Dairy product to strengthen defences
New product	Better quality products (e.g. new varieties, enriched products)	11	Use of bioactive ingredients (antioxidant, anti-inflammatory) for the development of new products
New product	Better quality products (e.g. new varieties, enriched products)	12	Legume-based snacks, bread and other
New product	Better quality products (e.g. new varieties, enriched products)	13	Corn-based products (demanded by consumers and retailers)
New product	Better quality products (e.g. new varieties, enriched products)	14	Research into the taste of insects as new raw material
New product	Better quality products (e.g. new varieties, enriched products)	15	Patents in products (celobiosa)
New product	Better quality products (e.g. new varieties, enriched products)	16	Lactose-free products
New product	Better quality products (e.g. new varieties, enriched products)	17	New ingredients (new proteins)
New product	Better quality products (e.g. new varieties, enriched products)	18	New technologies for cheesemaking without using a specific additive
New product	Better quality products (e.g. new varieties, enriched products)	19	Lactose-free products
New product	Better quality products (e.g. new varieties, enriched products)	20	New ingredients, new taste, new flavours
New product	Better quality products (e.g. new varieties, enriched products)	21	Reformulation: more special nutrients, proteins
New product	Better quality products (e.g. new varieties, enriched products)	22	Produce a premium product
New product	Developing new products	23	Sheep's milk cosmetic products
New product	Environmental-friendlier products (e.g. agro-ecological, eco-packaging)	24	Crop varieties allowing for more sustainable agro-practices (e.g. different planting forms)
New product	Environmental-friendlier products (e.g. agro-ecological, eco-packaging)	25	Organic production
New product	Functional foods	26	Enriched or functional products: rice, soya
New product	Healthier products (e.g. less salt, less sugar, less fat)	27	Products with reduced fat, salt and sugar content
New product	Healthier products (e.g. less salt, less sugar, less fat)	28	Dairy products with reduced sugar content
New product	Healthier products (e.g. less salt, less sugar, less fat)	29	Reformulation (using less salt, sugar and fats) and reducing controversial ingredients

Innovation category	Type of sustainability initiative	No.	Sustainability initiative
New product	Healthier products (e.g. less salt, less sugar, less fat)	30	Healthier products (reducing fats, salt and controversial ingredients)
New product	Healthier products (e.g. less salt, less sugar, less fat)	31	Reduce the use of sugar and unnecessary ingredients
New product	Healthier products (e.g. less salt, less sugar, less fat)	32	Snacks with lower sugar content
New product	Healthier products (e.g. less salt, less sugar, less fat)	33	Innovations / new ways of preparing fruits and vegetables: fresh-cut produce
New product	Healthier products (e.g. less salt, less sugar, less fat)	34	Reformulation: reduce salt, sugar and/or fat content
New product	Healthier products (e.g. less salt, less sugar, less fat)	35	Reformulation: less additives, sugar, salt
New product	Healthier products (e.g. less salt, less sugar, less fat)	36	Reformulation of more sustainable and healthy products
New product	Plant-based alternatives for animal products (e.g. meat, milk)	37	Plant-based meat alternatives
New product	Plant-based alternatives for animal products (e.g. meat, milk)	38	Legumes-based proteins
New product	Plant-based alternatives for animal products (e.g. meat, milk)	39	Alternatives for meat products
New product	Plant-based alternatives for animal products (e.g. meat, milk)	40	Plant-based products
New product	Plant-based alternatives for animal products (e.g. meat, milk)	41	Meat alternative proteins
New product	Plant-based alternatives for animal products (e.g. meat, milk)	42	Meat alternatives, plant based
New product	Using more sustainable packaging	43	Cardboard packaging
New product	Using more sustainable packaging	44	New packaging format for cheese wedges using vacuum thermoformed mono-material polyethylene terephthalate packaging which can be recycled
New product	Using more sustainable packaging	45	Replace plastic by paper packaging
New product	Using more sustainable packaging	46	New packaging with less paper and plastic
New product	Using more sustainable packaging	47	More sustainable packaging (polylactic acid, compostable, requires less energy to be produced, virtuous life cycle) using less plastic
New product	Using more sustainable packaging	48	More sustainable packaging (cardboard, less plastic, new plastic material)
New product	Using more sustainable packaging	49	New product formats (reduce packaging)
New product	Using more sustainable packaging	50	More sustainable packaging (eco-design, less plastic, monolayer instead of multi-layer)
New product	Using more sustainable packaging	51	Carboard punnets for fruit and vegetables; eco-packaging for eco-products
New product	Using more sustainable packaging	52	Top clip: top to connect beverages
New product	Using more sustainable packaging	53	Paper-based packaging (extend the properties of paper)
New product	Using more sustainable packaging	54	Alternative packaging: development of plastics from some vegetables
New product	Using more sustainable packaging	55	Peelable adhesives in food packaging (allowing consumers to separate plastic and cardboard for more effective recycling)
New product	Using more sustainable packaging	56	Compostable adhesives in food packaging
New product	Using more sustainable packaging	57	Delaminatable adhesives for flexible packaging (enabling the separation of different materials at the recycling plant)
New product	Using more sustainable packaging	58	Introduction of aluminium-free aseptic carton

Innovation category	Type of sustainability initiative	No.	Sustainability initiative
New product	Using more sustainable packaging	59	Packaging based mainly on fibres and/or biopolymers
New product	Using more sustainable packaging	60	Good packaging (size, easy to fold) to reduce food waste (i.e. maximising freshness and shelf-life)
New product	Using more sustainable packaging	61	Reduce the use of plastics
New product	Using more sustainable packaging	62	Removal of plastic from products (e.g. plastic lids and spoons and replacement of plastic straws with paper ones)
New product	Using more sustainable packaging	63	Replace fossil-based plastics with plant-based solutions
New product	Using more sustainable packaging	64	Substitution of plastics with more sustainable packaging (bioplastics, compostable material)
New product	Using more sustainable packaging	65	Improve product packaging (reduce plastic, promote refilling, reusing, recycling and reducing where possible)
New product	Using more sustainable packaging	66	Alternative packaging
New product	Using more sustainable packaging	67	Minimise the use of plastics
New product	Using more sustainable packaging	68	Packaging with less plastic
New process	Agro-ecological farming	69	Testing the effect of different ground covers (biodegradable, normal plastic, coloured plastic) on the production and quality of cabbage
New process	Agro-ecological farming	70	Organic production
New process	Agro-ecological farming	71	Addressing biodiversity concerns: skylark plots and flower planted zones. Skylark plots are unused patches in fields where birds can land and find food. Flower-planted zones create a space for flowers and pollinators to thrive.
New process	Agro-ecological farming	72	Increasing organic food production
New process	Agro-ecological farming	73	New apple models
New process	Hygiene and sanitation (food safety)	74	Hygiene and sanitation: ozone
New process	Improving operational efficiency of warehouse management (e.g. inventory management, warehouse space management)	75	Optimise warehouse locations to reduce the number of kilometres covered
New process	Improving operational efficiency of warehouse management (e.g. inventory management, warehouse space management)	76	Changes in logistic to be more efficient
New process	Improving the energy efficiency of means of transportation	77	Use of energy-efficient transport
New process	Improving the energy efficiency of means of transportation	78	More sustainable logistics (mega trucks to reduce miles)
New process	Improving the energy efficiency of means of transportation	79	Incorporation of natural gas trucks
New process	Improving the energy efficiency of means of transportation	80	Shifting to gas (compressed and liquefied natural gas) vehicles.
New process	Improving the energy efficiency of means of transportation	81	Ceramic material for trailer roofs
New process	Making changes in production to reduce carbon emissions	82	Innovation in baby-food production to decrease CO_2 emissions
New process	Making changes to improve product quality (e.g. healthiness, flavour)	83	Change the process to produce products with less salt or fat
New process	Making changes to reduce energy consumption in production/selling	84	Changes in the design of the facilities to reduce emissions inside the buildings, design of ventilation
New process	Making changes to reduce energy consumption in production/selling	85	Contract with energy companies to reduce the use of energy and using cleaner energy sources (wind and solar)
New process	Making changes to reduce energy consumption in production/selling	86	Energy-efficiency plants (water use)

Innovation category	Type of sustainability initiative	No.	Sustainability initiative
New process	Making changes to reduce energy consumption in production/selling	87	Control the quality of the air in refrigeration area to reduce energy consumption
New process	Making changes to reduce energy consumption in production/selling	88	Adjust formulation and process to reduce energy consumption
New process	Making changes to reduce energy consumption in production/selling	89	Reduce energy and food waste
New process	Making changes to reduce energy consumption in production/selling	90	Energy reduction programme
New process	Making changes to reduce energy consumption in production/selling	91	Reduce energy consumption (efficient equipment, maintenance of heating, air conditioning and cooling systems, transport and logistics)
New process	Making changes to reduce energy consumption in production/selling	92	Reducing the use of fossil energy in greenhouses (e.g. isolation, climate monitoring based on physiology)
New process	Making changes to reduce input consumption in packaging	93	Study of eco-design in Havarti cheeses, packaging more in line with the product's content, reducing the dimensions of the packaging to a minimum.
New process	Making changes to reduce input consumption in packaging	94	Thinner packaging
New process	Making changes to reduce input consumption in packaging	95	Reducing the grammage of polyethylene terephthalate bottles
New process	Making changes to reduce input consumption in packaging	96	Process adjustments to minimise plastic
New process	Making changes to reduce input consumption in packaging	97	Using thinner packages
New process	Making changes to reduce input consumption in packaging	98	Change bottle format and the glass
New process	Making changes to reduce input consumption in production	99	Planting of different aromatic plants (thyme, lavender, eucalyptus) to create a natural or biologic barrier against pathogens and microorganisms and to avoid the use of antibiotics
New process	Making changes to reduce input consumption in production	100	Include prebiotics and amino acids in the animal feed to reduce antibiotics
New process	Making changes to reduce input consumption in production	101	Use of microalgae and photosynthetic channels for CO_2 fixation
New process	Making changes to reduce input consumption in production	102	Plant flowers to encourage beneficial insects (natural enemies of many pests)
New process	Making changes to reduce input consumption in production	103	Plant-based meat alternatives using peas as innovative raw material due to its properties of fixing nitrogen and reducing the use of fertilisers
New process	Making changes to reduce input consumption in production	104	New packaging technology (less plastic, shrink film)
New process	Making changes to reduce input consumption in production	105	Sustainable use of resources through efficient production methods
New process	Making changes to reduce input consumption in production	106	New technologies to develop new materials with less plastics
New process	Making changes to reduce input consumption in production	107	Use of biological or thermal plant protection as an alternative to chemicals in order to protect crops from diseases, pests and weed competition
New process	Making changes to reduce input consumption in production	108	Reduce the use of antibiotics in farming
New process	Making changes to reduce input consumption in production	109	Searching for alternative techniques to pesticides: physical, biological, cropping systems, limiting the risk of pests and diseases.
New process	Making changes to reduce input consumption in production	110	Use of cold to grow apples
New process	Making changes to reduce input consumption in production	111	Fossil resources to increase the lifespan of trees
New process	Making changes to reduce the carbon footprint	112	Reduce milk's carbon footprint
New process	Making changes to reduce waste/loss generation in production	113	Minimise product waste (beetroot)

Innovation category	Type of sustainability initiative	No.	Sustainability initiative
New process	Making changes to reduce waste/loss generation in production	114	Reducing waste that goes to land
New process	Making changes to reduce waste/loss generation in production	115	Waste-reduction program
New process	Making changes to reduce waste/loss generation in production	116	Research on how to reduce food waste through better technology in production processes
New process	Making changes to reduce waste/loss generation in production	117	Reduce food waste
New process	Making changes to reduce waste/loss generation in production	118	Preventing and reduce food waste
New process	Making changes to reduce water consumption in production/selling	119	New cheese formats that reduce water consumption and allow expanding to the European market
New process	Making changes to reduce water consumption in production/selling	120	Return (cleaned) water upstream from where it was collected
New process	Making changes to reduce water consumption in production/selling	121	Water-, energy- and waste-reduction programs
New process	Making changes to reduce water consumption in production/selling	122	Optimise water use (water-efficient technology, wastewater treatment)
New process	Making changes to reduce water consumption in production/selling	123	Recirculation aquaculture systems and technologies
New process	Precision farming	124	Precision agriculture
New process	Precision farming	125	Nutrient supply plan based on soil samples
New process	Processing techniques to extend shelf life, enhance food quality and safety	126	Use of food processing technologies to extend the shelf-life of products with the same organoleptic properties
New process	Replacing non-renewable energy sources by renewable sources in production/selling	127	Installation of solar orchids in two of their farms for self-sufficient energy consumption
New process	Replacing non-renewable energy sources by renewable sources in production/selling	128	Using cleaner energy sources (wind and solar)
New process	Replacing non-renewable energy sources by renewable sources in production/selling	129	More sustainable energy resources (biogas plant to use biogas in production processes)
New process	Replacing non-renewable energy sources by renewable sources in production/selling	130	Generation and collection of own consumption energy meant for different usages
New process	Replacing non-renewable energy sources by renewable sources in production/selling	131	Renewable energy uses (photovoltaic panels)
New process	Replacing non-renewable energy sources by renewable sources in production/selling	132	More solar panels in the production plant
New process	Replacing non-renewable energy sources by renewable sources in production/selling	133	Pilot hydrogen plant
New process	Replacing non-renewable energy sources by renewable sources in production/selling	134	Use of renewable energy sources
New process	Replacing non-renewable energy sources by renewable sources in production/selling	135	Creation of a biorefinery plant
New process	Replacing non-renewable energy sources by renewable sources in production/selling	136	Test using 100 % biodiesel, an environmentally friendly alternative to tractors

Innovation category	Type of sustainability initiative	No.	Sustainability initiative
New process	Replacing non-renewable energy sources by renewable sources in production/selling	137	Use of renewable energy resources in farms
New process	Replacing non-renewable energy sources by renewable sources in production/selling	138	Biogas plant
New process	Replacing non-renewable energy sources by renewable sources in production/selling	139	Solar panel plant
New process	Replacing non-renewable energy sources by renewable sources in production/selling	140	Use more renewable energy in manufacturing: wind, solar and biomass
New process	Replacing non-renewable energy sources by renewable sources in production/selling	141	Solar panel pilot to test energy production, consumption and cost, geothermal energy.
New process	Replacing non-renewable energy sources by renewable sources in production/selling	142	New fuel technologies
New process	Replacing non-renewable energy sources by renewable sources in production/selling	143	Photovoltaic panels for self-consumption
New process	Use of recycled material in the production of packaging	144	Recycled packaging
New process	Use of waste to produce energy	145	Cogeneration plant using by-products: use of rice husks to produce electricity which is then sold (when surpluses are available) or self-consumed
New process	Use of waste to produce energy	146	Investment in cogeneration plants, use of waste to produce electricity
New process	Use of waste to produce energy	147	Use of agricultural waste in ethanol production
New process	Use of waste to produce energy	148	Using cow manure by turning it into biogas
New process	Use of waste to produce energy	149	Use of waste to generate energy and heat
New process	Use of waste to produce energy	150	Use of farm manure in biogas production (decreasing methane emissions)
New process	Using more sustainable production inputs	151	Agropaper (same functionality as plastic film but biodegradable – soil enrichment)
New process	Using more sustainable production inputs	152	Efficient breed of cattle
New process	Using more sustainable production inputs	153	Genetically improved fish material by patented selective breeding
New process	Using or selling by-products	154	By-products valorisation as fourth- and fifth-range products (e.g. ready-to-eat food products)
New process	Using or selling by-products	155	Slurry collection, slurry treatment plant on two farms (these plants make it possible to put numbers on the by-product – slurry – and quantity generated, to facilitate management)
New process	Using or selling by-products	156	Production of bioplastics from the by-product of corn/maize milling
New process	Using or selling by-products	157	Revalorisation of by-products that are marketed as business-to-business or used as ingredient in new products
New process	Using or selling by-products	158	Circularise processes using by-products within the own company or in collaboration with others
New process	Using or selling by-products	159	Valorisation of food by-products to reduce food waste
New process	Using or selling by-products	160	Not discarding fruit and vegetables the appearance of which no longer meet the customer's standards but that are otherwise in perfect condition so that they can be used for further processing – for example, for salad bars or other preparations
New process	Using recycled materials in production process	161	Recycled fertilisers for fields from leftovers from biogas production

Innovation category	Type of sustainability initiative	No.	Sustainability initiative
New process	Using recycled materials in production process	162	Sustainable packaging from recycled fabric
New process	Using renewable energy in the transportation means	163	Supplying the milk collection tanks of the supply chain with biomethane
New process	Using renewable energy in the transportation means	164	First diesel-free refrigerated trailer (the tractor head is powered by liquefied natural gas, and its trailer incorporates electric refrigeration equipment)
New process	Using renewable energy in the transportation means	165	Research in alternative vehicle fuels (electric and hydrogen)
New process	Using renewable energy in the transportation means	166	Programme to use biogas in milk trucks to reduce carbon footprint
New organisational practice	Adherence to the company code of conduct	167	Adherence to the company's code of good practice
New organisational practice	Cooperation in social programmes	168	Cooperation in social programmes (solidarity, local charities, international projects)
New organisational practice	Cooperation in social programmes	169	Social: 'Act for food' programme, actions for better eating and food transition
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	170	Advice and cooperation with domestic and international actors for R & D
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	171	Advise/support farmers on certification in animal welfare with technicians.
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	172	Collaboration with farmers along the food chain (to reduce CO_2, fertilisers, antibiotics)
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	173	Supporting farmers to introduce digitalisation, which would allow to collect data for increased sustainability
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	174	Study of how to use indicators and obtain data to reduce CO_2 (in collaboration with public research centres)
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	175	Cooperation projects with Africa
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	176	Advising and assisting farmers to switch to organic farming
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	177	Business partnership platform for more sustainable packaging
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	178	Agreement to participate in 'Lean and Green', an international initiative aimed at helping companies in all sectors to reduce their greenhouse gas emissions from logistics activities.
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	179	Adherence to the 'Climate Ambition Accelerator' from the UN Global Compact (accelerate progress towards setting science-based targets and achieve net-zero by 2050) focused on educational activities for companies to reduce emissions.
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	180	Cooperation on sustainability with suppliers, customers and stakeholders of the food chain (adherence to the Swedish sustainable food chain initiative)

Innovation category	Type of sustainability initiative	No.	Sustainability initiative
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	181	'Climate & Nature' initiative to reduce climate impact and boost biodiversity (program for farming of the future and has a number of concrete climate-smart measures).
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	182	Adherence to the UN Global Compact (accelerate progress towards setting science-based targets and achieve net-zero by 2050)
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	183	Collaboration with companies to develop biogas and electric and other renewable-energy-based trucks
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	184	Research and collaboration with companies on alternative packaging for dairy products
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	185	Cooperation with the university to study the health effects of dairy and dairy ingredients
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	186	Work with farmers to increase carbon stored in soils, land restoration, ensuring that supply chains are deforestation-free and protect biodiversity
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	187	Participating in the European Technology Platform – Food for life
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	188	Science-based information and training for the companies
New organisational practice	Cooperation with chain partners and other public or private institutions for a more sustainable chain	189	Multi-stakeholder initiatives involving member associations and national authorities
New organisational practice	Facility location into rural communities	190	Rural environment commitment (facilities located in rural communities, local employment, stable contracts)
New organisational practice	Focusing on more efficient/sustainable supply chains and business models	191	Redesigning fruit and vegetable supply chains to increase efficiency
New organisational practice	Focusing on more efficient/sustainable supply chains and business models	192	Research on new business models to promote sustainability habits for the companies and for the consumers
New organisational practice	Food donation	193	Donations to non-profit organisations of unsold products
New organisational practice	Food donation	194	Collaboration with food (milk) banks for hospitals
New organisational practice	Food donation	195	Cooperation with the European Food Banks Federation and FoodDrinkEurope to support food donations
New organisational practice	Food donation	196	Cooperation with food banks and other charity organisations
New organisational practice	Fostering woman employment	197	Foster women's employment
New organisational practice	Including sustainability targets and incentives for employees	198	Pay sustainability bonus to farmers that invest more in animal welfare than required by the law
New organisational practice	Including sustainability targets and incentives for employees	199	Women farmers awards (Innovation Award for Women farmers 2020)
New organisational practice	Including sustainability targets and incentives for employees	200	European Awards (European Award for Cooperative Innovation)
New organisational practice	Including sustainability targets and incentives for employees	201	Integrate sustainable development goals into the strategy of the company
New organisational practice	Including sustainability targets and incentives for employees	202	Competition for the best product of the year

Innovation category	Type of sustainability initiative	No.	Sustainability initiative
New organisational practice	Integrating sustainability in suppliers' qualification criteria	203	Advice and consultancy for farmers on sustainable practices and animal welfare to obtain certification standards
New organisational practice	Integrating sustainability in suppliers' qualification criteria	204	Use of certified inputs / new raw materials
New organisational practice	Integrating sustainability in suppliers' qualification criteria	205	Select suppliers meeting the company's sustainability criteria (e.g. animal welfare, reduced antibiotics, sustainable methods)
New organisational practice	Integrating sustainability in suppliers' qualification criteria	206	New (raw material) crop varieties
New organisational practice	Integrating sustainability in suppliers' qualification criteria	207	Requirement for suppliers to adopt environmentally friendly practices (form of fishing)
New organisational practice	Integrating sustainability in suppliers' qualification criteria	208	Requirement to suppliers of environmentally friendly practices
New organisational practice	Integrating sustainability in suppliers' qualification criteria	209	Fertiliser with low carbon footprint
New organisational practice	Integrating sustainability in suppliers' qualification criteria	210	Ensuring food safety and responsibility of the supply chain through a supplier approval and management process
New organisational practice	Monitoring suppliers' sustainability performance (incl. labour practices)	211	Calculation of the environmental food footprints of local suppliers in the País Vasco
New organisational practice	Monitoring suppliers' sustainability performance (incl. labour practices)	212	Establishment of the Sedex Members Ethical Trade Audit, social data exchange enabling businesses to assess their suppliers, monitoring health and safety for workers
New organisational practice	Monitoring suppliers' sustainability performance (incl. labour practices)	213	Carbon footprint calculator for farmers
New organisational practice	Promote employees' rights along the chain	214	Commitment with human rights and employees' well-being
New organisational practice	Reforestation	215	'Smurfit Kappa Foundation' programmes (reforestation, fauna, flora, health, community involvement)
New organisational practice	Reforestation	216	Forest programme to compensate CO_2 emissions regarding transport.
New organisational practice	Reuse, recycling and reverse logistics of packaging	217	Recycling collection system from customer for intermediate bulk containers (enabling recycling and reuse of part of the materials)
New organisational practice	Measuring and reporting on sustainability/quality	218	Sustainability report
New organisational practice	Measuring and reporting on sustainability/quality	219	Sustainability reports
New organisational practice	Measuring and reporting on sustainability/quality	220	Measuring and evaluating carbon footprint
New organisational practice	Measuring and reporting on sustainability/quality	221	Corporate social responsibility report
New organisational practice	Measuring and reporting on sustainability/quality	222	Sustainable reporting
New organisational practice	Measuring and reporting on sustainability/quality	223	Carbon footprint calculator
New organisational practice	Measuring and reporting on sustainability/quality	224	Developing sustainability indicators (e.g. food miles, animal welfare, carbon and water footprint)
New organisational practice	Measuring and reporting on sustainability/quality	225	Validating greenhouse-gas calculations, producing life cycle analyses
New organisational practice	Sustainability/quality measuring and reporting	226	Maintaining and measuring the quality of fruits and vegetables all the way to the consumer
New organisational practice	Training and education	227	Dual vocational education and on-farm (on the job) training for training, qualification or certification of professionals within the sector
New organisational practice	Training and education	228	New innovation strategy in the innovation department developing a personal training project, training in creativity and activism techniques creating an innovative group of 3–4 people from different departments

Innovation category	Type of sustainability initiative	No.	Sustainability initiative
New organisational practice	Training and education	229	Further advanced training programmes for employees guarantee a high standard of qualification and productivity
New organisational practice	Training and education	230	Education programmes
New organisational practice	Training and education	231	Programmes covering experimentation and research, driving innovation, training sessions and dissemination of information
New organisational practice	Use of local inputs	232	Cheese snack made from local, 100 % Galician milk
New organisational practice	Use of local inputs	233	Procurement of raw materials in the Mediterranean area
New organisational practice	Use of local inputs	234	Agreements with local suppliers
New organisational practice	Use of local inputs	235	Local procurement (be local, marketplace)
New organisational practice	Use of local inputs	236	Use of local milk
New organisational practice	Use of third-party verified certifications	237	The farm obtains Animal Welfare Spain Certification
New organisational practice	Use of third-party verified certifications	238	Certification on animal welfare, ISO
New organisational practice	Use of third-party verified certifications	239	British Retail Consortium (BRC), International Featured Standard (IFS) and SEDEX certifications
New organisational practice	Use of third-party verified certifications	240	High-quality and safety-certified requirements: SQM, BRC, IFS, BIO
New organisational practice	Use of third-party verified certifications	241	High-quality and safety-certified requirements: ISO 50001 and ECOCERT seal
New organisational practice	Use of third-party verified certifications	242	Certification as 5-star sustainable development goals
New organisational practice	Use of third-party verified certifications	243	Use of third-party verified certifications within the industry to demonstrate that key materials are sourced responsibly
New organisational practice	Use of third-party verified certifications	244	Carbon footprint certification (measuring and evaluating carbon footprint)
New organisational practice	Use of third-party verified certifications	245	International Featured Standard and British Retail Consortium certifications, which are international standards for food safety
New organisational practice	Use of third-party verified certifications	246	Certified organic farm
New marketing practice	Consumer awareness/education initiatives	247	Online information related to waste reduction (anti-waste recipes) and packaging disposal
New marketing practice	Consumer awareness/education initiatives	248	Information campaign to consumers (nutritional properties, nutrients, packaging, products and disposal methods)
New marketing practice	Consumer awareness/education initiatives	249	Guided visits to the farm
New marketing practice	Consumer awareness/education initiatives	250	Foundation focused on helping children make healthier food choices
New marketing practice	Consumer awareness/education initiatives	251	Biodiversity awareness
New marketing practice	Consumer awareness/education initiatives	252	Tips and trick for consumers to reduce food waste
New marketing practice	Consumer awareness/education initiatives	253	Promotion of healthy eating through website and social media
New marketing practice	Consumer awareness/education initiatives	254	Approach the consumer (activities in the farm)
New marketing practice	Consumer awareness/education initiatives	255	Meat label showing the consumer the story behind the meat
New marketing practice	Consumer awareness/education initiatives	256	Play farm to share agriculture passion with others
New marketing practice	Consumer awareness/education initiatives	257	Application to give additional information to consumers (e.g. how to recycle the packaging)
New marketing practice	Consumer awareness/education initiatives	258	Intervention (or experimental) research on new ways of communicating (storytelling, social norms, price, position in supermarket, nutriscore, ecoscore) sustainability to customers to promote healthier habits

Innovation category	Type of sustainability initiative	No.	Sustainability initiative
New marketing practice	Consumer awareness/education initiatives	259	Engage consumers with transparent communication on the health and environmental impacts of food products
New marketing practice	Consumer awareness / education initiatives	260	Digital technologies and big data analytics to monitor purchase data, health data and output from self-monitoring devices to better serve the customer
New marketing practice	Consumer awareness / education initiatives	261	Promoting a healthy lifestyle (programmes)
New marketing practice	Consumer awareness / education initiatives	262	Educational programmes
New marketing practice	Environmental labelling	263	Include ecoscore
New marketing practice	Health and nutritional labelling	264	Incorporating nutriscore
New marketing practice	Health and nutritional labelling	265	Include nutriscore
New marketing practice	Health and nutritional labelling	266	Responsible marketing: guiding and informing consumers on healthy choices (labelling, advertising)
New marketing practice	Market research	267	Improving insights from consumers with surveys, focus groups and innovative psychological techniques
New marketing practice	Market research	268	Monitoring the evolution of fruit and vegetable consumption patterns (consumer tests and preferences, analysis of consumption trends and patterns)
New marketing practice	Marketing the sustainability attributes of products	269	Promoting fresh products for better eating
New marketing practice	Offering dedicated sustainable brands/spaces	270	New, totally organic shops
New marketing practice	Offering dedicated sustainable brands/spaces	271	New organic line of products
New marketing practice	Offering dedicated sustainable brands/spaces	272	Green product range, zero waste
New marketing practice	Spaces/shops for close to best before date products	273	E-commerce platform and physical locations to reduce food waste
New marketing practice	Spaces/shops for close to best before date products	274	50 % discount zone to reduce food waste
New marketing practice	Spaces/shops for close to best before date products	275	Price-reduced areas for products close to the 'best before date'
Technologies/digitalisation	AI, robots, satellites, GIS, GPS, drones, the Internet of Things	276	Introduction of different technologies to digitalise the production (use of GPS, quality control or growth monitoring)
Technologies/digitalisation	AI, robots, satellites, GIS, GPS, drones, the Internet of Things	277	Technological transformation: artificial intelligence, business process management
Technologies/digitalisation	AI, robots, satellites, GIS, GPS, drones, the Internet of Things	278	Use of intelligent technologies to optimise production and minimise food waste
Technologies/digitalisation	AI, robots, satellites, GIS, GPS, drones, the Internet of Things	279	Artificial Intelligence algorithms storing history of events and information on the status of fields
Technologies/digitalisation	AI, robots, satellites, GIS, GPS, drones, the Internet of Things	280	Artificial intelligence at predictive level
Technologies/digitalisation	AI, robots, satellites, GIS, GPS, drones, the Internet of Things	281	Robotisation warehouses
Technologies/digitalisation	Biotechnology, nanotechnology	282	Packaging preventing food oxidation (selenium nanoparticles)
Technologies/digitalisation	Business intelligence	283	Digitalisation of vehicles to control fuel consumption (calculate and reduce)
Technologies/digitalisation	Data software	284	Digital transformation: helps to make measurements and have the data to act to be more efficient (e.g. in the use of water and energy)
Technologies/digitalisation	Data software	285	Online control systems (data processing) with focus on food quality
Technologies/digitalisation	Data software	286	Patent solution for product authentication (mobile app)
Technologies/digitalisation	Data software	287	Patenting anti-tampering food delivery box (incl. customised app to provide code to customer)
Technologies/digitalisation	Data software	288	Digitalisation
Technologies/digitalisation	Data software	289	Digitalisation

Innovation category	Type of sustainability initiative	No.	Sustainability initiative
Technologies/digitalisation	Digital labels / marketing communication	290	Nutritional web platforms
Technologies/digitalisation	Digital labels / marketing communication	291	Certification marks in new technologies
Technologies/digitalisation	E-commerce	292	E-commerce platform to reduce food waste
Technologies/digitalisation	E-commerce	293	Online shop for near-expired products
Technologies/digitalisation	E-commerce	294	Create online shops
Technologies/digitalisation	Enterprise resource planning	295	Implementation of enterprise resource planning for more efficient management process
Technologies/digitalisation	Enterprise resource planning	296	Digitalisation at administration and production level
Technologies/digitalisation	Farming software	297	Implementation of automation in processes and technology based on artificial intelligence
Technologies/digitalisation	Farming software	298	Digitalisation of the slurry collection process (by-production management)
Technologies/digitalisation	Farming software	299	Digitalisation: enterprise resource planning for the agronomy and field side
Technologies/digitalisation	Information Communication Technologies	300	Real-time temperature control in the trucks, accessible to customers
Technologies/digitalisation	Online training employees on how to integrate sustainability practices in their work	301	Mobile app for online driver training
Technologies/digitalisation	Process automation	302	Digitalisation in the production lines
Technologies/digitalisation	Process automation	303	Introduction of automation in warehouse for a more efficient storage and pick-up systems
Technologies/digitalisation	Process automation	304	High-pressure processing automation
Technologies/digitalisation	Process automation	305	Automation of packaging machines to collect information
Technologies/digitalisation	Process automation	306	Development of solutions for mechanisation and automation (e.g. precision agriculture: automated input and fertiliser management – automatic spraying, robotisation and machine-assisted harvesting)
Technologies/digitalisation	Process automation	307	Digitalisation (documentation)
Technologies/digitalisation	Process automation	308	Autonomous vehicles
Technologies/digitalisation	Sustainable food technology	309	Development of a new range of products (e.g. precooked lamb at low temperature, vacuum fresh lamb with a longer shelf life by applying high hydrostatic pressure , semi-cured and cured cheese and mule leg)
Technologies/digitalisation	Sustainable food technology	310	Patents in technology, i.e. pasteurisation
Technologies/digitalisation	Sustainable food technology	311	More sustainable production process (high-pressure processing, less energy consumption, automation)
Technologies/digitalisation	Sustainable food technology	312	Sustainable food technology: high-pressure processing and others
Technologies/digitalisation	Variable-rate technology	313	Develop technologies and methodologies (sensors in tractors) to increase the efficient utilisation of nitrogen
Technologies/digitalisation	Variable-rate technology	314	Use of new technologies

Annex 3. Categories of innovation, types of sustainability initiatives and their sustainability performance

Innovation categories	N	Types of sustainability initiatives	Economic score	Environmental score	Social (incl. health) score	Sustainability score
New product	1	Better quality products (e.g. new varieties, enriched products)	43 %	6 %	15 %	21 %
New product	2	Developing new products	50 %	25 %	0 %	25 %
New product	3	Environmental-friendlier products (e.g. agro-ecological, eco-packaging)	38 %	25 %	0 %	21 %
New product	4	Functional foods	50 %	0 %	25 %	25 %
New product	5	Healthier products (e.g. less salt, less sugar, less fat)	40 %	0 %	25 %	22 %
New product	6	Plant-based alternatives for animal products (e.g. meat, milk)	50 %	17 %	13 %	26 %
New product	7	Using more sustainable packaging	35 %	48 %	1 %	28 %
New process	8	Agro-ecological farming	50 %	40 %	5 %	32 %
New process	9	Hygiene and sanitation (food safety)	25 %	25 %	0 %	17 %
New process	10	Improving operational efficiency of warehouse management (e.g. inventory management, warehouse space management)	38 %	13 %	0 %	17 %
New process	11	Improving the energy efficiency of means of transportation	25 %	35 %	0 %	20 %
New process	12	Making changes in production to reduce carbon emissions	75 %	25 %	0 %	33 %
New process	13	Making changes to improve product quality (e.g. healthiness, flavour)	50 %	0 %	25 %	25 %
New process	14	Making changes to reduce energy consumption in production/selling	17 %	39 %	6 %	20 %
New process	15	Making changes to reduce input consumption in packaging	50 %	38 %	0 %	29 %
New process	16	Making changes to reduce input consumption in production	37 %	31 %	0 %	22 %
New process	17	Making changes to reduce the carbon footprint	50 %	25 %	0 %	25 %
New process	18	Making changes to reduce waste/loss generation in production	21 %	38 %	0 %	19 %
New process	19	Making changes to reduce water consumption in production/selling	30 %	40 %	0 %	23 %
New process	20	Precision farming	38 %	50 %	0 %	29 %
New process	21	Processing techniques to extend shelf life, enhance food quality and safety	50 %	25 %	25 %	33 %
New process	22	Replacing non-renewable energy sources by renewable sources in production/selling	24 %	29 %	0 %	18 %
New process	23	Use of recycled material in the production of packaging	50 %	25 %	0 %	25 %
New process	24	Use of waste to produce energy	50 %	50 %	0 %	33 %
New process	25	Using more sustainable production inputs	42 %	25 %	0 %	22 %
New process	26	Using or selling by-products	36 %	36 %	0 %	24 %
New process	27	Using recycled materials in production process	25 %	50 %	0 %	25 %
New process	28	Using renewable energy in the transportation means	38 %	31 %	0 %	23 %
New organisational practice	29	Adherence to the company code of conduct	50 %	25 %	25 %	33 %
New organisational practice	30	Cooperation in social programmes	0 %	0 %	25 %	8 %

Innovation categories	N	Types of sustainability initiatives	Economic score	Environmental score	Social (incl. health) score	Sustainability score
New organisational practice	31	Cooperation with chain partners and other public or private institutions for a more sustainable chain	25 %	24 %	9 %	19 %
New organisational practice	32	Facility location into rural communities	25 %	25 %	25 %	25 %
New organisational practice	33	Focusing on more efficient/sustainable supply chains and business models	25 %	0 %	25 %	17 %
New organisational practice	34	Food donation	13 %	19 %	31 %	21 %
New organisational practice	35	Fostering woman employment	0 %	0 %	25 %	8 %
New organisational practice	36	Including sustainability targets and incentives for employees	25 %	20 %	20 %	22 %
New organisational practice	37	Integrating sustainability in suppliers' qualification criteria	25 %	38 %	22 %	28 %
New organisational practice	38	Monitoring suppliers' sustainability performance (including labour practices)	17 %	17 %	25 %	19 %
New organisational practice	39	Promote employees' rights along the chain	25 %	0 %	25 %	17 %
New organisational practice	40	Reforestation	38 %	25 %	13 %	25 %
New organisational practice	41	Reuse, recycling and reverse logistics of packaging	50 %	50 %	0 %	33 %
New organisational practice	42	Sustainability/quality measuring and reporting	31 %	11 %	11 %	18 %
New organisational practice	43	Training and education	10 %	0 %	25 %	12 %
New organisational practice	44	Use of local inputs	40 %	10 %	5 %	18 %
New organisational practice	45	Use of third-party verified certifications	25 %	38 %	5 %	23 %
New marketing practice	46	Consumer awareness / education initiatives	27 %	9 %	23 %	20 %
New marketing practice	47	Environmental labelling	25 %	25 %	25 %	25 %
New marketing practice	48	Health and nutritional labelling	50 %	0 %	25 %	25 %
New marketing practice	49	Market research	25 %	0 %	0 %	8 %
New marketing practice	50	Marketing the sustainability attributes of products	25 %	0 %	25 %	17 %
New marketing practice	51	Offering dedicated 'sustainable' brands/spaces	42 %	50 %	0 %	31 %
New marketing practice	52	Spaces/shops for close-to-best-before date products	25 %	25 %	0 %	17 %
Technologies/ digitalisation	53	AI, robots, satellites, GIS, GPS, drones, Internet of Things	33 %	4 %	8 %	15 %
Technologies/ digitalisation	54	Biotechnology, nanotechnology	50 %	25 %	25 %	33 %
Technologies/ digitalisation	55	Business intelligence	50 %	25 %	0 %	25 %
Technologies/ digitalisation	56	Data software	29 %	4 %	13 %	15 %
Technologies/ digitalisation	57	Digital labels / marketing communication	13 %	25 %	25 %	21 %
Technologies/ digitalisation	58	E-commerce	33 %	17 %	0 %	17 %
Technologies/ digitalisation	59	Enterprise resource planning	38 %	0 %	25 %	21 %
Technologies/ digitalisation	60	Farming software	33 %	8 %	8 %	17 %

Innovation categories	N	Types of sustainability initiatives	Economic score	Environmental score	Social (incl. health) score	Sustainability score
Technologies/ digitalisation	61	ICT	50 %	0 %	25 %	25 %
Technologies/ digitalisation	62	Online training employees on how to integrate sustainability practices in their work	50 %	0 %	25 %	25 %
Technologies/ digitalisation	63	Process automation	36 %	4 %	4 %	14 %
Technologies/ digitalisation	64	Sustainable food technology	50 %	13 %	0 %	21 %
Technologies/ digitalisation	65	Variable-rate technology	50 %	25 %	0 %	25 %

Annex 4. Sustainability impact indicators and underlying factors

SSI	SSI sub-category	Factor
Economic pillar		
Economic direct economic performance	Increasing sales	Increasing sales by higher prices for sustainable products
		Increasing sales
	Improving efficiency	Reducing costs (e.g. by operational, organisational or chain efficiencies)
Competitiveness and growth	Company/product differentiation	Product differentiation
		Consumer loyalty
		Company competitiveness
		Company differentiation
	Market growth	New markets (e.g. new customers, new regions)
		Attracting funding opportunities
Indirect economic impacts (external)	Support the local economy	Use of local raw materials
		Support local employment
		Social and economic environment in the region
		Attract and retain and offer opportunities for better-qualified workers
	Focus fair chain	Ensuring fair distribution of income in the chain (e.g. fair trade)
Compliance (public or private)	Compliance (public)	Regulatory compliance
	Compliance (private)	Private/industry compliance
Environmental pillar		
Reducing negative externalities for the environment	Emissions	Improving carbon footprint
	Animal welfare	Improving animal welfare
	Biodiversity	Boosting biodiversity
		Afforestation or rewilding
	Inputs/materials	Reducing/replacing plastic
	Logistics	Optimising warehouse locations and reducing transport distances
	Emissions	Reducing CO_2 emissions
	Inputs/materials	Using more sustainable materials/inputs
	Renewable energy	Use of renewable energy
	Land use	Reducing soil/land use and contamination
More efficient use of resources	Chemicals	Chemical input use (e.g. fertilisers, pesticides)
		Antibiotics use
	Energy	Energy use
	Water	Water use
	Other inputs	Other inputs
Waste management	Minimising and diverting loss/waste from disposal	Minimising or diverting food loss/waste from disposal
	Recycling, recycled materials	Use of more/easier recyclable materials
		Promote packaging recycling to consumer
Compliance (public or private)	Compliance (public)	Environmental regulatory compliance
	Compliance (private)	Private/industry environmental compliance

SSI	SSI sub-category	Factor
Social pillar		
Labour practices (*in situ*, along the food chain)	Diversity and equal opportunity (incl. women, disadvantaged people)	Supporting women's employment / gender equality
		Supporting young employees
		Supporting disadvantaged people on the labour market (e.g. people with disabilities, immigrants, ethnic minorities)
	Fair conditions along the chain	Ensuring fair working conditions and promoting employee's rights along the chain
	Labour/management relationships	Supporting employment stability of workers
		Improve working environment
		Promote employees' rights
		Employees' salaries and benefits
	Occupational health and safety	Ensure workers safety and health
	Training and education	Employees' awareness/motivation for adoption of sustainable practices in business
		Supporting workers training and education
Product responsibility	Costumer health and safety	Support the production of healthier products
	Marketing communications	Promote healthy consumption
	Costumer health and safety	Quality control / safety
	Marketing communications	Consumers' education on sustainability practices
Society	Promoting food security, solidarity/social programmes	Promoting food security (e.g. collaborating with food banks), solidarity/social programmes
Compliance (public or private)	Compliance (public)	Meet regulatory requirements on social sustainability
	Compliance (private)	Meet private standards on social sustainability (e.g. private certifications, requirements of trading partners, consumers and stakeholders)

Annex 5. Drivers, barriers and financial factors and policy incentives

Element	Category of element	Factor(s)
Drivers	Meet regulatory requirements	Meet regulatory or legislative changes (EU or national)
	Respond to the market's supply and demand requirements	Meet market demand (i.e. changes in consumer preferences)
		Respond to pressure from competitors
		Respond to pressure from buyers
		Develop new growth opportunities
		Meet international sustainability goals (e.g. sustainable development goals, Green Deal, F2F)
		Increasing traceability demands and requirements
		Learning/experience/expertise
	Operators' intrinsic motivation to be sustainable	Company's awareness and management of sustainability
		Managers'/owners' personal motivation to move towards sustainability
	Alignment with emergent technologies	Emerging technologies
	Strengthening position and reputation	Build, maintain or improve company's reputation
		Attract, motivate, retain employees
		Competitive advantage
Barriers	Lack of knowledge, experience and culture in sustainability-related solutions	Lack of knowledge on available solutions in terms of sustainability and how to integrate it into the company (lack of methodology and processes)
		Management resistance to innovation
		Lack of employee participation/acceptance
		Finding relevant partners to build strong partnerships
		Few technology companies betting on the primary sector
		Lack of interest and/or culture of the company
	Lack of technical/human resources	Lack of access to technology
		Lack of qualified human resources (managerial and technical skills)
		Lack of access to distribution channels
		Lack of internet connectivity in rural areas
		Difficulties in negotiating clear intellectual property rights
		Lack of sustainable raw materials (e.g. competitive bioplastics, sufficient recycled materials)
	Lack of economic/financial resources	Lack of external financial resources (e.g. debt financing, equity funding)
		High upfront costs

Element	Category of element	Factor(s)
		Lack of internal financial resources
		Difficulties scaling innovation at industrial level
	Lack of long-term vision	Long gestation period of innovation, focus on short-term profits and uncertainty about consumer uptake of innovations
	Lack of public support and/or clarity in current policy applications and future regulation	Difficulties applying the current policies and regulations, lack of or unclear definitions, lack of concrete legislation (only general guidelines)
		Lack of public/policy support at EU level
		Lack of public/policy support at national level, lack of incentives for innovation and change
		Different rules in different countries and regions
		Uncertainty about future regulation or standards for long-term planning
		Functional validation (food validation and verification processes)
		Lack of a timely legal framework to protect and foster innovations
		Difficulties to obtain public funding from the EU (administrative burden)
		Insufficient execution periods for public funding
		Trade-offs between expected impacts
		Unfair competition from outside Europe in ecological products
	Lack of market/consumer recognition	Lack of access to final consumer
		Lack of retail/consumer/buyer awareness and acceptance (e.g. consumers not willing to pay the premium price of more sustainable products)
		Consumers do not value sustainability certifications or are confused by some of them
	Exogenous shocks	COVID-19 crisis
Financial factors and policy incentives	Availability of financial resources	Internal financial resources
		Private debt/credit financing from lenders
		External financial resources from trading partners (e.g. buyers)
	Government incentives (tax incentives, grants, subsidies, credit, bureaucracy)	Tax incentives and credits
		Government grants and subsidies
		EU grants and subsidies
		Government credit support
		Minimum mandatory sustainability criteria for public procurement
		Reducing administrative burden of public compliance and application

Element	Category of element	Factor(s)
	Meet public standards on food(s) operations	Minimum public sustainability standards for foods/food operations
		Minimum private sustainability standards for foods/food operations
		Voluntary adherence to the code of conduct for responsible food business and marketing practices
	Government technical support	Government/public research facilities
		Government-supported training programs
		Public consultancy/business support services
	Positive social/market recognition	Disclosing sustainability performance of business/companies (e.g. league tables, sustainability indices, awards)
		Public sustainable labelling / certification schemes
		Private sustainable labelling / certification schemes

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct centres. You can find the address of the centre nearest you online (european-union.europa.eu/contact-eu/meet-us_en).

On the phone or in writing

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

— by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

— at the following standard number: +32 22999696,

— via the following form: european-union.europa.eu/contact-eu/write-us_en.

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website (european-union.europa.eu).

EU publications

You can view or order EU publications at op.europa.eu/en/publications. Multiple copies of free publications can be obtained by contacting Europe Direct or your local documentation centre (european-union.europa.eu/contact-eu/meet-us_en).

EU law and related documents

For access to legal information from the EU, including all EU law since 1951 in all the official language versions, go to EUR-Lex (eur-lex.europa.eu).

Open data from the EU

The portal data.europa.eu provides access to open datasets from the EU institutions, bodies and agencies. These can be downloaded and reused for free, for both commercial and non-commercial purposes. The portal also provides access to a wealth of datasets from European countries.

Science for policy

The Joint Research Centre (JRC) provides independent, evidence-based knowledge and science, supporting EU policies to positively impact society

EU Science Hub
joint-research-centre.ec.europa.eu

@EU_ScienceHub
EU Science Hub - Joint Research Centre
EU Science, Research and Innovation
EU Science Hub
@eu_science

Publications Office
of the European Union