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Sustainable Supply Chain Management practices in the Food Industry

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ABSTRACT

The food industry is central to human beings and heavily impacts the lives of the entire society. Nowadays, the sustainable development goal and the introduction of new information and communication technologies have led food companies to deal with sustainability requirements. They require the implementation of sustainable practices that have the dual objective of improving the overall performance of the company itself and fulfilling the sustainable development goals. Research works on sustainable supply chain management practices in the food industry are quite fragmented, as they often consider just a part of the chain. Therefore, through a systematic literature review, the aim of this project is twofold: first, to provide an up-to-date analysis of supply chain management practices within the scope of sustainability, studying the findings of 224 reviewed papers. Second, to discuss the integration of sustainable practices into supply chain management in the food industry through an empirical analysis. In addition, the importance attributed to the three sustainability dimensions and their relationship with the implementation of sustainable practice is proposed. By exploiting the established and rigorous systematic literature review methodology and a survey questionnaire, this work represents a contribution that includes the point of view of professionals that, in their daily professional life, they are increasingly dealing with the sustainability issue. The implications of this work are relevant for academic research as they enlarge the body of knowledge and highlight key points where there is the need to investigate further. From a practical point of view, this study proposes an overview of the most common and adopted practices that can be implemented in order to achieve sustainable development and the degree of implementation of these practices and their impacts in Italian or French companies operating in the food industry.

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It is widely recognized that the food industry plays an important role in every individual's life. Especially during the pandemic period, along with the drug industry, the food industry gained crucial importance worldwide.

Nowadays, one of the biggest requirements companies are facing is compliance with sustainable development and the related Sustainable Development Goals, which, coupled with internationalization, has led to an increase in competition among organizations. These factors require the adoption of business practices able to satisfy a dual objective: improve the overall performance of a company and fulfill the sustainability requirement, defined as "*the development that meets the needs of the present without compromising the ability of future generations to meet their own needs*[1]". The integration of the sustainability concept within a supply chain makes up the core concept of Sustainable Supply Chain Management (SSCM).

The main objective of this research project is to analyze the integration of sustainable practices into supply chain management in the food industry and the related results. Starting from the literature gaps, the objectives of this work are as follows: first, the analysis of best SSCM practices is typically carried out for automotive, textile, apparel, and luxury industries while the food industry appears less analyzed in the literature. Second, even if the sustainability issue and the related sustainable practices are receiving a lot of attention from the scientific arena, studies across the food sector typically fails in considering the whole FSC or they focus on a subset of sustainable practices. The document is structured as follow:

- *PART 1 – Sustainable Food Supply Chain: Literature Review*. First, relevant theoretical concepts are introduced. Then, by exploiting the established and rigorous systematic literature review methodology, sustainable best management practices that companies operating in the food sector should implement to reach the Sustainable Development target are defined. All the practices identified are introduced as a conceptualization of a general model.
- *PART 2 – Sustainable Food Supply Chain: Empirical Analysis*. Based on the findings obtained through the systematic literature review, a large-scale questionnaire survey is administrated to professionals of the food sector in order to investigate the maturity of implementation of the identified practices in the food industry for in turn achieving

[1] CMED, 1987. "Notre avenir à tous", available at: http://fr.wikisource.org/wiki/Rapport_Brundtland.

Sustainable Development. In addition, the relationship between these practices and the three sustainability dimensions is explored. Results are quantitatively analyzed through descriptive and inferential statistics methodologies.

- *PART 3 – Sustainable Food Supply Chain: Face-to-face interviews*. In order to enlarge the results obtained, face-to-face interviews are carried out with some of the respondents who provided their availability. A general assessment of the impact of the implementation of sustainable practices on the three dimensions of sustainability is proposed. Finally, the results of the literature review of the empirical study are critically analyzed to highlight similarities or disparities.

Finally, a general conclusion that summarizes all the outcomes of this research study is proposed.

PART 1 – SUSTAINABLE FOOD SUPPLY CHAIN: LITERATURE REVIEW

The purpose of the first part of this document is to conduct a literature review to uncover the dimensions of sustainability that impact the management of a supply chain, as well as all the practices, carried out by a company to be sustainable. This part is decomposed into three chapters structured as follows:

- *Chapter 1 – The transition to Sustainable Development in Food Sector,* intends to discuss theories and concepts underlying this work. Before starting the analysis of the scholarly papers, it is necessary to introduce the notion of sustainable development and how this is applied in the food industry. The aim of this chapter is to look at the key concepts and to give a comprehensive model as a base for the whole document.

- *Chapter 2 – Systematic Literature Review*, presents the process of selection of the scholarly papers and their taxonomy as well as the methodology applied to conduct the literature review. The main findings related to the analysis performed in this field of study are described in this part of the document as well.

- *Chapter 3 – Sustainable Food Supply Chain Management,* describes the current state-of-the-art based on the research already carried out on this topic. First, the drivers and the barriers that a company face to achieve Sustainable Development are illustrated, then the practices found in the literature are described and discussed. This represents the starting point for the second part of this document.

1. The transition to Sustainable Development in Food Sector

1.1. Food Industry and Food Supply Chain

The food industry is central to human beings and heavily impacts the lives of the entire society. An *Agro-Food- or Food- Supply Chain (FSC)* refers to the set of processes that describe how food from a farm ends up on our table. The administration of the supply chain operations is defined as *Food Supply Chain Management (FSCM)*. The definitions found in the literature are reported in Appendix B. Supply chain management is also known as network management, value chain management, and stream management [1]. The main challenges in this environment are related to food security, food waste, farming, public health, climate change, oil dependency, fair trade, and localism. Because of this, some dimensions are especially critical in the FSC: quality, safety, sustainability, and logistic efficiency [2], [3], [4].

1.2. Towards Sustainability

Internationalization, along with the urge to keep up with *Sustainable Development Goals (SDGs)* (Appendix D), has made the worldwide competition among firms more complex, with conventional business models struggling to find appropriate solutions [5]. To gain a competitive advantage, organizations seek to empowering the conventional business models to meet the SDGs while maintaining productivity and profitability [6]. Sustainability transition can be defined as "*long-term, multidimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption*" [7]. The concept of Sustainability or Sustainable Development is defined by the World Commission on Environment and Development as "*the development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" [8], [9].

1.2.1. Triple Bottom Line: People, Profit and Planet

The pioneer of both "Sustainable Development" and "Sustainability" concepts concerning business activities was Elkington [10], whilst also introduced the "Triple-Bottom Line" approach i.e., the Economic-Social-Environmental impacts that businesses should be accountable for [11]. Therefore, the development of *Sustainable Food Supply Chain (SFSC)* should be abided by the idea of sustainable development, paying more attention to the *Triple Bottom Line (TBL)*: profit (economic aspect), planet (environmental aspect), and people (social aspect). Integrating the concept of "Sustainability" in supply chain operations allows a firm to

build a 'competitive advantage' in the market [12]. The three axes of the triple bottom line approach will be discussed in-depth in the next chapter.

1.2.2. CIRCULAR ECONOMY

The paradigm of *Circular Economy (CE)* emphasizes the idea of transforming products in such a way that there are workable relationships between ecological systems and economic growth, minimizing the use of primary resources by applying the 4R principles: reducing, recycling, reusing, and recovering on a micro (enterprise), meso (industrial park) and macro (regional) level, thus reducing the need for new inputs (raw materials and energy) into production system [13], [14], [15].

The CE principles are widely considered as a tool to implement and design a sustainable business model in the different sectors in response to currently unsustainable trajectories [5]. Therefore, another way to enhance sustainable supply chain management strategies seems to be aligning it to the circular economy concept [13]. In fact, CE is "*expected to promote economic growth by creating new businesses and job opportunities, saving materials' cost, dampening price volatility, improving security of supply while at the same time reducing environmental pressures and social impacts*" [16] thereby addressing all the three dimensions of sustainability.

Moreover, according to Maina *et al*. [17] and Raimondo *et al.* [18], the CE principle is complementary to the bio-economy one, that is "*economic, environmental, and social activities combined with the production, yield, transport, pre-processing, conversion, and use of biomass to produce bioenergy, bioproducts, and biofuels*" [19]. Therefore, the bioeconomy relies on the conversion of renewable carbon reserve from agricultural or forestry biomass and organic wastes into diversified end-products and materials, including food, feed, bio-based chemicals, biopolymers, fuels, bioenergy, and it is also considered a strategic lever for the creation of job creation opportunities. However, the adoption of these innovations is strongly influenced by the perception of high risks associated with the transition to circularity. Even if, Raimondo *et al.* [18] show the cost-effectiveness of producing innovative products obtained by processing waste, as a conclusion of their overview of the technologies applicable to enable bio-economy mechanisms, Golembiewski *et al.* [20] notice that the evolution of bioeconomy is stacked on a strategic level. To overcome the challenges associated with bioeconomy evolution, open innovation approaches and collaboration between value chains must be promoted to develop the knowledge and technologies needed to enable comprehensive, interdisciplinary research into the organization of future biomass flows across the boundaries of the sector.

1.2.3. Sustainable Production and Consumption

Sustainable Production and Consumption is one goal of sustainable development [21] and it is defined as "*a continuous economic and social progress that respects the limits of the earth's ecosystems and meets the needs and aspirations of everyone for a better quality of life, now and for future generations to come*" [22]. According to the United Nations Environment Programme (UNEP), one of the most striking examples of dysfunction about consumption and production is the issue of food loss and waste. According to that, Papargyropoulou *et al.* [23] suggest that the first step towards a more sustainable resolution of the food waste issue is the adoption of sustainable production and consumption patterns and tackle food surplus and waste throughout the global food supply chain.

These concepts will be addressed in detail in the third chapter.

1.3. Types of Sustainable Supply Chain Network in Food Industry

The supply chain is designed to meet consumers' demands as efficiently and profitability as possible. The success of a company depends on the efficiency of planning, manufacture, and distribute a product in a network. To achieve the sustainability goal, different terms used to describe several types of supply chains management networks can be distinguished (cf. **Figure 1**) by the following terms: sustainable, green, closed-loop, lean and short supply chain.

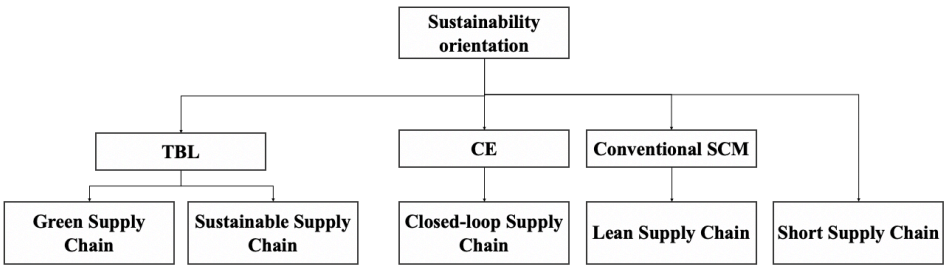

***Figure 1** – Types of Sustainable Supply Chain Networks.*

The transition to sustainable development can be achieved by aligning the supply chain management following the three pillars of the triple bottom line. In fact, Sustainable or Green are the terms used to describe the management of a supply chain by combining social responsibility with environmental factors to achieve better economic performances. Another way to achieve sustainability derives from the CE principle. According to the CE concept, the creation of a closed-loop supply chain consists of forward and reverse supply chains in which processes like collection, recovery, reuse, and recycling become extremely important. Furthermore, adopting the Lean paradigm in SCM helps to focus on wastages reduction that are processes or resources that have no value added for the end consumers, enhancing the

importance of the workforce commitment. Finally, by eliminating the middleman in the network, a direct connection between farmers and customers can be established that in turn leads to an increase in the economic performance for farmers and helps to preserve the environment. In fact, these are the three main characteristics of short chains which are raising in recent years in the food sector, in line with the demand for more sustainable development. A detailed description of these types of networks is provided in the following.

1.3.1. Sustainable Supply Chain Management

The response of supply chain management to the three issues of sustainability makes up the core concepts of sustainable supply chain management [24]. The most widely adopted definition for sustainable supply chain management is the one provided by Seuring and Müller [25] as: *"the management of material and information flows, as well as cooperation among companies, along the supply chain, while taking goals from all three dimensions of sustainable development (i.e., economic, environmental and social) and stakeholder requirements into account"*, in which the key points are the paid attention toward TBL approach and to the stakeholder as well as the need to collaborate with other actors in the supply chain.

1.3.2. Green Supply Chain

Green supply chain management is considered as a strategic approach to achieve economic performance while minimizing the effect on the environment. Green Supply Chain can be defined as: *"an integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumer as well as end-of-life management of the product after its useful life"* [26]. Several definitions of SSCM and GSCM are found in the literature (Appendix B). It can be noticed that the distinction between SSCM and GSCM is blurry. In fact, some authors distinguish Sustainable (that follows the TBL approach) from Green (dual approach: economic and environmental) supply chain management but some others do not. Considering the most recent documents published, these two terms are often used interchangeably.

1.3.3. Closed-Loop Supply Chain

In line with the Circular Economy principle, a closed-loop supply chain describes both forward distribution operations and reverse flows. The forward supply chain includes the activities of procurement, design, manufacture, and distribution to consumer while reverse supply chain is related to the handling, storage, and transport of reusable products, components, waste, or packaging [4]. Therefore, a CLSC is referred to as 'reverse logistics' or 'product-

recovery management' [27] or 'reverse supply chain management' [13]. In the food supply chain, the reverse flows of products concern the recycling, substitution, reuse, disposal, refurbishment, and repairing of residual products, by-products or co-products and other waste, in particularly the packaging [4]. Several authors provide evidence to illustrate that collaboration is better than competition to stay in the market. They conclude that collaboration among firms within a CLSC minimizes the waste by inputting the returned used products or parts of the products into another manufacturing process [5]. In fact, Genovese *et al.* [13] make a distinction between reverse supply chain management of the type open-loop (if materials are recovered by other parties) or closed-loop (if the manufacturer of a product can recover value or a part of it taking back products from customer). In their work, Sgarbossa and Russo [27], noted that in traditional CLSC the waste goes to disposal stage of supply chain and this approach analyzes the flows concerning just the products, without considerations on the other outputs. Therefore, there is the need of reconfiguring networks applying the new models for the design and the management of CLSC to include also the resource recovery into traditional approaches.

1.3.4. Lean Supply Chain

Even if, as a result of this literature review, research that combines FSCM and Lean Philosophy is very limited, lean management's intrinsic focus on waste reduction coupled with its people-centered hands-on pragmatism provides an inherent congruency between the lean paradigm and sustainability strategies and tactics [28]. Lean management approach considers everything that enable operators to rationalize resources input and avoid mistakes that cause inefficiencies by reducing related costs of quality efficiency [29]. According to the lean philosophy, seven critical issues are normally subjected to wastes: transport, inventory, motion, waiting, over-processing, overproduction, and defects. To face these issues, several lean tools can be applied: total productive maintenance, value stream mapping, Kaizen, JIT (Just-In-Time), Poka Yoke, 5S (Sort, Set In Order, Shine, Standardize and Sustain), training of employees and root cause analysis [30], [31]. Pearce *et al.* [32], identifies six main categories of determining factors that drive sustainable organizational performance through the application of lean methods (cf. ***Table 1***).

Table 1 *– Determining Factors of Lean practices. Adapted by* [32].

	Determining Factors
Knowledge	Knowledge of sustainability and lean concepts and practices, contextual knowledge, specialist knowledge/skills, common area of value between organization and company, perception of value between stakeholders.
Workforce and Training	Training, teamwork, self-direction and worker participation, procedures and work habits, worker needs and workplace ergonomics.
Operational Context	Marketplace complexity, marketplace dynamism, increasing/decreasing customer expectations, high number/variety of stakeholders in supply chain.
Organizational Structure	Size and magnitude of practices, suppliers, site-layout, culture, resource availability.
Alignment, Integration and Prioritization	Degree of integration of sustainability objectives, prioritization of management or infrastructure, prioritization of internal or external stakeholders alignment between operations and strategy, alignment between organization, staff and project objectives , technology integration
Technology and Decision Support	Technology, 4th sustainability dimension, advanced methods for dealing with complexity, planning, monitoring and evaluation, measurement and metrics

1.3.5. SHORT FOOD SUPPLY CHAIN

Short Food Supply Chains (SFSC) have been identified as an economic opportunity for agriculture under urban pressure, as well as a driver for a more sustainable farming system [33]. These types of chains are characteristic of the food industry. The growth of the food processing sector, the increasing industrialization, and urbanization as well as the development of long-distance transportation processes caused a transformation in the supply networks for the food sector [34]. Nowadays, a continuous increase of consumers' demand on food safety, product diversity, local, organic and seasonal food, higher packaging, quality of services, and high-quality food near their place of residence caused a renaissance of traditional, direct ways of delivering food [35], [36], [37], [38]. Traditional food deliveries based on direct supplies or sales on farmer's markets were the forerunner of today's SFSCs [39]. The blossoming of this new food production, distribution and consumption networks of small size and scale farms, consumers, retailers, logistics and other actors built upon the re-connection or close communication between producer and consumer makes up the concept of Short Food Supply Chain (SFSC). Adopting the definition provided by the European Parliament, a SFSC is: *"a limited number of economic operators, committed to co-operation, local economic*

development, and close geographical and social relations between producers, processors and consumers" [40]. However, in the public and scientific debate, SFSCs definition is hotly debated. In fact, these appear to be identified by various authors with little consensus [39]. The terms "alternatives modes of food supply and consumption", "community supported agriculture", "grow-your-own", "alternative food chains", "sustainable food chains" or "alternative food networks (AFNs)" are used interchangeably to identify SFSCs [41].

In this context, a possible classification is provided by Horská *et al.* [42] that is face-to-face (purchases directly from producers), proximate or extended, based on the number of intermediaries in the chain, the physical distance, and the organizational arrangements among them.

According to Berti and Mulligan [43], the main features of those new organizational forms that distinguish it from conventional SC are:

- Transparency: includes the concepts of provenance, traceability, composition of products and modes of production;
- Democracy: producers reconfigure power relations along the supply chain or network with reaffirmed control;
- Equity: fair income for the small-scale producers, equitable distribution of added value along with the food network, reasonable price for the consumer, accessibility also for lower-income groups;
- Access: organizational and physical structures of the appropriate scale for moving locally grown food to consumers.

1.4. Food Supply Chain: Main Actors

The impact of 'greening' a supply chain is related to the image of the firm and its goods from the point of view of various stakeholders [44]. The stakeholder is "*any group or individual who can affect or is affected by the achievement of the organization objectives"* [45]. According to Morais D. S. B., [46], the primary stakeholders with reference to the focal company, are companies that are directly involved in supply chain operations such as manufactures, suppliers, distributors, and customers. The secondary stakeholders are organizations indirectly involved in the supply chain such as governments, agencies, non-governmental organizations (NGOs), and media. In network theory, the focal firm depends on the perspective considered [47]. Shifting from SCM to SSCM will lead companies to rethink their relationship management strategies to accommodate changes in the business landscape (cf. **Figure 2**) driven by sustainability needs [48].

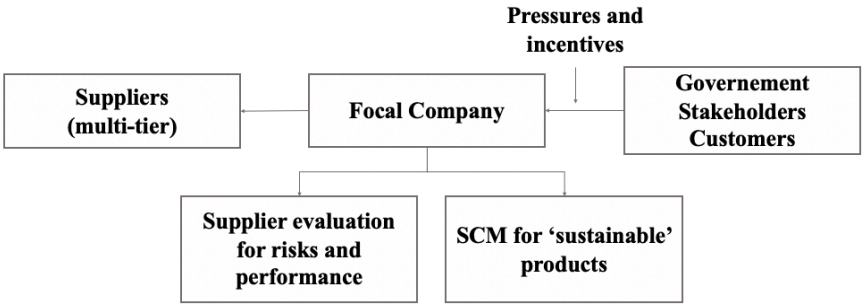

Figure 2 *– Triggers for sustainable supply chain management. Adapted from [49].*

2. SYSTEMATIC LITERATURE REVIEW

According to Toubolic and Walker [50], a review is a structured and comprehensive methodology to select relevant theoretical perspectives and practices in the foremost literature in the field while a systematic literature review is an approach of making sense of large bodies of information in a systematic way to provide convincing evidence to address some compelling issues [51]. This systematic review attempts to find all existing and published research on Sustainable Food Supply Chain Management. In fact, the criteria chosen for the review are general i.e., not restricted to a specific topic or a stage of the supply chain, to cover as much as possible all the research made in food industry concerning the sustainable development. In this research, the main objective is to identify the present status of the literature in the area of SSCM in the food industry, to assess which are the practices that a company should implement to achieve the SD goal. A best practice is defined as: "*Any practice or experience which has proved its value or which is used in an efficient way in an organization, and can be applied in other organizations*"[2]. A best practice has three characteristics: it is formalized, reusable and effective [24]. The third criteria include the relevance, coherence, effectiveness, efficiency, robustness and sustainability of the value created by the implementation of a practice.

2.1. THE SAMPLING

The review's main objective is to discover the existing approaches, challenges, and advancements in the Sustainable Supply Chain Management field, related to the Food industry, to assess which practices can lead to a sustainable supply chain management. Therefore, to accomplish this purpose, the search deploys a combination of several key terms to sample the open access documents written in English or French published in Scopus and Science Direct databases. The terms "Sustainable AND Supply AND Chain AND Management" and "Food AND Supply AND Chain" applied to the titles, abstracts and keywords of research journal articles or review articles, result in a total of 379 papers in different periodicals. The studies published from 2008 (first year found through the query) to 2020 are counted for the review process. Documents that will be published in 2021 but already available on-line are included. In addition, taking in consideration the subject area of these studies, some filters are applied to exclude all the documents not relevant for scope of this review. Because of this, 24 papers are excluded a priori from Scopus database and 15 from ScienceDirect. In the end, a total of 324 relevant articles are identified, of which 11 are in common between the two databases. A flow

[2] American Productivity and Quality Council (APQC). Available on http:// www.apqc.org.

diagram of the entire database research methodology is presented in **Figure 3**. The titles, abstracts, and conclusions of the selected papers were then read and analyzed to determine whether they should be included in the review or not. The criteria applied during this screening step have been consistent with the purpose of this research, consequently, the documents dealing with Food-Energy-Water nexus, food rescue, Ho.Re.Ca (Hotels, Restaurant, Catering) supply chain or case studies related to the same subject, articles dealing with the process to recover energy or produce fuels e.g. anaerobic digestion, are not taken into account because too specific or out of the context of the study. Because of that, 137 papers are excluded. For the same reasons, 19 documents are excluded after the analysis of the full text. In the end, 157 articles are selected, covering three main topics: Supply Chain Management concerning the Food industry and its transition towards sustainability, food management in a broader context (food surplus, food loss, and food waste), and the role of Information Technology in the FSC context to consider one of the most relevant topics of the 21st century which is Industry 4.0 and how it can be applied to drive sustainability in the food supply chain. This made up the initial set of papers to conduct the literature review.

Furthermore, focusing on Scopus database, the snowballing procedure outlined in steps in **Figure 4**, is carried out, by applying the same criteria chosen during the original search that are described above. In the end, 224 articles are considered relevant for further analysis. In a general way, the snowball effect is defined as "*a situation in which something increases in size or importance at a faster and faster rate*" [52]. In the context of literature analysis, snowballing refers to using the reference list of a paper (backward snowballing) or the citations to the paper (forward snowballing) to identify additional papers. Also known as "citation tracking", "bibliographic search" or "pearl growing", the snowballing technique is an effective approach to literature searching which helps to ensure that all relevant literature has been identified when performing reviews on the topic of interest [53]. The adoption of this technique in fact, assures that valuable knowledge within the scope of the research was captured from the papers not selected through the initial search process [54].

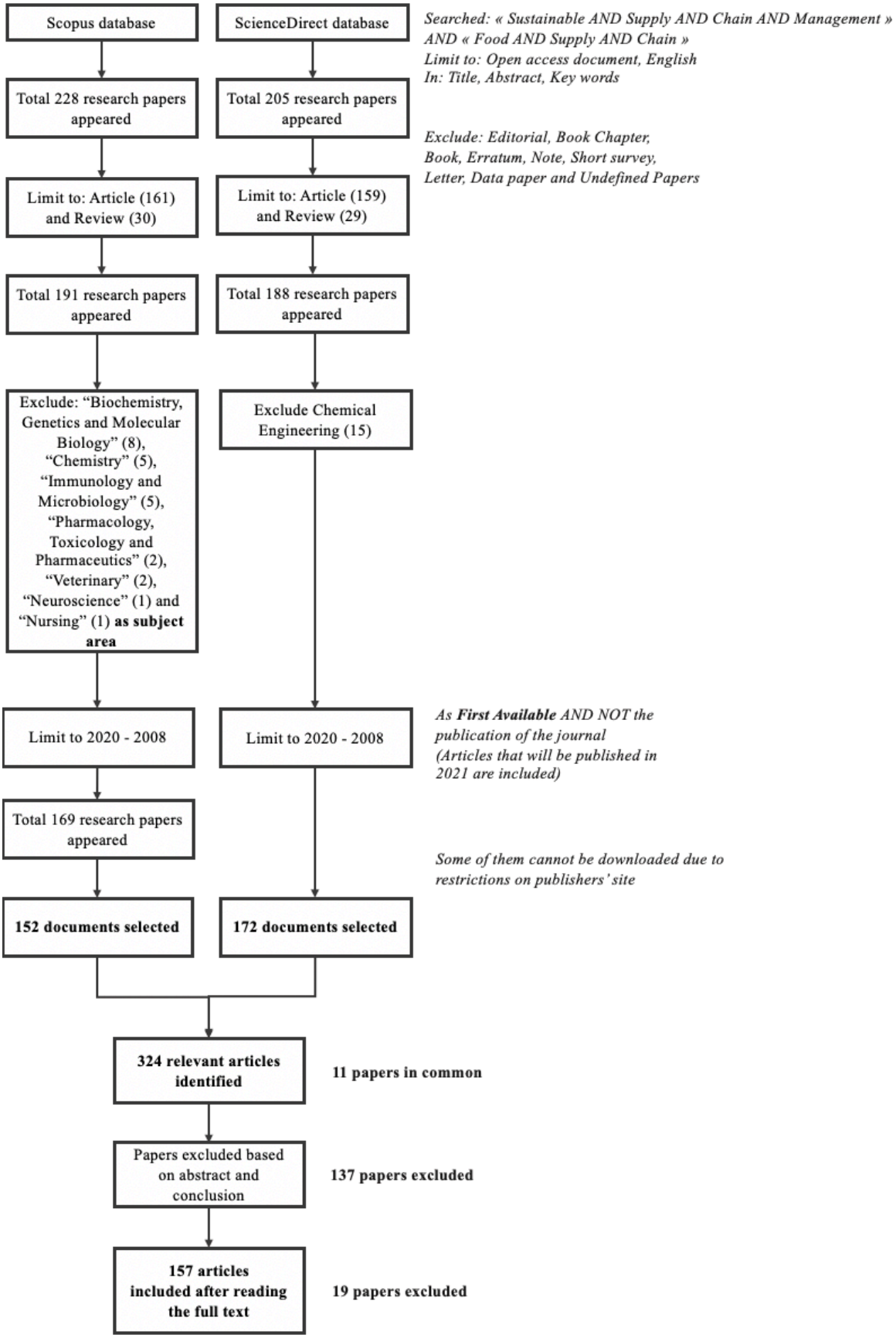

Figure 3 *– Research Methodology.*

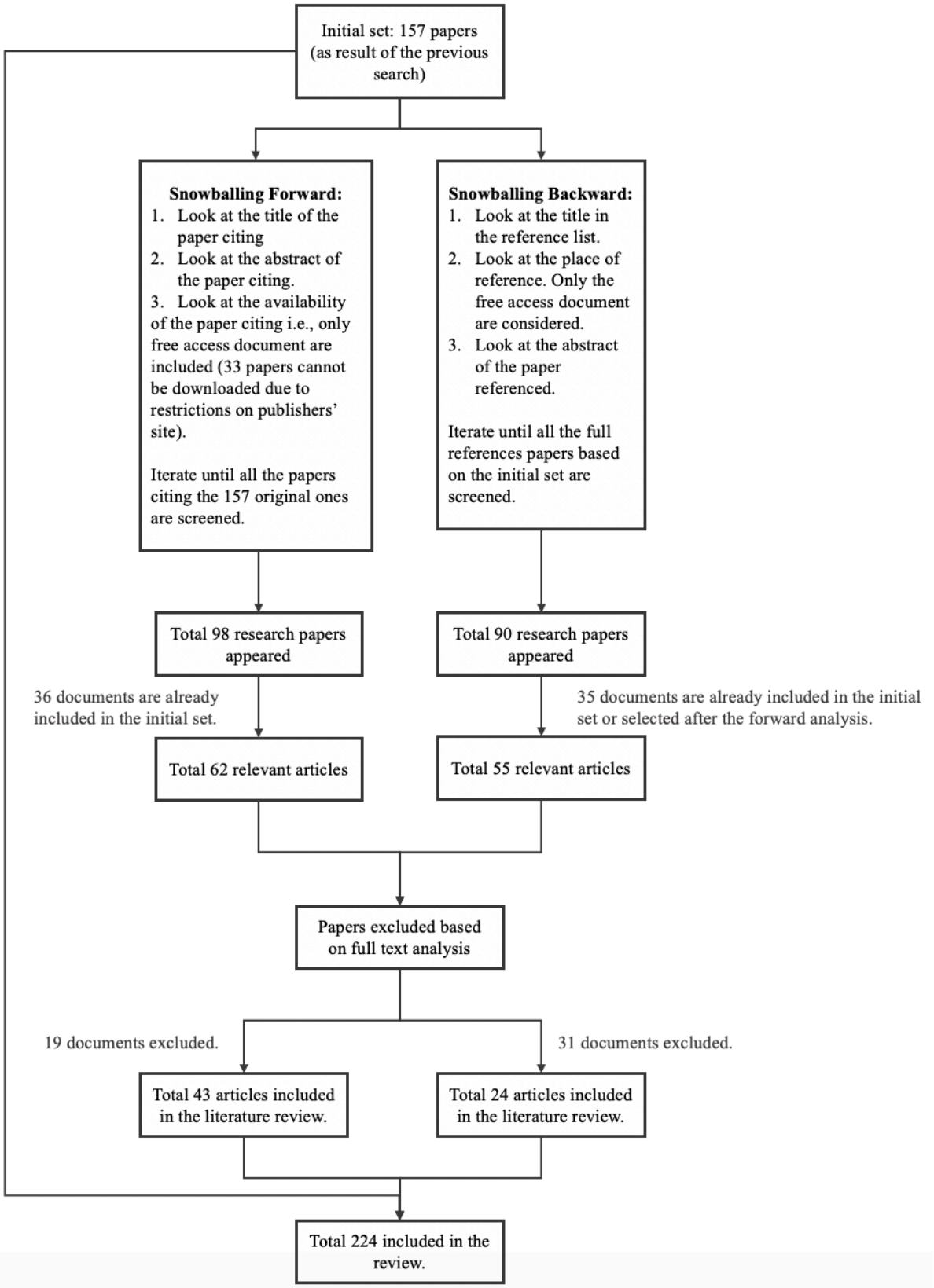

Figure 4 *– Snowballing procedure.*

2.2. THE TAXONOMY

The taxonomy represents the framework based on which the documents have been analyzed. The approach applied will offer an in-depth understanding of this literature review and relevant conclusions are derived.

Starting from the year-wise distribution of the papers (cf. **Figure 5**), this topic appears to be little discussed in the literature from 2008 to 2010 (2008 is included in the parameters of the original search even if no document is selected). Then, the papers fluctuated slightly from 2012 to 2014. Another change of emphasis in research can be seen in the years from 2015 to 2017. Currently, there is a considerable increase in research related to this topic. This points out that sustainability in the food industry is a recent field of study and that the general interest in sustainable supply chain management in the food industry can be expected to increase in the future. In fact, by looking at the result of the snowballing procedure (cf. **Figure 4**), papers included after the forward analysis are twice with respect to the backward one.

The causes underpinning this incremental increase of the studies are not strictly discernible from the review of the literature, however, as already mentioned in the previous chapter, one of the most influential factors requiring the industries in this sector to move towards a more sustainable future is represented by the "*2030 Agenda*", agreed in 2015 by the United Nations General Assembly (Appendix D).

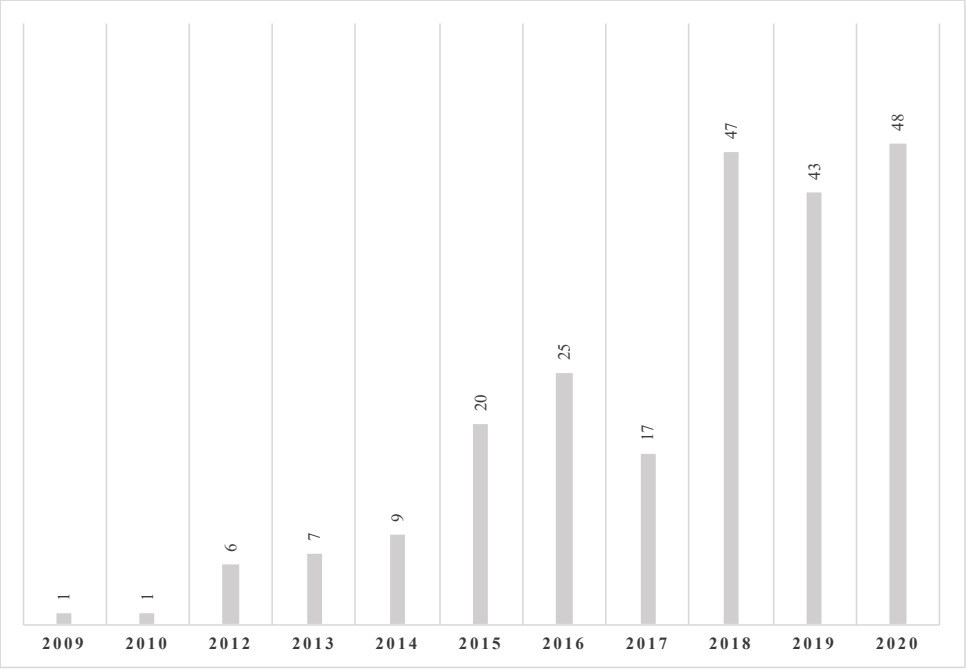

Figure 5 *– Year-wise distribution of the 224 selected documents.*

Most of the reviewed papers are from leading international journals such as *Sustainability* (64), *Journal of Cleaner Production* (36), and *International Journal of Production Economics* (11). *Sustainability*, published semi-monthly online by MDPI, is an open-access journal of environmental, cultural, economic, and social sustainability of human beings [53]. *Journal of Cleaner Production* and *International Journal of Production Economics* are both published by Elsevier. The former is a transdisciplinary journal focused on Cleaner Production [54], Environmental and Sustainability research and practice, the latter is focused on the interface between engineering and management [55]. The contribution of these three journals represents exactly 50% of the documents set, the remaining 50% is made up of 79 different journals with a frequency of fewer than 5 articles per journal. This shows that this topic is covered in a great variety of journals, therefore sustainability in the food industry is a granular and horizontal topic, discussed from the point of view of different journals. The entire classification is reported in the Appendix A.

With regard to the publisher, the most relevant contributions are from Elsevier (47%, 106 over 224 documents in total), MDPI (36%, 80 over 224), Springer (3%, 8 over 224), and Taylor & Francis (2%, 6 over 224).

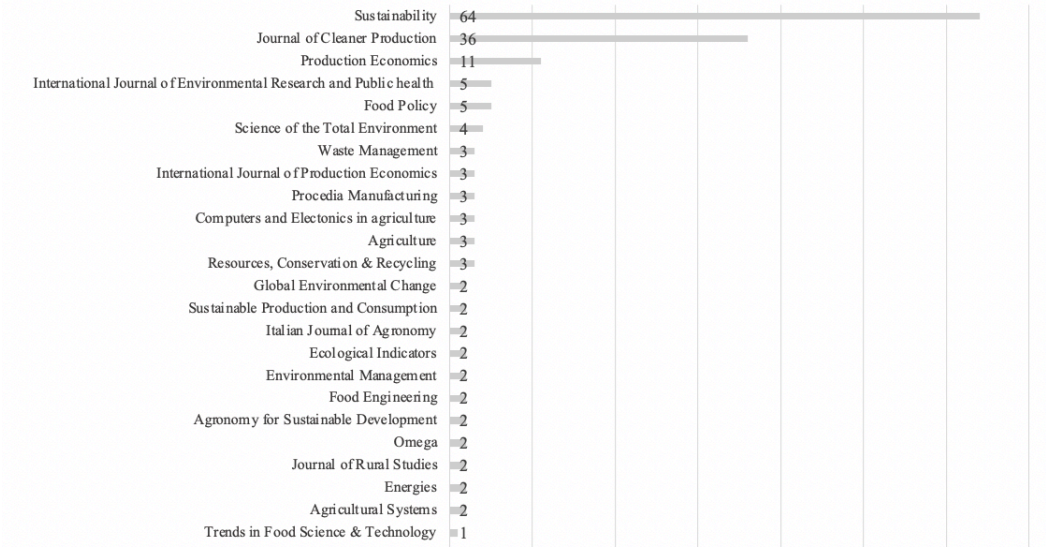

Figure 6 *– First part of the Journals distribution, over a total of 224 selected documents.*

To categorize the article based on the type (cf. **Figure 7**) the following criteria are considered:

- *Empirical Research,* that is research by using empirical evidence i.e., observation and documentation of pattern and behavior through experimentation. Empirical research relies on quantitative or qualitative data, with the aim to answer empirical questions [55], that could lead to the conceptualization of new a framework or to the development of theories.

- *Literature Review,* "a systematic, explicit, and reproducible design for identifying, evaluating, and interpreting the existing body of recorded documents" [56]. The Literature Review documents are intended to look at the research previously carried out on a topic, collecting a huge amount of information as input, and processing it to give a comprehensive and exhaustive output. Because of this, these are qualitative.
- *Case-study,* that is a research strategy that focuses on understanding the dynamics present within single settings. Case studies typically attempt to answer both "why" and "how" questions [28], combining data collection methods such as archives, interviews, questionnaires, and observations. The evidence may be qualitative, quantitative, or both [57].

During the discussion of the obtained results based on this classification, special attention has been given to the number of papers that make up the literature review section. As stated before, the subject of this review appears to be very recent as a field of study, and the literature review articles are intended to look at the past. This seems to be a subtly contradictory result. To get in detail, the year-wise distribution according to the type of articles is shown in **Figure 8**. The numbers reported in the figure refer to the number of literature review per year. Unlike case studies and empirical research, literature reviews follow the same distribution pattern as the totality of the document.

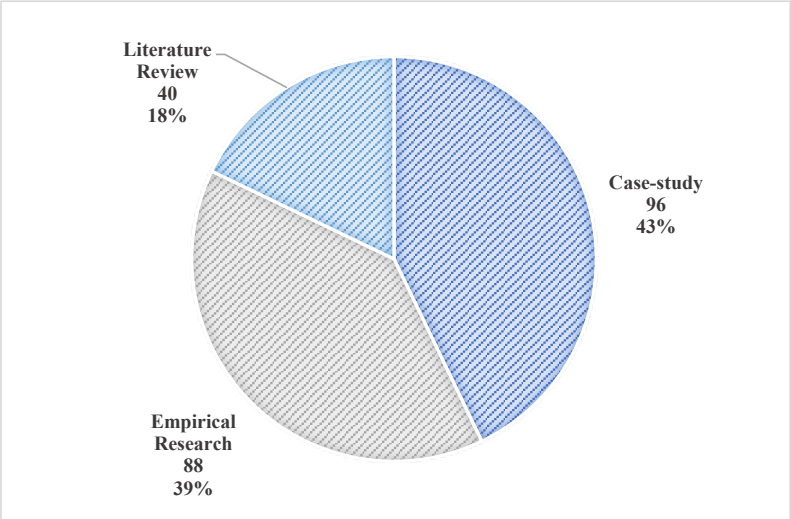

***Figure 7** – Classification of articles based on the typology, over a total of 224 documents.*

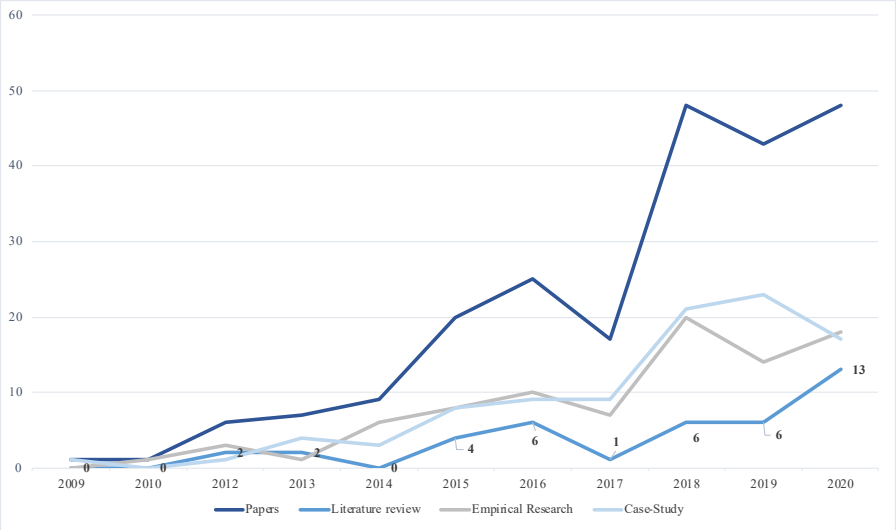

Figure 8 *– Year-wise distribution of articles based on the type, over a total of 224 documents.*

Six research methodologies are differentiated: Systematic Literature Review, Simulation, Statistical Model, Mathematical Modelling, Survey, Multi-Criteria Decision Making, and Empirical Analysis, based on the way in which data are analyzed and not to their collection. The approaches (Qualitative or Quantitative, Ex-ante vs. Ex-post) of these studies are considered. The charts are depicted in **Figure 9** and **Figure 10**. Ex-post works i.e., the analysis is performed by looking at the result of an event, accounting for 72% of the total (162 over 224 documents) while Ex-ante studies account for 27% of the total (61 over 224 documents). Just one case study adopts an Ex-ante and Ex-post approach.

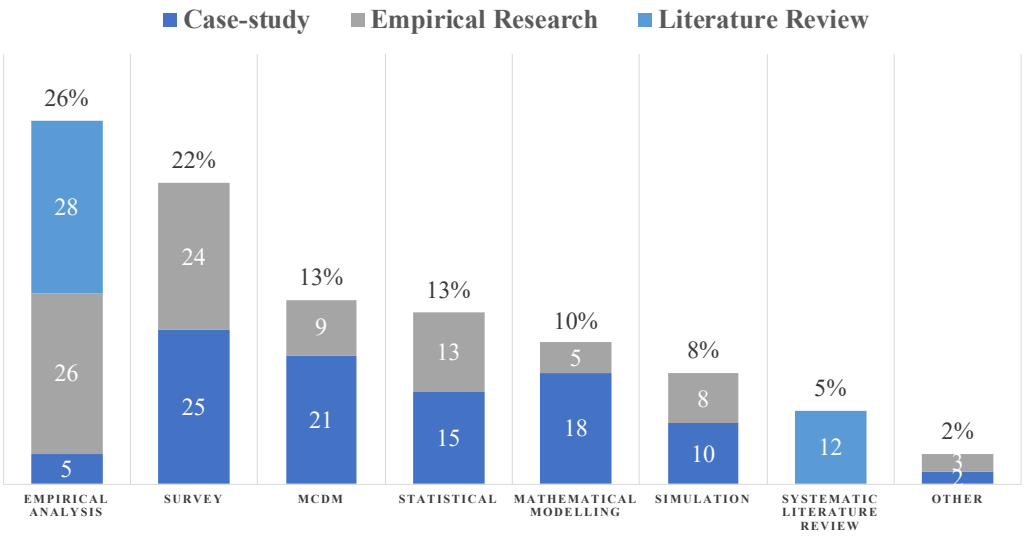

Figure 9 *– Classification of articles based on the methodology over a total of 224 documents.*

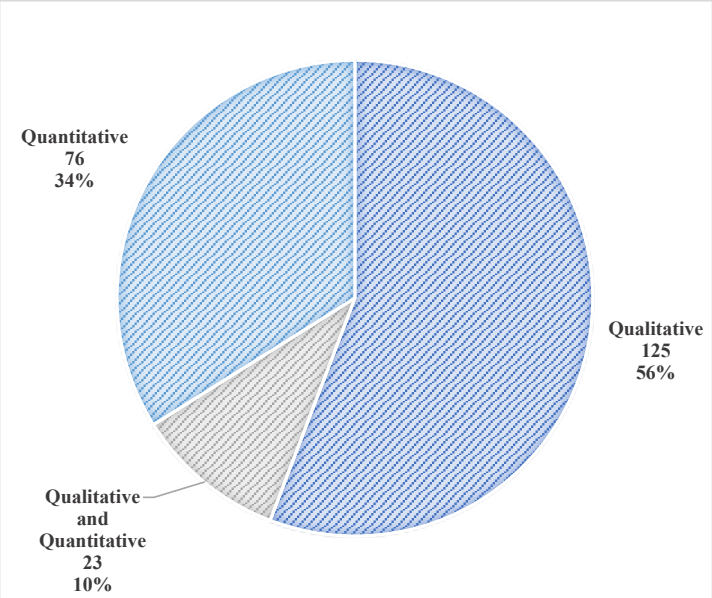

Figure 10 *– Classification of articles based on the approach, over a total of 224 documents.*

The methodologies applied in the Literature Reviews, qualitative by nature, are Systematic Literature Review or Empirical Analysis, mostly based on the content-analysis of previous findings. The other methodologies are applied in both Caste Studies and Empirical Research (cf. **Figure 11**).

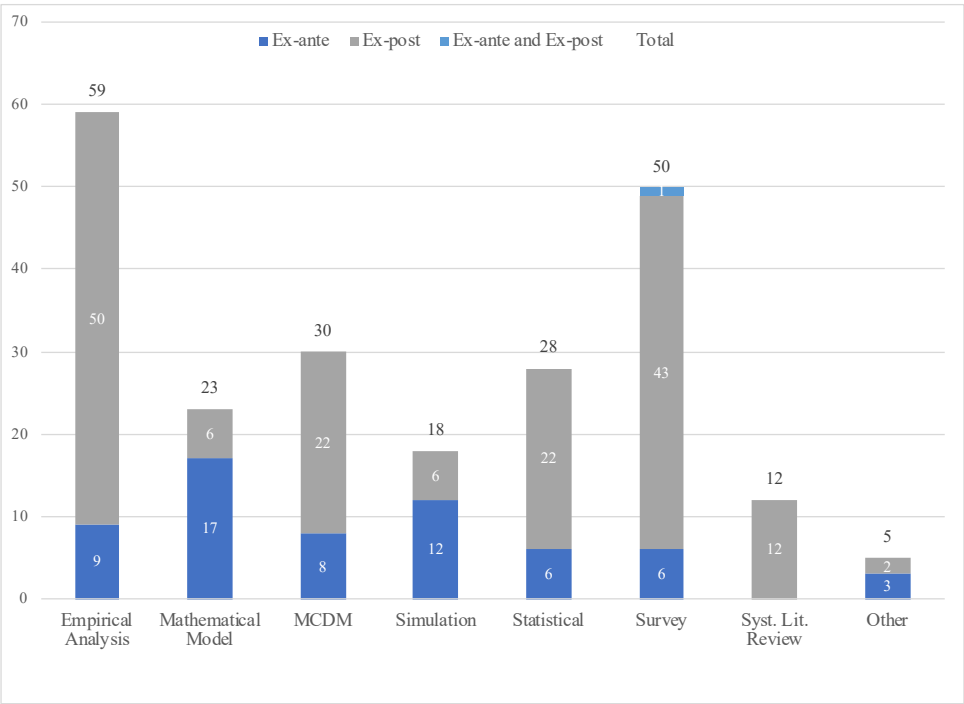

Figure 11 *– Relation between the methodology adopted to evaluate data and the Ex-ante or Ex-post approaches.*

Most of the works are performed by analyzing a set of both primary or secondary data that according to Joop and Boeije [58] are information that are collected for the specific research problem at hand, using procedures that fit the research problem best and/or a new collection of data added to the existing knowledge. All these studies are categorized under the Empirical Analysis label. Surveys (semi-structured interviews, direct or online interviews, field observation, workshops, or surveys themselves) are mostly carried out to evaluate the level of satisfaction of several individuals (Ex-post survey). In fact, only 14% of these (7 over 50) are intended to appraise the potential interest concerning the selected topic (Ex-ante survey). Statistical analyses are generally conducted to test hypotheses and uncover trends. Conversely, simulations are performed to optimize a given situation. With the intent to assess and predict possible outcomes, are mostly adopted in Ex-ante evaluation. Multicriteria analysis (MCDM – Multi-Criteria Decision Making) is a widespread methodology that deals with the economic, environmental, and social impacts i.e., the three recognized dimensions of sustainability, that are perceived in the food chain. The MCDM methodologies employed are for example the Life Cycle Thinking (LCA – Life Cycle Assessment, LCC – Life Cycle Cost) approach or the Analytical Hierarchy Problem (AHP) technique. These are intended to give proofs of a current situation and support decision-makers by providing alternative strategies. Even if, the life cycle thinking seems to be one of the key topics that show up from this review (cf. paragraph 2.3), the adoption of LCA approach to deal with sustainability issues is critically questioned in the literature (Appendix D). In the end, mathematical modeling is applied to solve Multi Integer Linear Programming or Multi Objectives Linear Programming problems, Inventory Routing Problem or it simply refers to mathematical models. In that case, the work performed can be labeled as quantitative data analysis. When it comes to delivering general judgments around sustainability, models that relies only on quantitative data struggles with the quantification of intangible benefits that compose the social aspect, such as employees and community well-being, animal welfare, stakeholders' willingness, and so on. That can be identified as the reason why some authors perform both qualitative and quantitative analysis.

Since this literature review intends to look at the supply chains operations, it should be noted in which part of the network the reviewed studies are focused on and which type of commercial transaction is analyzed. The framework selected as classification is the generic food supply chain model proposed by [59] that include the following:

- *Agricultural production*, which is referred to as the first level in a supply chain. In addition to that, in this stage are included breeding and fisheries activities.

- *Postharvest Handling and Storage*, which includes the operations that occur between agricultural production and processing.
- *Processing*, food process, and its output.
- *Distribution*, i.e., sales, and distribution from the factories to the retailers, involving warehouse, inventory, and transportation operations.
- *Consumption*, stage related to consumers.

Moreover, the *End-of-life* stage is added to this model to count for papers that deal with the recycling, reuse, recovery, and disposal of materials. Generally, papers consider more than one stage. In addition, 57 over 224 papers are not focused specifically on one or more activities of the SC. Therefore, **Figure 12** is depicted for a total of 167 documents.

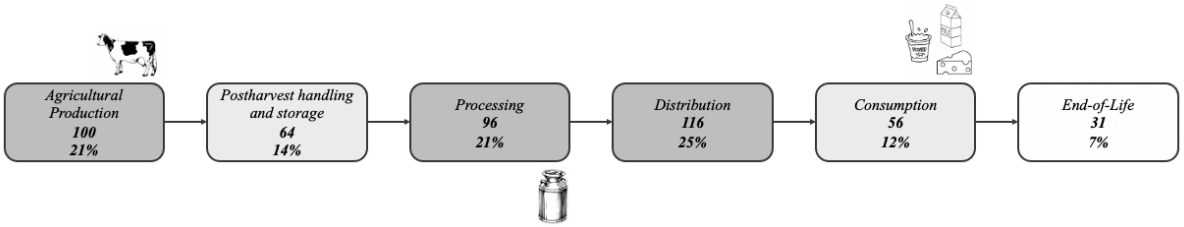

Figure 12 *– Generic food value chain model.*

Agricultural production, processing, and distribution stages are equally addressed. This is an interesting result, most of all in comparison with other sectors in which the primary production is rarely considered. Because of that, the conclusion that can be made is that to reach sustainability in the food industry, agriculture, breeding, and fisheries activities have to be taken into with the same importance as all the other more industry-related steps. Moreover, the End-of-life stage is added to this model to count for papers that deal with the end-of-life processing of materials. It is very important to consider this phase in a FSC because, as introduced in the previous chapter, the adoption of a circular economy model or the creation of a closed supply chain (intra- and inter- company) is a key requirement for achieving sustainable development. The LCA cradle-to-grave studies also fall in this category. Surprisingly, this stage appears to be less addressed in the scholarly papers compared to the others. Because of that, it is possible to conclude that, even if the sustainability challenge of the food sector is increasingly studied, the research papers are mostly conducted to quantify the impacts and not to find solutions. It is worth noting that 57 over 224 of the documents are not focused specifically on one or more activities of the supply chain, that is the case for example of the literature reviews or empirical analyses related to the introduction of new

technologies or their effect on the food industry. Because of that, these are not considered in the classification made (cf. **Figure 12**).

A look at the commercial transactions described gives the following results (cf. **Figure 13**). The type of commercial transaction can be both B2B and B2C. B2B stands for "Business to Business" while B2C refers to "Business to Consumers". B2B businesses sell products and services directly to other businesses. B2C businesses sell products and services to customers for personal use. This is clearly the case of the Short Food Supply Chain or retailers that sell products destined for consumers' personal use. Studies classified as B2B and B2C mostly refer to closed-loop supply chain studies in which a part of the final product is recovered and taken back in the chain while another is destined for final consumption. The obtained result is in line with previous findings (cf. **Figure 12**), B2C and B2B transactions are equally analyzed. The type of the commercial transaction is not distinguished for 76 papers. Because of that, the graph is depicted for a total of 148 documents.

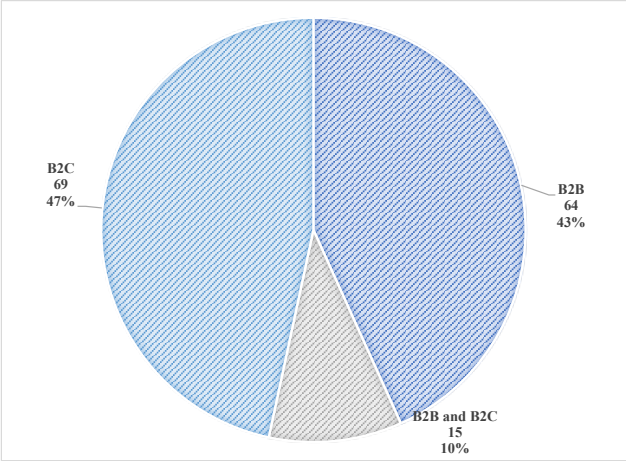

***Figure 13** – Commercial Transaction type.*

In addition, the type of foodstuffs offered by a company and the extent to which these foodstuffs are processed are retrieved according to the classification provided by FAO [60] and Monteiro [61]. The former classification refers to the extent and purpose of the industrial processing applied to them (cf. **Figure 14**) while in the latter the nature of the product is analyzed (cf. **Figure 15**). Food processing describes the series of operations by which unprocessed foods are converted into foodstuffs to prolong their duration, enable storage, and reduce time and effort spent in culinary procedures. The first category i.e., unprocessed, or minimally processed foods refers to minimal modifications of the raw produce, ingredients category include the extraction of substances from the whole foods while ultra-processed products consider the formulations of ingredients made by a series of industrial processes.

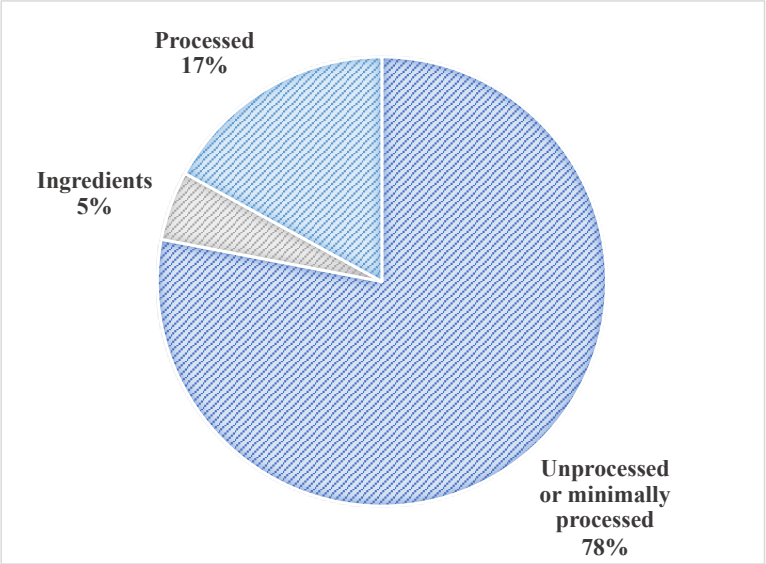

Figure 14 *– Degree of processing of the foodstuffs.*

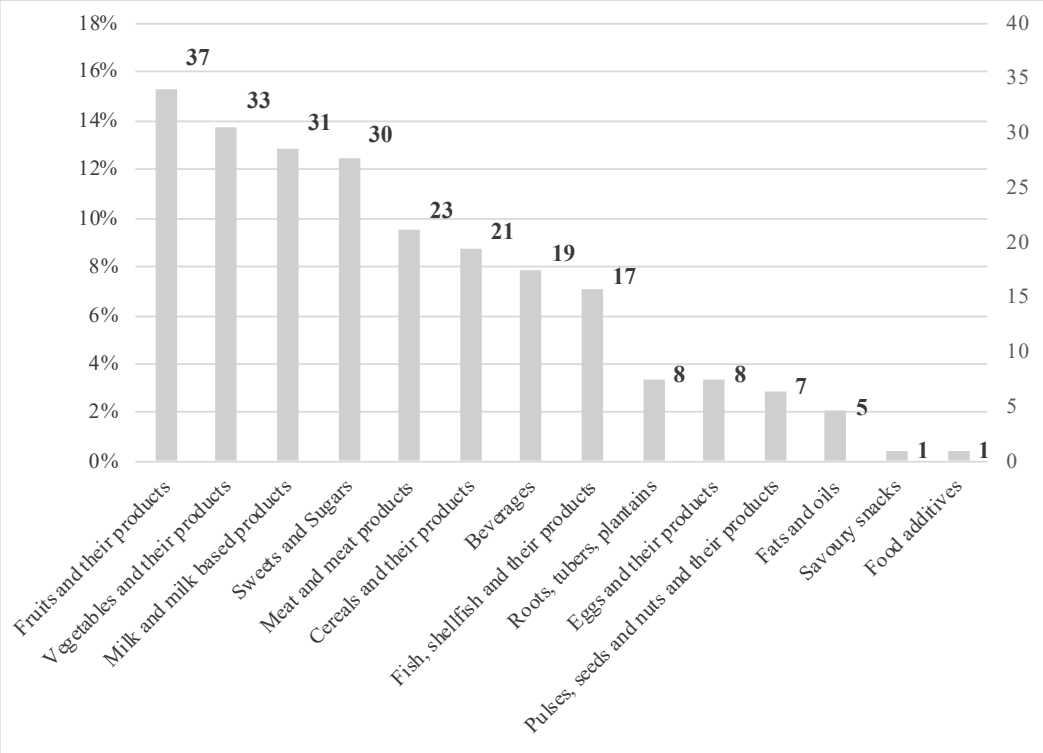

Figure 15 *– Distribution of the food products addressed in the literature.*

The majority of the studies address unprocessed or minimally processed food products (78%) while only a little percentage of the research are devoted to ingredients (5%) or processed foodstuffs (17%). In line with this, it is worth noticing that most of the paper address fruits- and vegetable-based products. Surprisingly, beverages produce counts for the 8% over the total, even if during the search of the papers no filter were applied referred to the food sector.

Articles vary in terms of geographical positioning: most of the articles are focused on European countries or developed nations in general, but developing countries are not excluded (cf. **Figure 16**). It is worth noticing that papers can consider more than one state and 70 studies have not a specific location. Results are in line with the conclusions traced by Yu *et al.* [62] that emphasize the strong acceptability of sustainability ideas in developed nations while developing countries are starting to realize the importance and benefits of sustainable practices. The same can be concluded by looking at the authors' country of origin (cf. **Figure 17**). The details of these distributions are reported in Appendix A.

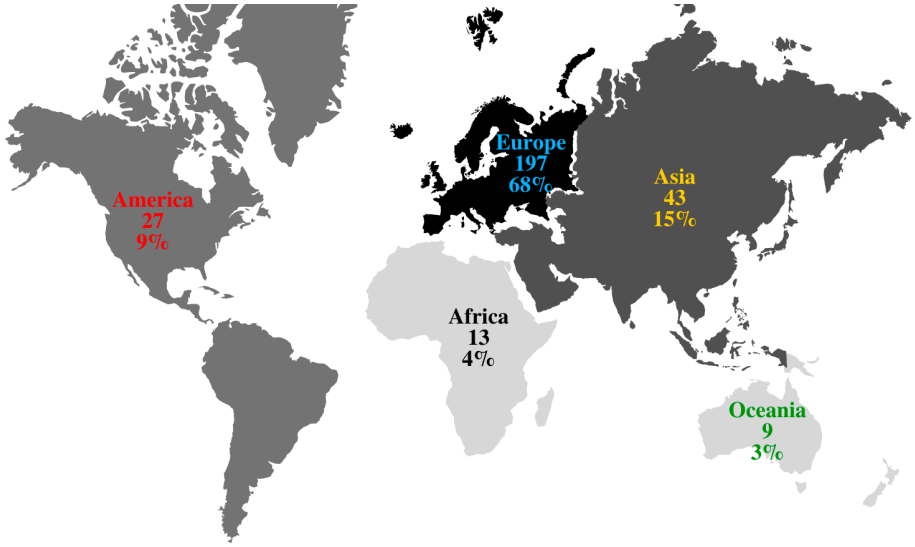

Figure 16 *– Geographical distribution of the studies.*

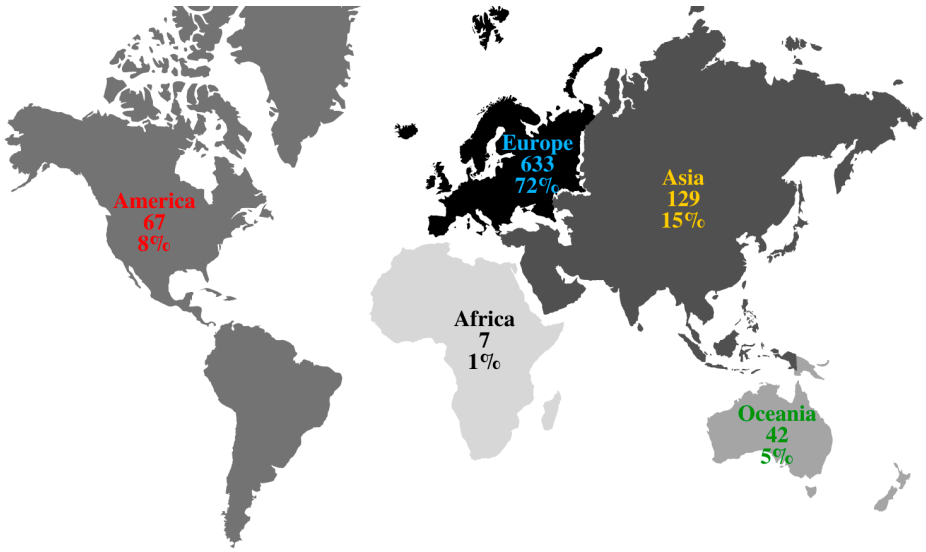

Figure 17 *– Geographical distribution of the authors, over a total of 878 authors per 224 papers.*

During the discussion of the results obtained for Europe, the data both in terms of the number of authors and the number of studies seemed out of the ordinary (cf. **Figure 16**, **Figure 17**), as they show great attention towards this sector compared to the other continents and also results within individual states. As such, they warrant further investigation. First, it is worth noting that the food and drink industry is the EU's biggest manufacturing sector both in terms of employment, turnover and gross value added. Turnover is the net sale measure for a business. According to the European Commission [63], in the last 10 years, EU food and drink exports have doubled, reaching over EUR 90 Billion and contributing to a positive balance of almost EUR 30 Billion.

With regard to the results obtained from the literature, the six leading countries in terms of both numbers of authors and numbers of studies are the UK, Italy, Spain, France, the Netherlands and Germany. The same countries are the largest EU food and drink producers by turnover with reference to the 2020 report provided by the FoodDrink Europe organization. FoodDrink Europe is a food industry confederation in the European Union with the objective to facilitate the development and sustainable growth of all European food and drink companies [64]. The 2020 report, which is the latest accessible, contains data referred to the results of 2018 for this sector, the previous report related to the data obtained in 2016 resulted in the same conclusions in terms of leading countries. **Table 2** provides country-specific information. Data are ranked in descending order according to the turnover. The findings obtained from the analysis of the literature review can be considered in line with the reported statistics.

Table 2 *– Comparison between data obtained from the literature review and official EU statistics [63], for the first six leading states.*

State	***Number of Studies***	***Number of Authors***	***Turnover (€ billion)***	***Number of Employees (1,000)***	***Number of Companies***	***Ranking***
France	17	32	213.1	674.8	54,260	1
Germany	9	28	211.1	992.9	28,800	2
Italy	35	176	141.3	462.1	56,400	2
UK	35	112	119.5	433	10,715	1
Spain	14	52	116.9	426.3	31,342	1
Netherlands	12	52	72.6	135.6	7,038	1

2.3. Literature Findings With Respect To The TBL Dimensions

Since the aim of this study concerns sustainability at the supply chain management level, it would be interesting to consider the integration of its three axes in literature (cf. **Figure 18**). Papers addressing the three dimensions of sustainable development or discussing 'Sustainability' in general without specifying the axes are classified under the 'Sustainability' label. The first conclusion that can be drawn is that, while the economic and environmental aspects are generally included in the studies, the social aspect remains slightly less analyzed. Economically, cost remains the key factor in the decision-making process as profit margins for food products are often low, competition is high and the affordability of food, in general, is a key issue today [3]. In addition to costs, the economic dimension is studied in the literature by focusing on the eco-efficiency i.e., the ratio between the environmental costs and the related economics benefits, the profitability, the stability of the market, the productivity and the reliability, the quality of the inputs and outputs and so on.

The environmental dimension of sustainability mainly focuses on issues related to environmental management. The focus is on lowering the environmental burden that derives from human production and consumption. Such issues include for example the depletion of natural resources, the release of toxic gases into the environment, the energy consumption, the water consumption, and waste generation, the ecological soundness of the production methods. The social aspect refers to the real effect of 'sustainability' performances on the social sphere related to the image of the firm and their goods from the point of view of various stakeholders such as suppliers, employees, customers, and the public institution (both government and non-governmental organizations). At the individual level, health aspects and nutrition play the most prominent role in the food system while at the global level, attention is paid towards the development of the community.

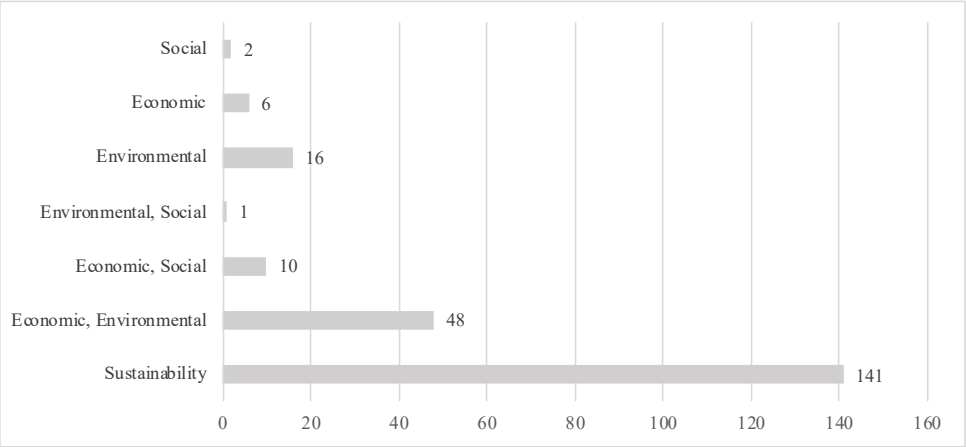

***Figure 18** – TBL distribution of the papers over a total of 224 documents.*

Quantification of environmental, economic, and social impacts provides a detailed analysis of where all the resources are spent. Decisions within companies and financial institutions are often guided by key performance indicators (KPIs) targets that result from a set of considerations aimed at promoting the organization's priorities. Under pressure for great transparency and accountability, these entities are increasingly called upon an expanding list of operational KPIs, including non-financial KPIs that reflect sustainability commitments, actions, and desired status changes. **Figure 19** reports the main indicators deriving from the literature. These are classified according to the model proposed by Chardine-Baumann and Botta-Genoulaz [24], developed with the aim to assess the sustainability of a SC. This framework follows the TBL approach. The three dimensions of sustainability are described by using fifteen issues, five for each dimension. The economical aspect is decomposed into Financial Performance, Reliability, Responsiveness, Quality and Flexibility. The environmental dimension is characterized by Environmental Management, Resource Use, Pollution, Dangerousness, and Natural Environment. In the end, the social axe is focused on Work Conditions, Human Rights, Societal Commitment, Customer issue, and Business Practices. This analysis confirms what has been previously concluded. Profit and Planet dimensions are the most addressed in the literature also with regards to the KPI deployed to measure their impacts, while People remains the least studied. In fact, the indicators used to describe the economic aspect count for 40% of the total and in particular, a significant part is represented by Financial Performance of which cost analysis remains the most relevant component. Among the environmental issues, which in total account for 36%, the Resource Use, the Environmental Management and the Pollution are equally addressed. Surprisingly, Dangerousness that is related to the release of toxic substances in the environment and to the consumption of toxic/harmful material, represent just 2% of the total. About the social dimension (24%), the Human Rights category is the one that gets the least attention.

Figure 19 *– Distribution of the KPIs addressed in the literature.*

2.4. KEYWORDS AND ABSTRACTS PROCESSING WITH PYTHON

In this review, some basic Natural Language Processing (NLP) techniques were applied to analyze the abstracts and keywords of selected papers in order to understand which topics are most discussed in the literature. The results obtained allow to distinguish among all the concepts which are the most studied and furthermore this analysis can be seen as proof of the robustness of the selected papers. NLP is a domain that lies between computer science, artificial intelligence, and the modern concept of "data mining" [65]. The focus of this discipline is working with human language, that is languages used primarily for human-to-human communication. The aim to understand how humans can program computers to process large amounts of data represented in the form of natural language (such as written text or oral conversation) in a way that is productive and efficient [65], [66]. Text mining (also referred to as text analytics) is a branch of Natural Language Processing (cf. **Figure 20**) that deals specifically with the extraction of information from textual input, suitable for analysis or to drive machine learning algorithms. The main difference between data mining and text mining is that while the former handles structured data, the latter deals with unstructured text data i.e., text that is not pre-defined or organized in any way. The final purpose of text mining research

is therefore to study new methods and algorithms to automatically extract knowledge from text, for example, to classify or group documents based on their content [65].

Within the machine learning algorithms, it is possible to distinguish supervised and unsupervised learning. According to Balestri [65], supervised learning is carried out using ground truth, or in other words an "a priori knowledge" of what the model must provide as output values. For this reason, the objective of supervised learning is to learn a function that, given a sample of data and the desired outputs, approximates at best the observable relation in the data between input and output. On the contrary, unsupervised learning does not have any a priori knowledge of which must be the structure of the output. For this reason, the objective of unsupervised learning is just to deduce which is the natural structure that unites and better represents a set of data.

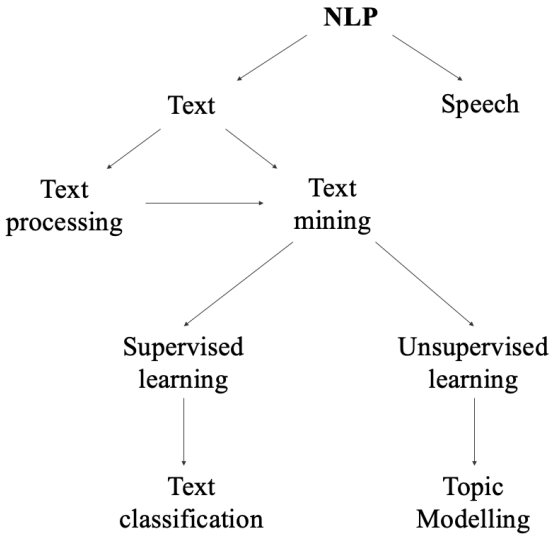

Figure 20 *– Schematic representation of the relationships between the various domains of NLP.*

All the analysis has been conducted using Jupyter Notebook, IDE of the Python programming language. The libraries provided in Python for basics NLP data manipulation used in this document are:

- *NLTK (Natural Language Toolkit)*, a leading platform for programming by processing human language data [67];
- *spaCy*, an open-source NLP Python library designed to be fast and production-ready [68];
- *Genesim*, an NLP Python framework used in topic modeling and similarity detection [69].
- *WordCloud*, library mostly used to perform exploratory data analysis for NLP.

Some other common libraries are employed to work in Python such as *Numpy, Regular Expression*, *Pandas,* and *Matplotlib*.

2.4.1. Word Cloud

The distribution of the most used key concepts among all the texts is depicted by using a word cloud (cf. **Figure 21**). The word cloud generated is related to the way in which information is arranged within our documents. The representation size of a word is directly related to its popularity within the dataset. Among the first top three key concepts, the fundamentals i.e., 'Supply Chain' 'Sustainability' and 'Food', of this document shows up. In addition, the results perfectly match previous findings: the term '*environmental*' appears in the 10-word word cloud while '*social*' only occurs in the 35-word word cloud.

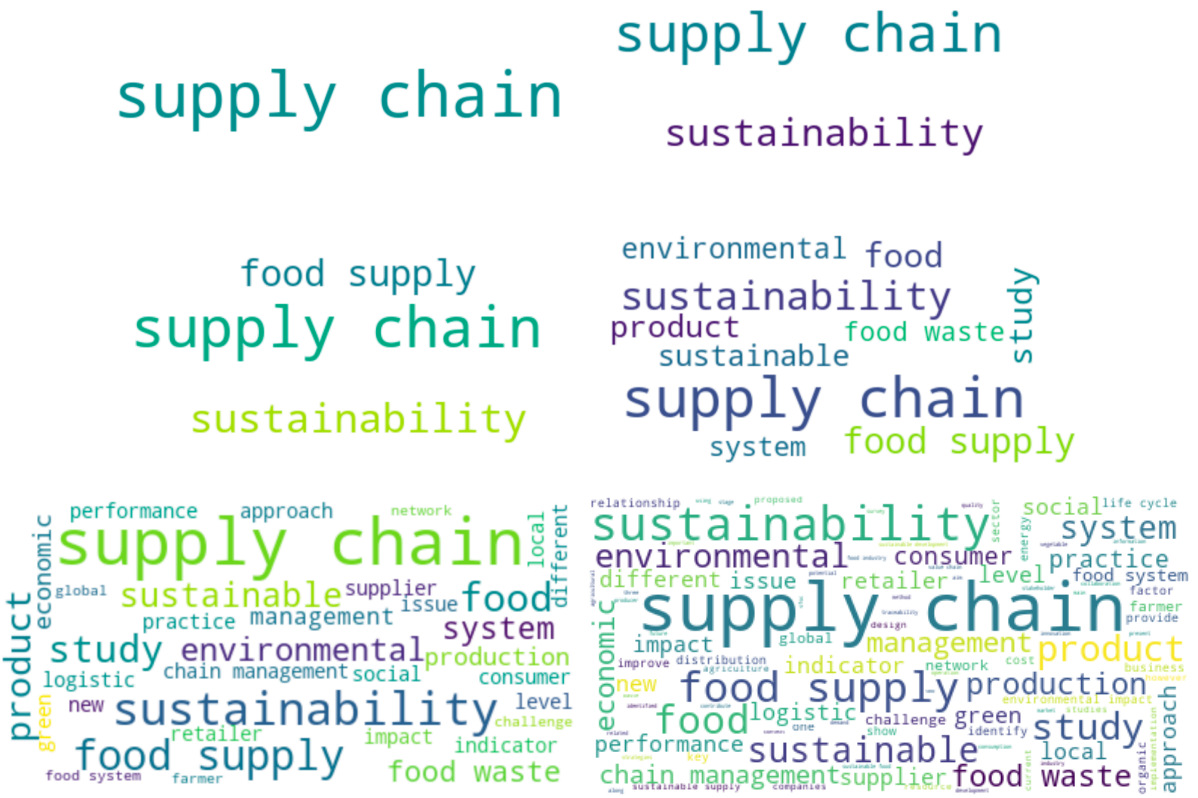

Figure 21 *– Wordcloud with 'max_words' equal to = 1, 2, 3, 10, 35, 100, over a total of 354 350 different concepts identified by the code.*

By isolating from the following concepts, those used in the original research i.e., 'Sustainable AND Supply AND Chain AND Management' and 'Food AND Supply AND Chain', some topics turn out to be extremely interesting. In fact, simply referring to the word cloud obtained (cf. Fig. 2.17), the concepts of "Sustainability" and the TBL approach described by "environmental, environmental impact, social, economic, cost" appears to be the most relevant as well as all the actors involved in food industry such as "farmer, agriculture, retailers, companies, distribution". Moreover, attention is focused on the "food waste" issue. "Local"

seems to be more considered than "global". In this context, the great importance of short food supply chains should be highlighted.

2.4.2. PRE-PROCESSING

Textual documents contain most of the information generated manually by humans. To make the texts easily processable by a computer, it is necessary to transform the abstracts and keywords from the unstructured format in which they are found to a more structured format. To complete this conversion, a series of operations must be carried out on the texts, in the absence of which highly unsatisfactory results could be obtained. Tokenization, stopword filtering, lowercasing, and stemming are applied for this purpose.

Tokenization

The first real stage of text manipulation is to break the document into shorter, easier to process parts [65]. The most used technique to perform this operation is the so-called tokenization whose purpose is to divide the text contained in a document into tokens: depending on the application they can be single words, whole sentences, or parts of them. The main goal of this analysis is to study the frequency and dependency within the most used terms. Because of that, the data frame is decomposed in words by using the *word_tokenize* function. The tokenized set is made up of 50 300 tokens i.e., the number of different words used, taking into consideration all abstracts and keywords.

StopWord elimination and Lowercasing

In the human language, there are a series of terms that do not carry any semantic meaning such as articles, conjunctions and prepositions, common words, and common verbs. These are identified with the name of *stopWord*. The list provided by NLTK library is made up of 179 terms specifically for the English language. In addition, some other terms are generally used in the abstract of the papers such as paper, review, document, journal, analysis, literature, based, model, subject and, so on. Since these are not relevant for the scope of this analysis, they have been taken out from the data frame as well. In the end, 249 different relevant stopWord are selected. In addition, all characters in the text are converted to lower case to ensure that identical words are recognized as such regardless of the characters used to represent them. At this point, the frequency of use of the most relevant individual words (the top 40 terms are investigated, over a total distinct 30 532 tokens) in our document is considered (cf. **Figure 22**). Moreover, the least common tokens are studied as well by using the function *.hapaxes()* that returns all the tokens that appear exactly once. This list is composed of 2 266 terms.

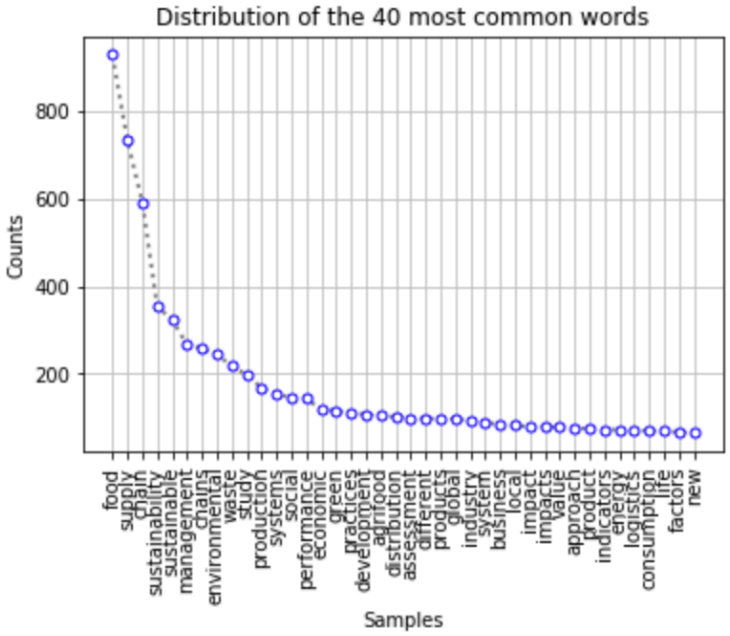

Figure 22 *– Distribution of the 40 most frequent tokens.*

The number of times each word appears can be considered as the relevance that an argument has in the literature. Under this lens, these results confirm the previous ones. Without considering the words used in the original research, "environmental" (that appears 244 times) and "waste" (that appears 218 times) are used as often as the word "chains" (that appears 258 times). Surprisingly, "social" appears 145 times and "economic" only appears 118 times. In the context of sustainable development aligned with the TBL approach, therefore, the attention to the environment seems to have more relevance than social aspects and economic factors.
It is worth noting that the word "short" (with reference to the short food supply chains) never appears while "local" is slightly less relevant than "global". This is interesting because, as previously discussed, the transition to sustainable development has caused a renaissance of short supply chains, typical of the food sector. However, this topic seems to have attracted less attention in the literature than others.

Stemming

Stemming is the process of reducing the form of a word to its root form, called the theme [65]. The theme does not necessarily correspond to the morphological root of the word: it is usually sufficient that related words are mapped to the same theme, regardless of whether or not it corresponds to a valid root of the word in question. Two types of stemmer are provided in NLTK Python library: the Porter stemmer and the Lancaster Stemmer. For the purpose of this document, the Lancaster stemmer performs better compared to the Porter one. Because of

this, the latter is the one that was chosen to conduct the analysis. By looking at the previous result (cf. Fig. 2.18) the words “chain” and “chains” are considered as two distinct terms. Thanks to the adoption of the Lancaster stemmer, these words will be considered as a single word i.e., chain.

2.4.3. N-GRAMS

The essential concept in text mining is n-grams, which are defined by the global collaborative encyclopedia as “a contiguous sequence of n items from a given sample of text or speech” [70]. This represents a set of co-occurring or continuous sequences of n items (n defined by the user) from a sequence of large text or sentences, that is this case is the sum of all abstracts and keywords. The Ngrams classification is made by using tokens i.e., single words are chosen in this case. This results in continuous sequences of words. The same can be performed for sentences for example. The assumption made in this analysis is to study Ngrams by removing both tokens that appear only once and the most commons words in the english language as well (cf. paragraph 2.4.2.2). This choice is made with the intention to study only the most relevant combinations of words used within the data frame.

The most current sequences of words in the abstracts and the keywords (cf. **Figure 23**), address some of the topics already discussed in the previous chapters such as the importance of the CE theory as support for the transition towards Sustainable Development (underlined in orange) as well as the TBL approach (underlined in grey) and specifically the attention towards the environment (underlined in green), the LCA (underlined in light blue), the concept of Corporate Social Responsibility (CSR, underlined in red), the Human Resource Management (HRM, underlined in dark blue) and the Food Waste and Loss Generation (underlined in yellow). The number in **Figure 23** represent the frequency i.e., the number of time that a specific sequence of tokens appears in the document. Because of their importance, all these topics will be discussed in the next chapter.

30 most common stemmed bigrams.

```
[(('supply', 'chain'), 680),
 (('food', 'supply'), 216),
 (('food', 'wast'), 122),
 (('chain', 'man'), 102),
 (('food', 'system'), 65),
 (('food', 'produc'), 63),
 (('environ', 'impact'), 62),
 (('lif', 'cyc'), 60),
 (('sustain', 'supply'), 60),
 (('sustain', 'food'), 58),
 (('food', 'industry'), 52),
 (('valu', 'chain'), 48),
 (('sustain', 'develop'), 44),
 (('sustain', 'perform'), 40),
 (('food', 'sec'), 38),
 (('food', 'chain'), 37),
 (('chain', 'sustain'), 35),
 (('cyc', 'assess'), 34),
 (('agrifood', 'supply'), 34),
 (('soc', 'respons'), 32),
 (('environ', 'soc'), 30),
 (('reduc', 'food'), 30),
 (('food', 'loss'), 30),
 (('circul', 'econom'), 29),
 (('econom', 'environ'), 27),
 (('environ', 'sustain'), 27),
 (('chain', 'food'), 24),
 (('decid', 'mak'), 24),
 (('green', 'supply'), 24),
 (('short', 'food'), 23)]
```

30 most common stemmed trigrams.

```
(('food', 'supply', 'chain'), 192),
(('supply', 'chain', 'man'), 99),
(('sustain', 'supply', 'chain'), 57),
(('lif', 'cyc', 'assess'), 34),
(('agrifood', 'supply', 'chain'), 33),
(('supply', 'chain', 'sustain'), 30),
(('supply', 'chain', 'food'), 21),
(('sustain', 'develop', 'goal'), 21),
(('green', 'supply', 'chain'), 21),
(('short', 'food', 'supply'), 18),
(('reduc', 'food', 'wast'), 17),
(('sustain', 'food', 'supply'), 16),
(('cyc', 'assess', 'lca'), 15),
(('corp', 'soc', 'respons'), 15),
(('food', 'wast', 'gen'), 13),
(('hum', 'resourc', 'man'), 12),
(('food', 'loss', 'wast'), 12),
(('food', 'valu', 'chain'), 11),
(('supply', 'chain', 'memb'), 11),
(('supply', 'chain', 'fsc'), 11),
(('sustain', 'food', 'system'), 10),
(('econom', 'environ', 'soc'), 10),
(('supply', 'chain', 'act'), 10),
(('greenh', 'gas', 'emit'), 10),
(('green', 'hum', 'resourc'), 10),
(('supply', 'chain', 'system'), 10),
(('supply', 'chain', 'sfscs'), 9),
(('econom', 'soc', 'environ'), 9),
(('glob', 'warm', 'pot'), 9),
(('chain', 'man', 'sustain'), 9)]
```

30 most common stemmed fourgrams.

```
(('sustain', 'supply', 'chain', 'man'), 27),
(('short', 'food', 'supply', 'chain'), 18),
(('green', 'supply', 'chain', 'man'), 17),
(('lif', 'cyc', 'assess', 'lca'), 15),
(('sustain', 'food', 'supply', 'chain'), 15),
(('food', 'supply', 'chain', 'sustain'), 11),
(('food', 'supply', 'chain', 'fsc'), 11),
(('food', 'supply', 'chain', 'sfscs'), 9),
(('supply', 'chain', 'man', 'sustain'), 9),
(('sustain', 'agrifood', 'supply', 'chain'), 9),
(('food', 'supply', 'chain', 'food'), 8),
(('supply', 'chain', 'man', 'pract'), 8),
(('along', 'food', 'supply', 'chain'), 8),
(('green', 'hum', 'resourc', 'man'), 8),
(('supply', 'soc', 'respons', 'pract'), 8),
(('corp', 'soc', 'respons', 'csr'), 7),
(('supply', 'chain', 'man', 'sscm'), 7),
(('glob', 'food', 'supply', 'chain'), 7),
(('supply', 'chain', 'food', 'industry'), 6),
(('food', 'supply', 'chain', 'man'), 5),
(('chain', 'food', 'supply', 'chain'), 5),
(('long', 'food', 'supply', 'chain'), 4),
(('supply', 'chain', 'lif', 'cyc'), 4),
(('log', 'supply', 'chain', 'man'), 4),
(('supply', 'chain', 'loc', 'food'), 4),
(('throughout', 'food', 'supply', 'chain'), 4),
(('lif', 'cyc', 'assess', 'sustain'), 4),
(('sustain', 'agricult', 'supply', 'chain'), 4),
(('develop', 'food', 'supply', 'chain'), 4),
(('man', 'sustain', 'supply', 'chain'), 4)]
```

Figure 23 *– Stemmed ngrams distribution.*

2.4.4. Topic Modelling

In NLP, a topic model is a statistical model whose objective is to find the abstract topics contained in a set of documents. The topics are not known a priori but are identified autonomously by the algorithm based on the frequency and number of occurrences of the words in the various texts [65]. According to [71], topic models are built around the idea that in a document there are some hidden, or "latent", variables that could not be directly observable. The purpose of this analysis is to uncover these latent variables i.e., topics that shape the meaning of the entire document. Several topic modeling techniques can be adopted. The most widely used are the Latent Semantic Analysis and the Latent Dirichlet Allocation. Since the explanation of the mathematical models underlying these techniques it not the objective of this paper, it will not be discussed.

The Latent Dirichlet Allocation (LDA)

LDA is a generative probabilistic model that assumes each topic is a mixture over an underlying set of words and each document is a mixture of over a set of topic probabilities [72]. Unlike Latent Semantic Analysis, in LDA model the distribution of topics is based on an a priori distribution called the Dirichlet prior. The idea is that each document covers only a limited set of topics and that in turn, the topics use a limited subset of words [65]. The LDA technique is shown in **Figure 24**. An LDA model is built for ten topics within the collection of abstracts and the related keywords.

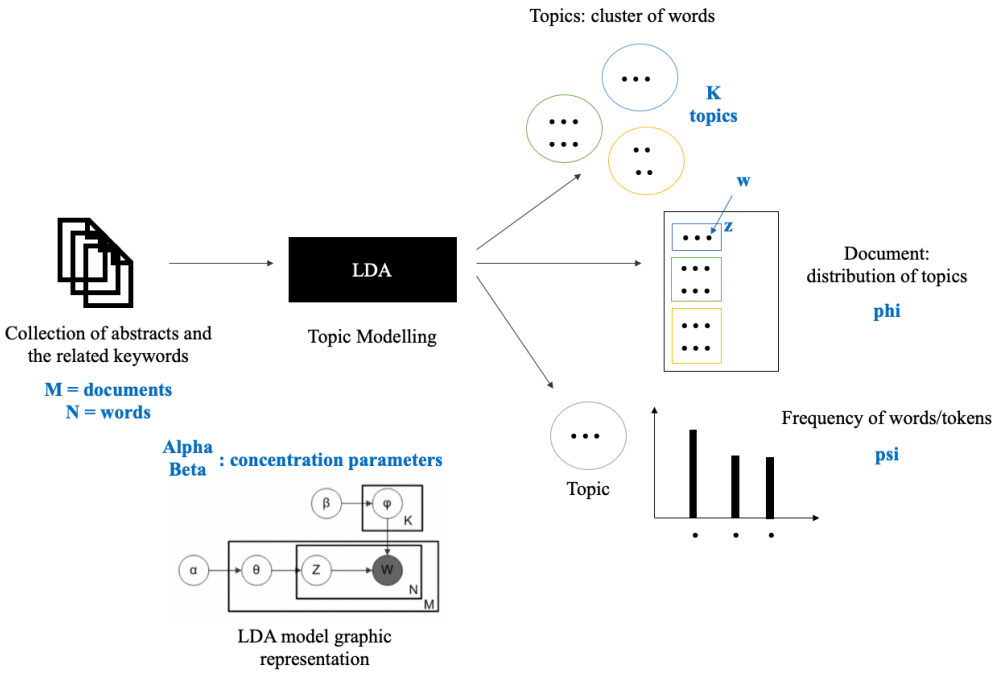

Figure 24 *– Topic modelling: LDA technique. Adapted by [73].*

Finally, *pyLDAVis* is selected to visualize the information contained in the topic model (cf. **Figure 25**). In this mapping:

- Each bubble represents a topic. The larger the bubble, the higher percentage of the documents are about that topic.
- The further the bubbles are away from each other, the more different they are i.e., the more topics are different one to each other in fact, the distance between the topics approximates the semantic relationship between them.
- Blue bars represent the overall frequency of each word in the set of documents. If no topic is selected, the blue bars of the most frequently used words will be displayed.

  Surprisingly, the 30 most salient terms adopting LDA modeling technique are food, supply, sustainability, chain, sustainable, systems, green, study, management, chains, social, distribution, environmental, energy, local, different, system, suppliers, production, logistics, waste, approach, collaboration, blockchain, value, organic, short and emissions.

  Compared to the results previously found (cf. **Figure 23**) the manifestation of the words blockchain and short is interesting. The word short is related to 9 topics over 10 while blockchain is included within 6 topics. Words representing social aspect does not appear among the top-30 most salient terms.
- Red bars give the estimated number of times a given term was generated by a given topic.

- The image below (cf. **Figure 26**) shows that there are about 900 of the word 'food', and this term is used about 400 times within topic 1. The word with the longest red bar is the word that is used the most by the documents belonging to that topic.
- In pyLDAVis visualization it is possible to rank words in topics based on their frequency by varying λ parameter in the range (0,1). Decreasing the lambda parameter, increase the weight of the ratio between the frequency of the terms for that specific topic and the overall frequency of the terms from the set of documents. In simple terms, values of lambda that are very close to zero will show terms that are more specific for a chose topic. That is, the shown terms are important for that specific topic but not necessarily for the whole set of documents. As opposite, values of lambda that are very close to one will show those terms that have the highest ratio. That is, the shown terms are important for that specific topic but not necessarily for the whole set of documents.

Reference for pyLDAvis interpretation: [74], [75], [72], [76].

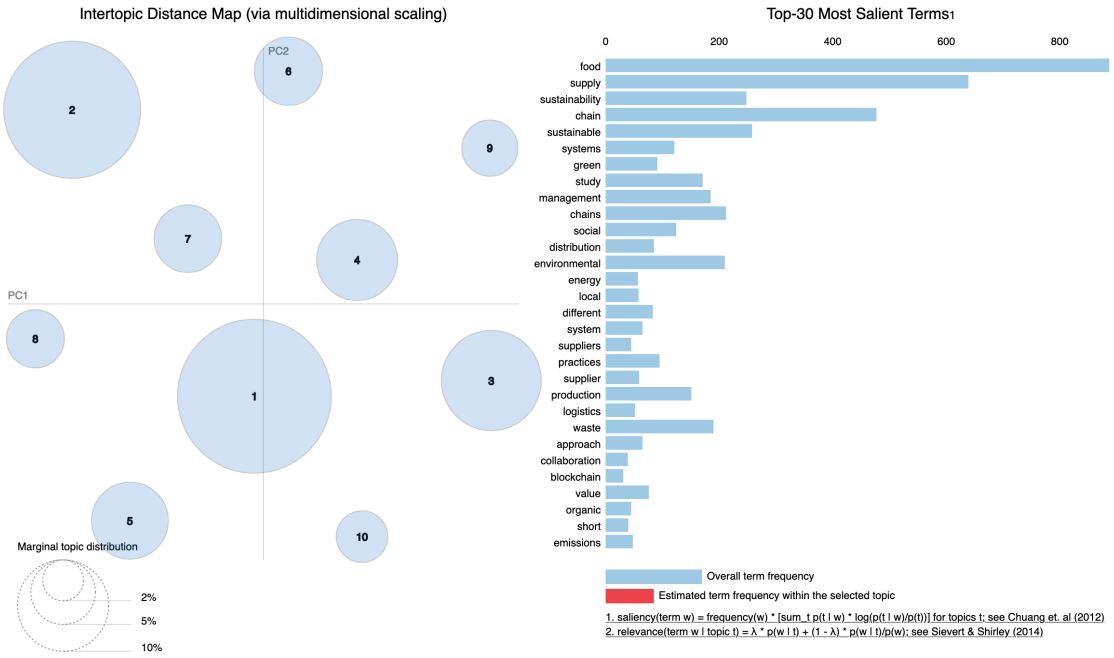

Figure 25 *– LDA model results.*

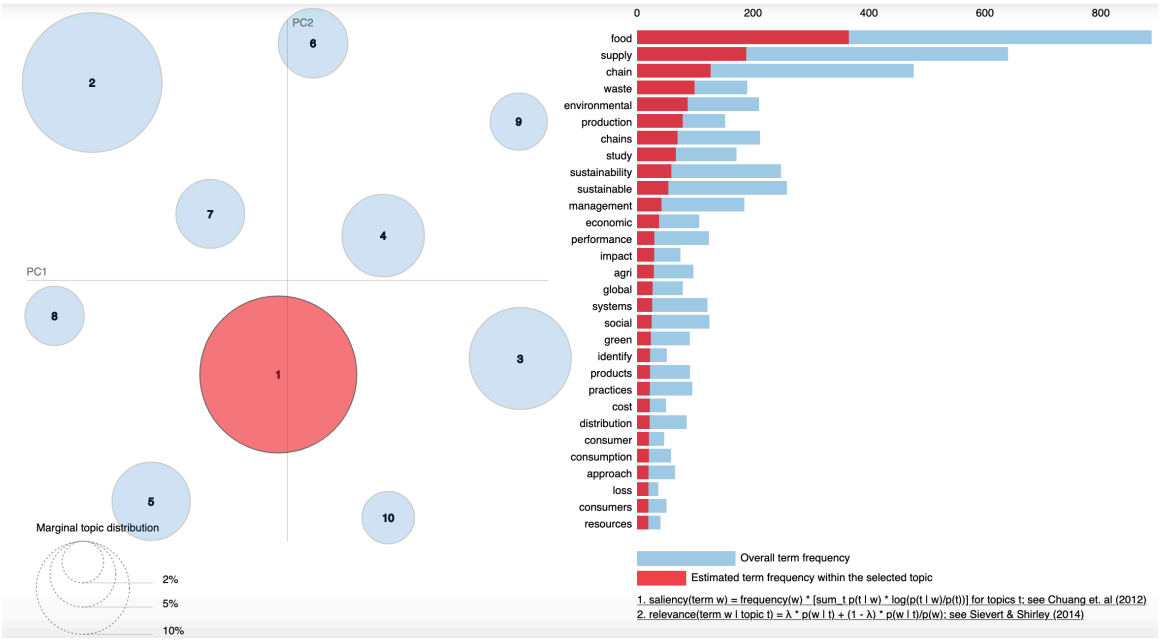

Figure 26 *– LDA model results for the first topic with λ = 1.*

However, topic modeling is generally used to organize a collection of documents into a structured archive without having to read them all. Having performed this analysis after the documents had already been selected makes it difficult to interpret the results obtained. In fact, the outcomes observed through the application of the LDA model are satisfactory in the sense that bubbles i.e., topics, do not overlap each other. Therefore, the algorithm recognizes them as distinct ones. However, they are described by words that made impossible to interpret the result by the human mind, both setting λ parameter equal to 0 or 1. The same can be concluded by performing LSA modeling therefore the results obtained are not displayed and discussed.

3. Sustainable Food Supply Chain Management

Following the description of the key concepts and the lens under which papers have been analyzed, this chapter tries to answer the following questions:

- How a company in the food sector accomplish the need to achieve sustainable development?
- What are the most common practices that a company should implement to reach this goal?

3.1. Sustainability Drivers

As previously discussed, nowadays it is essential that food companies move towards sustainability [8]. Production organizations, whether they want to or not, must commit to thinking about the environment in a sustainable way because there are environmental and social factors called drivers that force them to adhere to sustainability standards. According to Yu *et al.* [62], drivers or motivating factors are the principal reasons for the implementation of sustainable practices in a food supply chain. Drivers can be both internal and external. Internal drivers are studied according to the resource-based view of the firm showing that the unique resources of a firm include all its assets and capabilities, its organizational culture, its attributes, information, and the knowledge it controls. These enable the firm to conceive of value-creating strategies and implement them to improve its efficiency and effectiveness [77], [8]. External motivating factors are dependent on the surrounding conditions so that they force members of the supply chain (suppliers, distributors, and consumers) to have a tendency towards sustainability. **Table 3** provides a classification of the main drivers derived from this literature review. In their work, Emamisaleh and Rahmani [8] conclude that although environmental drivers play a role in the development of sustainability strategies, policymakers, and regulatory organizations must pay more attention to internal ones as the top managers' sustainability thinking has become a necessity to avoid failure in no time.

Table 3 *– Sustainability drivers.*

	Concept	***Definition***
External drivers	Mimetic Pressure	Competitors successfully adopt sustainability initiatives
	Coercive Pressure	Sustainability-related political influences exerted by governmental regulations and/ or firms on which the focal firm depends, such as important customers and a parent company
	Normative Pressure	Collective societal expectations, such as important suppliers, local communities, and NGOs about sustainability.
	Managerial attitude	The attitude of managers to the issue of sustainability

	Concept	*Definition*
Internal Drivers	Top management support	The support of the senior management of the sustainability activities
	Employee motivation	The motivation of employee to participate in sustainability activities of the organization

3.2. SUSTAINABILITY BARRIERS

Waste is considered the biggest barrier to FSC sustainability. As reported in Appendix B, there are plenty of definitions for the concept of Food Loss (FL) and Food Waste (FW). Some authors differentiate the use of these terms based on the supply chain stage in which they occur, some others do not. Moreover, what is considered FW in some parts of the world cannot be identified in the same way in some others. According to Girotto *et al.* [78], FL and FW generation have a huge impact at the environmental, social, and economic levels. Economic impacts are due to the costs related to food wastage and their effects on farmers and consumer incomes [78]. From an environmental point of view, FLW contributes for example to GHG emissions, natural resources depletion, disruption of biogenic cycles due to intensive agricultural activities, and all other characteristics impacts at any step of the SC. The social impacts of FL and FW may be ascribed to ethical and moral dimensions within the general concept of global food security. According to the definition provided by the FAO [79], Food Security [is] "*a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*".

In categorizing the many different approaches dealing with FLW in the FSC, Papargyropoulou *et al.* [23] created the so-called Waste Management Hierarchy, derived from the waste hierarchy defined in European legislation in the Community Strategy for Waste Management in 1989. As noted by Papargyropoulou *et al.* [23], the Waste Management Hierarchy as a framework primarily focuses on delivering the best environmental option. It is generally represented by a reverse triangle. This framework is adopted in this document, to classify the contribution of many authors concerning the most common actions carried out to reduce FWL generation. The result is shown in **Figure 27**. According to this model, prevention that involves reducing or avoiding food surpluses or losses during production and consumption within the FSC is the most desirable form of action while the disposal is in the last level of the hierarchy. This is in line with other frameworks applied in the literature related to the same issue, such as

3Rs i.e., Reduce, Reuse, Recycle. A great deal of research has focused on addressing FWL preventions, while the other levels of the Waste Management Hierarchy seem to be less studied. This can be due also to how papers have been selected. In fact, as already mentioned at the beginning of the second chapter, documents specifically focused on processes to recover energy or produce fuels e.g., anaerobic digestion, are not considered because out of the purpose of this literature review.

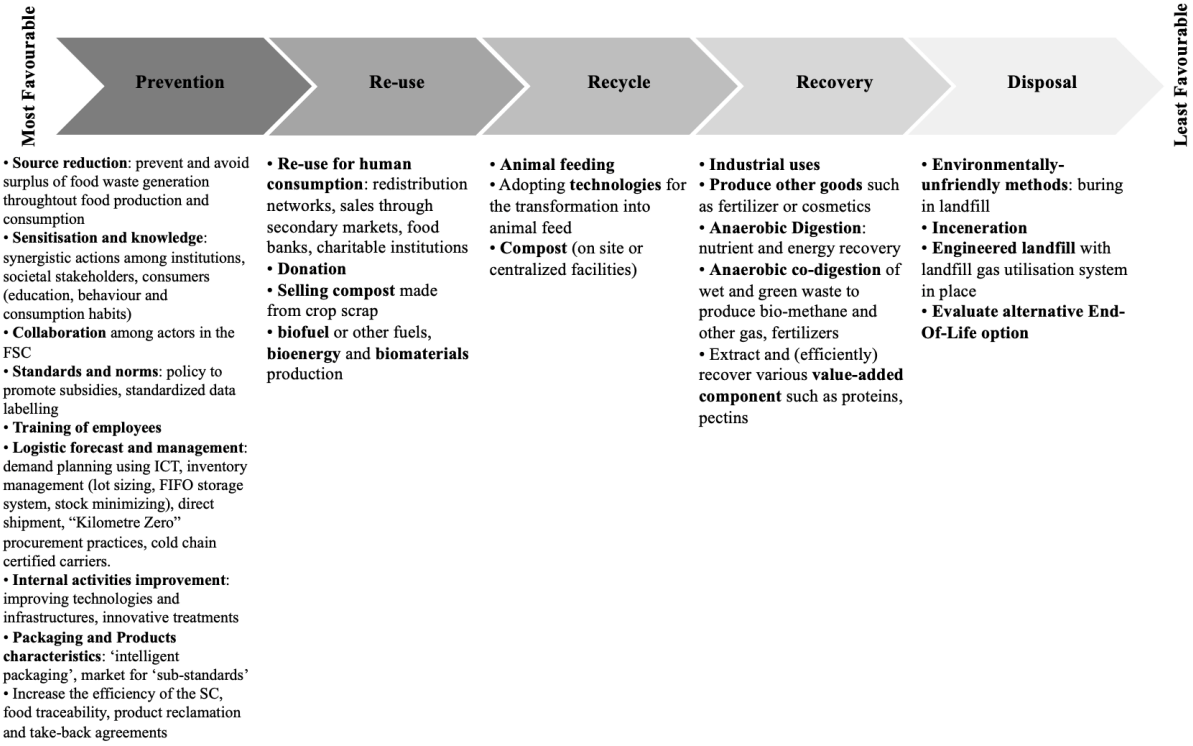

***Figure 27** – The Waste Management Hierarchy.*

3.3. Sustainable Food Supply Chain Management Practices

Balance between social responsibility, environmental preservation, economic prosperity [27] and technological revolution [15] are the key topics that derive from the objectives of achieving sustainability. The concept of corporate social responsibility, that from the abstracts and keywords analysis results as extremely important, underpin the commitment of a corporation to reach the Sustainable Development goal. However, Sustainability in the supply chain management covers all phases of the life cycle of a product, from the raw material extraction to the end-of-life and involves all the actors engaged. The analysis of the literature shows that there is a wide range of practices that companies can pursue to "greening" its whole supply chain. A best practice is defined as: "*Any practice or experience which has proved its value or which is used in an efficient way in an organization, and can be applied in other*

organizations"[3]. A best practice has three characteristics: it is formalized, reusable and effective [24]. The third criteria include the relevance, coherence, effectiveness, efficiency, robustness and sustainability of the value created by the implementation of a practice.

Sustainable SCM practices can be both internal and external. The former refers to the ones without direct supplier or customer involvement which can be managed and implemented by an individual company while the latter describes management practices which need partial cooperation and transactions with suppliers and customers [80].

Sustainable supply chain management practices are identified and classified according to four main dimensions (cf. **Figure 28**) typically considered in dealing with SCM [81], [82]. Sustainable supplier management practices are related to the upstream part of the SC. Sustainable operations practices are described from the perspective of the focal company interacting with suppliers and customers, while some practices typically involve the downstream part of a SC. Finally, some practices overlap multiple dimensions, i.e., transversal practices. Percentages in brackets (cf. **Figure 28**) refer to the relative attention the literature gives to each practice. It is worth emphasizing that, among sustainable supplier management practices, P_1 is widely addressed in the literature, as it is P_3, while less attention is paid to P_2. Green operations practices mostly focus on introducing green technologies or methods that consider processes as a whole (P_6 - P_{11}) instead of the product itself (P_4 and P_5). Less attention is paid to sustainable practices from the downstream perspective, except for P_{14}. Among transversal practices, companies' commitment to sustainable development (P_{18}) and collaboration among SC actors (P_{21} – P_{24}) are widely recognized as the most important practices for achieving sustainability in a FSC. Moreover, great attention is paid to the effectiveness of the adoption of standards and certifications (P_{19}) and information and communication technologies (P_{15}) while P_{17} and P_{19} appear to be less discussed.

3.3.1. Upstream Practices

Voluntary practices that companies pursue to improve their social and/or environmental management of their suppliers' activities can be defined as *sustainable-sourcing practices* [83], [84], [85]. These include two key activities*: Suppliers' Assessment (P_1)* and *Supplier Collaboration (P_2)* [86]. Moreover, this first category includes *Green Purchasing (P_3)* practice. Considering the attention paid to the practices included in this category from the point of view of both the number and the year-wise distribution of the works performed so far, it can be stated

[3] American Productivity and Quality Council (APQC). Available on http:// www.apqc.org.

that these practices are well-established as their importance have been long discussed in literature as support in achieving SSCM (cf. **Figure 29**).

P1: Supplier Assessment. Assessment practices are those activities that enable the firms to evaluate suppliers' sustainability performance [47], [87]. This includes request certifications (independent third-party certifications or private internal standards), conducting audits and supplier monitoring that allow to be sure that some specific practices are being used and ensure adherence to social expectations [88].

P2: Supplier Collaboration. The depth and quality of the relationship between a firm and its suppliers is the most cited facilitator of sustainable supply chain management. In particular cooperation and inter-organizational learning have been shown to improve SC performance [89]. Differently from supplier assessment, supplier's collaboration refers to the supportive activities that seek to improve relationship between the buyer and the supplier such as supplier development programs, corrective actions plan, training, workshops and employees transfer [47] [87]. These processes aim to develop new capabilities and skills [88]. An example is the establishment of formally constituted Suppliers Engagement Programs. SEP are *"formally structured programmes of activity through which a focal company in a supply chain seeks to control or influence the behavior of suppliers through additional engagement alongside any contractually-related arrangements, often based on a two-way flow of information or knowledge exchange"* [25].

P3: Green Purchasing. Green Purchasing means considering environmental concerns along with cost, quality, performance and other traditional factors when making decisions on product purchase from the suppliers, service providers or sub-contractors with the primary aim to reduce and prevent waste and pollution [90], [91]. Examples of actions that should be implemented during all the phases of a purchasing process are increasing supplier diversity, confidentiality, eliminating deception and impropriety, transparency, proper purchasing processes (reciprocity, fairness, no power abuse or special treatment), local sourcing that result in shorter lead-times. Moreover, product price, transportation cost, quality assurance i.e., quality related certifications like ISO9000 and QS9000, the ability to meet delivery schedules or promises as well as the ability to react quickly to customer orders, order fulfillment rate, energy consumption, solid waste generation, air emissions, wastewater treatment, food safety i.e., assess and control hazards in the food production process, environment-related certificates

such as ISO14000, technology as R&D dedicated infrastructures and new designs capability and his corporate social responsibility that is labor relations, suppliers' labor programs, human rights and interests of employees and compliance with local regulations and policies should be considered [90], [92], [84], [83], [93]. Since in the literature the distinction between the terms *Green Purchasing and Green Procurement* is blurry, these terms can be considered as equivalent, as noted by Luthra *et al.* [94].

3.3.2. Sustainable Operations Practices

From the focal company's point of view, the activities implemented to achieve Sustainability are *Green Design (P_4)*, *Green Packaging (P_5)*, *Green Production (P_6)*, *Green Manufacturing (P_7)*, *Materials and Products Recycling and Remanufacturing (P_8)* and environmental management systems activities that is decomposed in *Protection of Animal Welfare (P_9)*, *Soil Conservation and Management (P_{10})* and *Responsible Use of Natural Resources (P_{11})*. It is worth noticing that P_6 and P_7 have gained more attention in recent years with respect to the others (cf. **Figure 29**).

P4: Green Design. Green design or eco-friendly design [95] means conceiving the product by enhancing its biological quality and by reducing its adverse impact on the environment throughout its life cycle [91], [94], [96], [97], [98]. The type of materials used (harmful/toxic), the number of materials and energy required in order to be processed, the end-of-life scenario (reuse, recycling, etc.), the type of storage required during the transport (room temperature/cold storage and storage area [94]) as well as the warehousing phase of a product, must be taken into account during the design phase of the product. It is known also as eco-design [99] and can be assessed by counting for the percentage of product that can be reused (reusability), the percentage of product that is biodegradable, the use of recycling and hazardous materials [9]. Moreover, the packaging required, and its environmental impact should be taken into consideration [100].

P5: Green Packaging. Green Packaging means selecting and using the proper material, size, and shape of packaging that, in turn, reduce damage deriving from handling, transportation, and other logistic processes, helps efficient inventory management and prevent the waste of food (e.g., better portion sizing, resale opportunity, empty-ability or clearer expiration information) [101], [102]. The packaging issue is a key topic in the food industry. In fact, foodstuffs require primary, secondary, and tertiary packaging solutions to limit the

phenomena of oxidation and water activity, which would generate a rapid decay of the shelf life and trigger the phenomena of bacteria growth affecting food safety [4]. The use of modified atmosphere packaging and vacuum and skin packs [103] can extend the shelf life of fresh products.

Moreover, biodegradable packaging or bio-based plastics [104] are the alternatives of the traditionally used plastics (PE or PET). In addition, the use of reusable (plastic) packaging provides ecological, social, and economic benefits [84]. It should be noticed that the use of reusable packaging containers requires dedicated reverse logistics with rising logistics costs, complexity, and environmental emissions. However strong reduction in the raw packaging material use occurs saving resources and preventing waste from incineration or landfilling [105], [106].The inputs or opinions taken from the suppliers or vendors contribute to greening the supply chain by standardizing the packaging [94]. In addition, the packaging must contain clear information on how to dispose of the materials and how to recycle them [104].

P6: Green Production. The term Green Production encapsulates all the environmentally friendly methods i.e., with the intent to reduce the environmental burden, adopted at the agricultural or primary stage within a food supply chain (e.g., grass-fed beef, free-range poultry, certified organic food) [107]. Organic farming is one of the best ways to lower the environmental impact associated with the production stage and to achieve a sustainable system [108]. In the organic farming system, some production protocols are adopted to preserve the fertility of the land and the hydrographic ecosystem, maintain traditional methods of cultivation by giving priority to the use of manual or mechanical methods and avoid the use of chemicals as fertilizers or pesticides as much as possible. Because of that, it promotes practices such as crop diversification and organic fertilizers [109], [110], [111]. The benefits provided by adopting an organic agriculture system can be identified both in the short and long term. It contributes to the conservation of the natural environment, animal welfare, and rural development. According to Naspetti *et al.* [112], another innovation in sustainable production is agroforestry that implies integrating livestock farming and trees in the same part of the land used for crops [113].

P7: Green Manufacturing. Green manufacturing, green processing, or sustainable manufacturing are equivalent terms used to describe the set of actions carried out during the processing stage that seeks to lower the environmental impact. This can be achieved for example by employing efficient technologies that are using emission control systems to control

greenhouse gases and waste generation in order to reduce unsafe emissions and waste, and lessening consumption by reducing the utilization of energy and raw materials [91], [94]. Moreover, green technologies in food processing can be introduced with the aim to control microbial formation. These are for example microwave and radio-frequency heating (MW/RF), pulsed electric fields (PEF), high-pressure processing (HPP), ionizing radiation, ohmic heating (OH), treatment with ultraviolet light [113]. The term green technologies mean "*the application of one or more of environmental science, green chemistry, environmental monitoring and electronic devices to monitor, model and conserve the natural environment and resources, and to curb the negative impacts of human involvement''* [113]. The monitoring of keys indicators could help to achieve a sustainable manufacturing system [114], as well as the development of lean manufacturing solutions [4].

P8: Materials and Product Recycling and Remanufacturing. Recycling is the process of converting food wastages into new materials. According to the Food Waste Management Hierarchy this process involves the following two main practices i.e., recycling food into animal feed and via composting [23]. Product recovery and remanufacturing refers to all activities aimed at extract and efficiently recover value-added components from waste. These are discussed in the previous paragraph in the fourth step of the Food Waste Management Hierarchy framework.

Integration of Environmental Management Systems

Environmental management systems can be defined in a general way as the set of activities aimed at preserving the external environment and increasing the operational efficiency of a company. This includes practices that seek to reduce energy consumption, emission, waste, water, and air management. Plenty of actions are found in literature. A possible classification is:

- ***P9: Protection of Animal Welfare,*** elimination of cruelty, safe handling, housing, processing, and transport [84], [15].
- ***P10: Soil conservation and management***, conservation of forest and species, prevent soil erosion and pollution, prevent loss of arable land and biodiversity, responsible farming methods (reducing fertilizer and pesticides, compliance with the European directive on the sustainable use of pesticides and the mandatory application of pest management [115]), elimination of contaminant and pollutant agents, integrated crop management schemes

[84]. In addition, other activities are the absence of mineral fertilization, soil sampling, pH management, eco-friendly tillage practices, reduced application of agrochemicals [116].

- ***P11: Responsible Use of Natural Resources,*** deployment of systems that aims to reduce water consumption, efficient water use, wastewater reuse, and recovery [84], for example, micro-irrigation grants uniform distribution of water and allow relevant water-saving [115], installing renewable energy sources and lowering fossil-fuel consumption [117].

As already discussed, to quantify the impacts on the three dimensions of sustainability that in turn helps to provides a detailed analysis of where all the resources are spent and their corresponding effects, the main methodology currently deployed are MCDM techniques and in the specific case of the food sector, the most widely adopted relies on the life cycle thinking approach (cf. Appendix D).

3.3.3. Downstream Practices

This cluster of activities includes *Inventory Management (P_{12})*, *Green Warehousing (P_{13})*, *Green Shipping and Distribution (P_{14})*, *Reverse Logistics (P_{15})*, and *Corporate Green Image Management (P_{16})*.

Logistic is a function that is contained within SCM operations [118] and is defined by the Council of Logistic Management as "*that part of the supply chain process that plans, implements, and controls the efficient flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customers' requirements*" [119]. This includes transportation, warehouse, and inventory management. A short discussion about eco-logistics practices is provided in the following.

Eco-Logistic

According to [4], eco-logistics can be defined as the cluster of activities i.e., plan the purchasing and consolidation of raw materials by the strategic and operative perspective, distribution towards final consumers/customers, reverse flow of packages due to post life treatments in agreement with shelf-life constraints, that takes in consideration the impact on the environment in addition to the costs. A prominent role in green logistics is played by the digital-based techniques that help to monitor the whole process and ensure the quality and safety of agricultural products as well as reduce losses, such as RFID, GPS, GIS, EDI systems, information systems for cargo tracking and inventory management [120].

To connect small-scale producers with retailers, a new model of community-based organizations focused on improving local access options more than economic profits has

become popular in recent years [43], [118], that is the agro-food hubs. An agro-food hub is "*a business or organization that actively manages the aggregation, distribution and marketing of source-identified food products primarily from local and regional producers to strengthen their ability to satisfy wholesale, retail and institutional demand[s]*" [121]. Therefore, this results in enhancing environmental sustainability by reducing the carbon footprint, as well as affecting economic and social sustainability by creating jobs for the community [122].

P12: Inventory Management. Inventory management means monitoring and deciding how much inventory to stock, what is in stock and how inventory should be stored. According to [118], inventory management practices to reach sustainability include warehouse inventory management systems that relies in the adoption of electronic marketplaces (e-sourcing) and MRP system that can assist in making efficient long-range demand planning, purchasing, scheduling, and inventory management decisions; the use of inventory tracking systems, matching supply with demand through demand forecasting methods, improving supplier reliability and collaborative inventory management.

A collaborative inventory management practice that supports the transition to sustainability is known as Vendor Managed Inventory. VMI refers to "*a collaboration between a vendor and its customers in which the vendor takes on the responsibility of managing inventories at customers* [123]". VMI policy is a win-win approach as suppliers can better coordinate deliveries to customers and in turn, they do not have to manage their inventory. This allows to reduce logistics cost, energy use or emissions, and waste [124], [125].

P13: Green Warehousing. According to Amjed and Harrison [126], a warehouse is "*a distribution center where a specific location, a building or a logistics service center which is used for storing goods from inbound and for outbound as well as used for many other functions ranging from distribution and composite storage*". Warehouses are normally handling not only storage yet provided various types of value-added services depend on the operation of the warehouse. To practicing green or sustainable warehousing, the following activities should be implemented [127]:

- *warehouse facility design*, the location of the warehouse facility should be designed to minimize transportation time, expense, and emissions. Regional food aggregation facilities should be located near major transportation routes and as close to customer bases and growers as possible, particularly when handling perishable goods [118].

- *warehouse layout*, Facchini *et al.* [29] investigate the optimal solution in terms of carbon footprint and related costs in warehouse activities taking the longitudinal, transversal, and fishbone configurations as models. They conclude that economic and environmental sustainability are optimized when the warehouse layout is fixed over time. This is strictly related to the turnover index of the stored goods and if for long SC this seems not to be a problem when comparing it to the short one, the seasonality of the stored goods becomes a relevant issue. In fact, seasonal fruit and vegetables carry different turnover indexes and the sustainability of the performance is subjected to change over the seasons.
- *inventory management*, FEFO (First-Expired First-Out) vs. FIFO (First-In First-Out) policies are the most suited to manage foodstuffs.
- *warehouse staff*, training programs should be implemented for workers.
- *mechanical handling equipment*, examining the energy usage in the forklift material handling should be considered for minimizing the environmental impact of the warehouse activities [29].

P14: Green shipping and Distribution. Green shipping and distribution involve the set of choices targeting the reduction in the consumption of oils products and other forms of energy used during this process. It involves using the less polluting mode of transportation like shipping, rail, or combined transportation e.g., railroad, sea-road to reduce GHGs emissions, pollution, and fuel consumption as well as use backloading opportunities to reduce empty returns. For the transportation of the produce in cold storage, eco-friendly refrigerants need to be used which contribute to reducing global warming and provide a positive brand image to the company [94]. Transportation can also be scaled back by limiting warehouses on the provision chain and reducing the traffic volume [91], [84] or by improving the vehicle load rate carrying goods on return trips, rather than returning with empty trucks. This practice is known as backhauling [118].

In addition, another solution to improve load rates and product traceability as well as reduce customers' costs and eliminate the need for suppliers to invest in information infrastructure, can be outsourcing the management of the shipping and distribution activities to a third-party logistics provider (3PL). A 3PL is an external provider who manages, controls, and delivers logistics activity on behalf of the shipper [118], [128].

P15: Reverse Logistics. Reverse logistics can be defined as the process of handling and collecting all the returned end-of-life equipment, materials, products, or components from end-

user back to the point of origin to be recycled, reused, reconditioned, refurbished, repaired, or disposed [4], [91], [94], [129]. This could lead to the creation of a closed-loop network [130] (cf. Paragraph 1.3.3). Since for perishable food products the life cycle ends with the consumption, the reverse logistics system in FSC tackles the main issue of packaging collection, consolidation, and recycling. The return flow of materials involves the collection activity of product/packages at collection centers or retail outlets, the transfer and consolidation at centralized distribution centers, and finally the recovery of return products/packages [4].

P16: Corporate Green Image Management. The implementation of environmentally friendly activities of a firm from the point of view of various stakeholders such as NGOs, governmental organizations, suppliers, and customers is conceptualized under the term of green image. According to [94], it has become essential for companies to implement green practices in their business activities to sustain the competition in the market. In fact, the green image of a firm in today's businesses provides a strong competitive advantage.

3.3.4. TRANSVERSAL PRACTICES

The activities that make up the bottom of the model are *Green Product Innovation Design (P_{17}), Corporate Social Responsibility Programs (P_{18}), Green Human Resource Management (P_{19}), Adoption of Standard and Certifications (P_{20}), Collaborative Supply Chain: Information (P_{21}) and Green Targets (P_{22}) planning, Strategic Supply Chain Collaboration (P_{23}), Supply Chain Integration System (P_{24}) and Adoption of Information and Communication Technologies (P_{25}).* Based on the resulting frequency distribution of the keywords and the abstract processing, discussed in the second chapter (cf. Paragraph 2.4.4), although the concept of Corporate Social Responsibility and Green Human Resource Management are treated as practices, these seem to be more relevant than the others in the transition towards sustainability.

P16: Green Product Innovation and Design. The terms Green Innovation of Eco-Innovations define any activities of an actor (manufacturer or supplier) that result in new ideas or improvement addressing some specific sustainability targets or reducing environmental burden [131], [132]. Product innovation and design refers to the introduction of- or improvement to obtain- environmentally friendly products. According to Piedra-Munoz *et al.* [133], green product innovation is strictly related to market eco-innovation that refers to changes in product presentation, sales placement, communication, new methods of delivery,

promotion, or pricing strategies. Moreover, significant green changes in packaging are also considered important marketing eco-innovations.

P17: Corporate Social Responsibility Programs. An initial step toward achieving holistic sustainability objectives lies in a corporation's orientation toward sustainability. The set of voluntary initiatives carried out by a company to address social or environmental challenges in their own operations or in neighboring communities is known as Corporate Social Responsibility (CSR) [134], [135], [83]. There is no single, commonly accepted definition of the concept of CSR (Appendix B), as this term covers a variety of theories and practices to underline *"(i) that companies have a responsibility for their impact upon society and the natural environment, sometimes beyond legal compliance and the liability of individuals; (ii) that companies have a responsibility for the behavior of others with whom they do business (e.g., within value chains); and (iii) that business needs to manage its relationship with wider society, whether for reasons of commercial viability, or to add value to society"* [136], [137]. By observing the yearly paper's distribution, not surprisingly P17 appears to be one of the first discussed in the literature (cf. **Figure 29**).

In their own operations, a company specifies its sustainability commitment by setting up Corporate Sustainability Standards (CSS) which commonly comprise statements and policies to comply with legal requirements, many times incorporating aspects that exceed regulatory requirements [47], [138], [139]. Any party in the SC that does not comply with CSS can damage the image of a firm. Examples of CSS include the adoption of certifications established by NGOs or individually defined CSS that are specific to corporations such as *Ethical Code* [140], *Code of Conducts* [47] [137], *written environmental objectives* [94] [94] [137], that defines the moral responsibility of each figure who contribute to the firm's action. Social reports or environmental balance sheets are then written with reference to the company's sustainable behavior [140].

According to [15], the CSR of a company focus should be:

- *Health and Safety*: improved product quality, food safety, food security, traceability, and transparency. Promotion of healthy lifestyles and local food sources [84].
- *Work and Human Rights*: better working conditions that result in higher levels of motivation and productivity and less absenteeism. Training, education advancement. Regular employment, elimination of illegal and child labor, respect of worker rights, gender equality, freedom of association, safe working conditions [84].

- *Community*: donation, collaboration with NGOs, philanthropy, support to economic development in local communities, educational practices, health care, job training, volunteering, childcare [84].

P18: Green Human Resource Management. The 'green version' of Human Resource Management to drive Sustainable Supply Chain Management makes up the concept of Green Human Resource Management. GHRM seeks to spread green values and culture within organizations, and it is considered as a valid mechanism that can be used by firms to enhance SSCM implementation which in turn can positively influence their sustainable performance [80]. GHRM bundle include:

- *Green Teams*, with the aim to engage the workforce in environmental management, a company can create teams of people that work together to solve environmental problems. The final aim is to generate ideas and foster environmental learning [141].
- *Green performance appraisal*, managers are held accountable for their performances such as environmental incidents, communication of and engagement in the company's environmental policies [141], [142].
- *Green Performance Management and Compensation*, employees are compensated on the basis of their "green" performances [142]. This can be achieved by setting environmental target objectives and, on the basis of their fulfillment, rewarding both managers and employees with monetary or non-monetary benefits [80].
- *Green Training and Involvement* i.e., organize ecological training for managers and employees with the aim to educate the workforce about their environmental responsibility. This includes training them in working methods that conserve energy, reduce waste, diffuse environmental awareness within the organization such as the 'paperless office' initiative, and provide opportunities to engage employees in environmental problem-solving [80], [142], [141].
- *Green Hiring or Green Recruitment* describes the process of hiring individuals considering both company's environmental criteria and their environmental commitment. Environmental responsibility can be a part of the work description [80], [142].

P19: Adoption of Standard and Certifications. Compliance with standards and certifications is a key point across the whole supply chain. They play a role in supplier selection, internal business management, and from a market perspective. Essentially the

adoption of standards and certifications is used as a demonstration that products or processes are carried out according to environmentally friendly methods and by respecting social criteria. At the retail level and as part of green purchasing and/or green sourcing, green market development is based on two market tools: *third-party certifications* or *eco-labels* and private *eco-branding* [143], [91], [144], [94]. However, the distinction between these two market instruments became increasingly blurred as more retailers launched private eco-branded products backed up by third-party certification schemes [145], [146]. Eco-branding aims to capture higher market share through means of product differentiation based on sustainability attributes. The work conducted by Chkanikova [143] demonstrates that the mechanism of private eco-branding helps to lower the sourcing price of products, thus contributing to the cost-effectiveness of greening the food supply chain. Like other certification schemes, labels attempt to solve asymmetric information problems by signaling that the product or its process has some intrinsic quality that is otherwise difficult for the consumer to observe [144]. As a result of their study, Asche *et al.* [144] underline that the price premium that derives from eco-labeled products can only be assessed when accounting for the fact that individual retailers charge different prices for eco-labels.

On the consumption side, these tools connect the consumer with the producer, allowing more sustainable choices to be made [23], [147], [148]. Eco-labels and eco-brands lead to change consumers' behavior towards purchasing environmentally friendly and ethical products and facilitate corporate ability to influence sustainability upstream in the supply chain. With the intent to provide information about the sustainability of a product as well as the circumstances under which goods are produced, eco-labels and eco-brands are considered as one of the most prominent traceability systems [148]. **Table 4** provide a short summary of the most recurrent standards and certifications discussed in literature.

Table 4 *– Standard and certifications.*

Name	***Description***	***Lit. support***
	NGOs led standards	
ISO 14000	Focuses on the environmental impact of the firm's activities.	[140] [91] [94] [137] [149]
ISO 9000	Describes the fundamental concepts and principles of quality management which are universally applicable.	[91] [94] [88]
ISO 26000	A guide to all types of organizations on concept, terms and definitions related to social responsibility.	[140], [88] [149]
ISO 22000	Focuses on food security. It sets out the requirements for an effective food safety management	[81]

SA 8000	Supports CSR policies based on compliance with the main international conventions on human rights and freedom. Nine key dimensions are considered.	[140], [88] [149]
BS OHSAS 18001	Concerns workers' safety conditions.	[140]
	Production standards and labels	
GlobalGAP	Third-party sustainability certification developed through collective efforts of British and European retailers. "compliance criteria for all stages of production, from pre-harvest activities such as soil management and fertilizer use to post-harvest activities like packing and storing."	[150], [151]
Fair Trade	Originates from the Dutch Max Havelaar certification scheme for coffee. Require a consistent adherence to underlying sustainability requirements and traceability up to the raw material production.	[87], [148]
Flandria quality label	Includes requirements on (i) cultivation practices such as planting material and fertilizers used; (ii) quality standards such as the shape of the product and the absence of foreign products; and (iii) traceability and control in order to be able to trace each product from the soil to the consumer	[150]
MSC - Marine Stewardship Council	Label that certifies fisheries according to three principles i.e., sustainable fish stocks (avoiding overfishing), minimizing environmental impact (e.g., limit destructive fishing gear and bycatch), and effective management. Other Stewardship Council labels are: *FSC - Forest Stewardship Council* and *ASC - Aquaculture Stewardship Council.*	[144]
Geographical Indication scheme (GI)	Protected Designation of Origin (PDO): Every part of the production, processing and preparation process must take place in the specific region (e.g., all ingredients used must originate from a specific region and the PDO product will be made in this same region).	[152], [153], [116], [115]
	Protected Geographical Indication (PGI): For most products, at least one of the stages of production, processing or preparation takes place in the region (e.g., some ingredients used may not originate from or be sourced from the region where a PGI product is made).	[152], [153]
Others: Organic label, Round Table on Responsible Soy (RTRS), Round Table on Sustainable Palm Oil (RSPO)		

Collaboration

Collaboration within a SC is recognized as one of the most important practices to achieve sustainability. Value Chain Collaboration is defined as the "*voluntary associations between different actors in the chain that increasingly involve non-chain actors such as non-*

governmental and (in the case of public–private partnerships) governmental organizations that aim to integrally address multiple objectives in the landscapes in which these chains are embedded" [154]. Trust and cooperation are at the base of all supply chain activities implemented in collaboration. Many authors discuss the collaborative values and actions implemented in a Food SC. According to [155], collaboration is a common way for companies throughout the SC to share information, make strategic alliances, and reduce overall costs, also in terms of sustainability. To this extent, this involves, but it is not limited to, collaborative supply chain planning actions, strategic supply collaboration, and supply chain integration system.

P20-P21: Collaborative Supply Chain: Information and Green Targets Planning. To design sustainable supply chains, there is the need to involve upstream and downstream supply chain partners to share planning information (exchange relevant, complete, accurate, and up-to-date SC information and knowledge), that can be achieved by arranging inter-organizational meetings [155] and by working together with partners to reduce environmental impacts [156]. Such as collaborate with suppliers and customers to develop products according to eco-design principles, for green packaging decisions and cleaner production initiative. In addition, collaborative activities can be carried out to reduce energy consumption during the transport of products and make joint decisions with other members of the supply chain regarding ways to reduce the overall environmental impact of products and resolve environmental issues [91], [80].

P22: Strategic Supply Chain Collaboration. Strategic alliances are "*purposive, substantive, and sustainable relationships between independent organizations*" [157]. These are established to achieve mutually relevant benefits, which can be technical, financial, and strategic through the exchange, sharing, and co-development of resources and capabilities. Policies and strategies have to be reformulated for encouraging actors within a SC to share GSCM targets [94].

P24: Supply Chain Integration System. Collaboration can be vertical or horizontal, to reduce or increase the profit, fulfill the quality assurance, and as the result gaining the trust of consumers [158]. Examples of collaborative SSC activities are collaborative waste reduction, environmental innovations, adoption of environmental technologies, and joint development of recyclable products [50].

Finally, collaboration is a practice historically well known to farmers. According to Lutz *et al.* [159], it can be informal such as farmers sharing machinery, agricultural know-how, and helping one another at times of high workload. Informal cooperation can also be expressed through informal farmer cooperatives which are arrangements in which one farmer brings the products of other farmers to the market and sells them without a surcharge. The incentive is that each farmer's products become more attractive because they are marketed alongside a wider range of other local products. Furthermore, to reduce costs, farmers can implement unstructured and informal collaborative transport agreements based on trust rather than formal contracts. In recent years, with the upscaling of local food supply systems, farmers are facing the need to formalize their collaborations [160]. The most relevant example is the foundation of agricultural cooperatives, enterprises that are essentially user-owned and user-controlled and that distribute benefits fairly on the basis of use or membership [159]. Moreover, farmers have increasingly started to join and form local, civic, or alternative food networks such as Community Supported Agriculture (CSA) or solidarity purchasing groups.

P25: Adoption of Information and Communication Technologies. The use of new information technologies has a significant impact on supply chain sustainability [161], [162] and it appears to be a very recent field of study (cf. **Figure 29**). The results of the work conducted by [161], reveal the need to introduce technological innovations that improve logistics and the management of the entire supply chain. Moreover, many studies pointed out that the emerging information and communication technologies play a vital role in FSC [163] since the main problems in current food supply chain are high perishable products [4], inefficient traceability, information asymmetry, information fraud, poor supply chain management, central power authority on the information flow, communication and coordination among actors in a supply chain, unpredictable supply variations, food safety requirements etc. In addition, tracking and authenticating the information throughout the whole food supply chain can improve consumers' trust and purchase willingness and promote the shift toward a more sustainable food chain [164], [165]. The impacts of adopting ICTs in the food industry are summarized in **Table 5**. According to [4], there are two main categories of traceability technologies and devices: identification tags (i.e. *barcode, label, RFID (Radio Frequency Identification) tag, GPS devices*) which address products, or "*black boxes"* also known as *"data loggers"* devices which reproduce and simulate ex-post real environmental conditions experienced by the products and packaging along the food chain.

Many authors identify, among others, the adoption of *blockchain* as a feasible solution to solve the problems mentioned above. A blockchain is a distributed database of records in the form of encrypted blocks of all the transactions or digital events that have been executed and shared among parties and can be verified at any time in the future [161]. The main features of blockchain technologies, once used properly, are decentralization that brings transparency, immutability, security, and smart contract [166], [167]. The final aim in deploying this solution is to record transactions, tracking products, and build trust among the actors involved [168].

Table 5 *– Impact of ICTs on TBL. Adapted by [162].*

Sustainability Dimension	***Positive Impact***	***Negative Impact***
Environmental	• increasing efficiency of the use of resources and inputs • reducing footprint and negative environmental externalities • decrease GHG emissions • reducing food losses and waste	• generating e-waste and disposal of ICT equipment in rural areas
Economic	• reducing production, transport, and distributions costs • increase productivity and profitability • reducing transaction costs • connecting small-scale producers to markets	• initial investment • risk of market dominance by few multinational
Social	• increase transparency • easier access to information by all actors • improve traceability/food safety • fostering networking	• disconnecting producers and consumers • increasing dependency on technology • increasing the power of globalization • exclusion of small-scale computer illiterate producers

Moreover, the importance of e-commerce is underlined by many authors. Especially for Small and Medium Enterprises (SMEs), it represents an opportunity for business expansion, cost reduction, and demand enhancement [157], [169]. In fact, pick-your-own operations, viewed as sustainable offline marketing for farmers and SMEs, can bring more profits when combined with the online market [170]. In addition, according to [153], e-commerce is recommended as one of the best practices for smallholders in combating COVID-19 related market access restrictions.

Upstream	Focal Company	Downstream
P1. Supplier Assessment (10.9%) P2. Supplier Collaboration (2.2%) P3. Green Purchasing (5.5%)	P4. Green Design (3.3%) P5. Green Packaging (2.8%) P6. Green Production (5.5%) P7. Green Manufacturing (5.1%) P8. Material and Product Recycling and Remanufacturing (8.6%) P9. Protection of Animal Welfare P10. Soil Conservation and Management P11. Responsible Use of Natural Resources *Integration of Environmental Management systems (8.3%)*	P12. Inventory Management (1.3%) P13. Green Warehousing (2.0%) P14. Green Shipping and Distribution (4.9%) P15. Reverse Logistics (2.0%) P16. Corporate Green Image Management (0.2%)

Transversal Practices

P17. Green Product Innovation and Design (1.2%)
P18. Corporate Social Responsibility programs (10.8%)
P19. Green Human Resource Management (2.2%)
P20. Adoption of Standard and Certifications (5.8%)

Collaborative practices (10.2%)
P21. Collaborative Supply Chain: Information Planning
P22. Collaborative Supply Chain: Green Targets Planning
P23. Strategic Supply Chain Collaboration
P24. Supply Chain Integration System
P25. Adoption of ICTs (7.3%)

Figure 28 *– Sustainable Supply Chain Management Practices.*

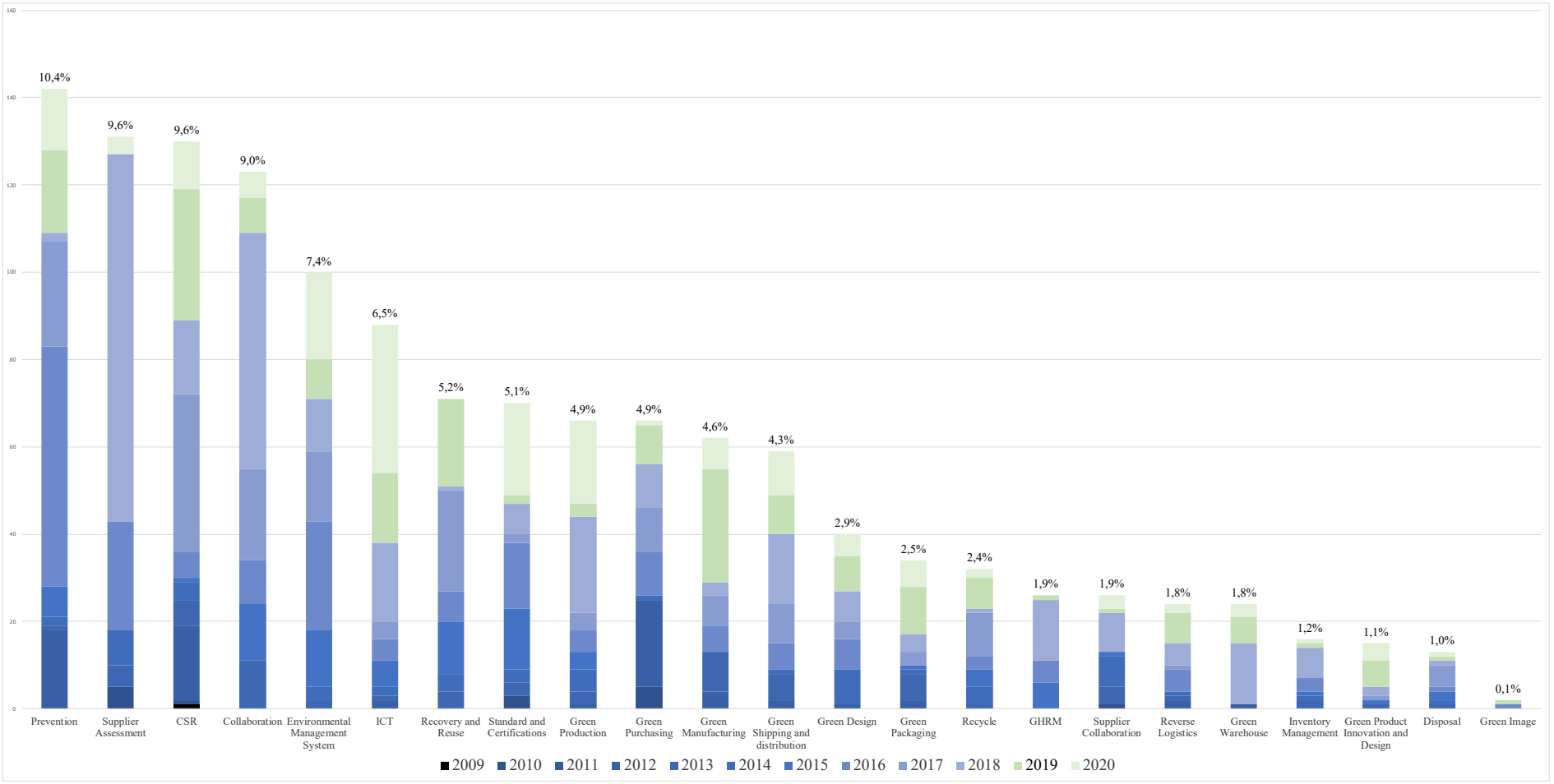

Figure 29 *– Year-wise distribution of the practices and their relative importance.*

4. Conclusion To The First Part

Based on this first part of the document, some important conclusions can be drawn. First, although the concept of Sustainable Development was introduced some time ago, the transition to reach Sustainability remains an increasing challenge, at least in the food industry. To date, the food industry has not yet been analyzed in depth compared to other sectors. In fact, the first study found through the queries is dated 2008. Moreover, during the pandemic, along with the drug industry, the food industry gained crucial importance worldwide. Thus, it deserves specific studies and analysis. The set of documents collected allowed us to frame the problem in-depth. Through a detailed analysis of the scholarly papers, key concepts are discussed in the first two chapters. Among them, the TBL approach and the circular economy principle can be considered as the milestones of the transition to sustainability. The former results in the creation of SSCs or GSCs, while the latter aims at the establishment of closed-loop networks. Moreover, the renaissance of short supply chains in recent years seems to have a prominent role in this transition in the food industry. To support the transition towards sustainable development, collaboration among FSC actors is a key requirement.

Finally, the third chapter reveals the drivers and barriers that a firm faces in the transition to reach sustainable development and the practices that companies in this sector can and should carry out to ease the alignment with sustainability models and SDGs. A total of twenty-five main practices has been identified, classified, and discussed. Thus, the first part of this work provides a novel SCM practices summary obtained via a systematic literature review as a precise approach methodology able to identify the most important research trends.

This represents the starting point for the discussion in the second part of this document that aims to discover the activities currently implemented in the food sector that lead to preserve the natural environment while enhancing the economic benefits and that are socially responsible. In fact, none of the studies proposed in the literature allows us to determine their degree of implementation and impacts, if any.

PART 2 – SUSTAINABLE FOOD SUPPLY CHAIN: EMPIRICAL ANALYSIS

The second part of this study attempts to empirically assess which are the most popular supply chain management practices in food companies, which practices a firm should implement as first to successfully manage its supply chain, and what is the impact of supply chain management practices on the TBL dimensions. The main purpose is then to investigate which are the best practices currently implemented in the food industry to achieve Sustainable Development. In fact, from the conducted literature review many practices have been identified as suitable to achieve sustainability in a supply chain. Specifically, in the third chapter a list of twenty-five practices, those most frequently reported in scientific research, were described. This represents the starting point of our analysis. The empirical analysis conducted relies on survey and statistical methodologies. The former is adopted as a method to collect the data and the latter as a procedure to analyse and interpret the data gathered. The second part of the document is structured as follows:

- *Chapter 5 – The survey*, intends to discuss how the survey is designed to conduct this analysis and which key points are selected for empirical evaluation.

- *Chapter 6 – Research method,* describe the descriptive and inferential statistics techniques employed to evaluate data.

- *Chapter 7 – Sample characteristics,* provide an in-depth description of the sample characteristics, necessary to contextualize the results obtained.

- *Chapter 8 – Research hypotheses and discussion,* research hypotheses are derived, analyzed, and discussed.

- *Chapter 9 – Critical analysis of the results*, provides a summary of the most important results obtained from the empirical analysis carried out.

5. THE SURVEY

As a result of the literature review conducted, it is evident that surveys are a widely adopted technique in scientific research. Survey research generally relies on questionnaires or interviews sometimes combined with direct field observations. In fact, survey research is defined as *"the collection of information from a sample of individuals through their responses to questions"* [171]. According to Visser *et al.* [172], survey research is a specific type of field study that involves the collection of data from a sample of elements drawn for a well-defined population using a questionnaire. This instrument, based on different sets of questions, serves four functions: data collection from respondents, lends a structure to interviews, provides a standard means for writing down, and helps in processing collected data [173]. Developing a good survey is critical to the success of the research conducted because ambiguous questions, inappropriate wording, the length of the questionnaire, or the interview itself can affect the response rate and makes the survey insignificant. Questionnaire-based studies however have some potentially negative drawbacks. In fact, questionnaires have been criticized for superficiality and providing an inconsistent description of a target phenomenon. In addition, a bias towards desirable responses and issues of validity related to the translation of questionnaires are to be considered [174]. This last can be mitigated by back-translation that is the translation of the questionnaire into the target language and then, translate this version back into the first language. The two versions must convey the same meaning.

5.1. THE DESIGN PROCESS

The step-by-step procedure followed to design the questionnaire is shown in **Figure 30**. The rest of this chapter describes the design of the questionnaire and its content (from step 1 to step 4). The following chapters discusses the way in which the survey has been conducted and provide an analysis of the results obtained (step 5 and 6).

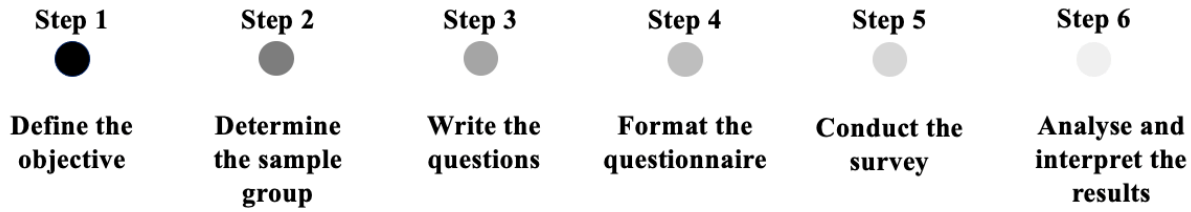

Figure 30 *– Questionnaire design process [175].*

The objective of this questionnaire is to investigate which are the best practices currently implemented in the food industry to achieve Sustainable Development.

5.1.1. Determine The Sample Group

This stage of the design process aims to define the number of the respondents (called sample) and the way in which those are selected. The objective of sampling strategies in survey research is to obtain a reasonable sample that is representative of the population of interest for the purpose of making statistical observations and inferences about that population [176]. Therefore, the population represents the entire group to draw conclusions about while the sample is the specific group of individuals from which information is collected. The two main types of sampling strategies are probability sampling and non-probability sampling (cf. **Figure 31**). The former refers to a sample that has been randomly selected. Thus, each unit in a population has a probability of being selected. In this case, it is very difficult to select a truly representative sample and probability sampling is beyond most researchers as it is simply too painstaking and costly to undertake. The latter relies on defining a suitable collection of respondents to complete the survey [174]. According to [174], the sample size depends on accessibility, time constraints, cost, and the statistics collected in the research. Dörnyei [177] recommends that for a study aiming to describe features of a population between 1% and 10% of the population should be sampled, with a minimum of 100 participants as a rule of thumb. However, "*the more scientific the sampling procedures, the smaller the sample can be*" [177], which means adapting the size of the sample to the procedure carried out to evaluate the information collected. For example, correlation research must rely at least on 30 participants, comparative and experimental research must count for at least 15 participants in each group. In this context, according to Young [174], it is important to recognize the limits of what a sample allows to deduce and the significance of the findings.

5.1.2. Write The Questions

The first choice that needs to be made when preparing a survey, is the mode in which the questionnaire will be administrated. According to Meadows [178] and Ferrara [179], the main types are:

- *Self-completion questionnaire.* The questionnaire is completed in writing by the respondent. The most common use of self-completion questionnaires is delivery and return by post. However, they can also be completed in the presence of the researcher (supervised self-completion) who can help the respondent and verify that all the questions are answered.
- *Face-to-face interview*. The interview is conducted by a supervisor who reads the questions and answer options in the exact order and language adopted in the questionnaire, then reports the answers as they are given by the respondent.
- *Telephone interview*. The interview is carried out through telephone calls. Answers are

collected in the same way as face-to-face interviews.

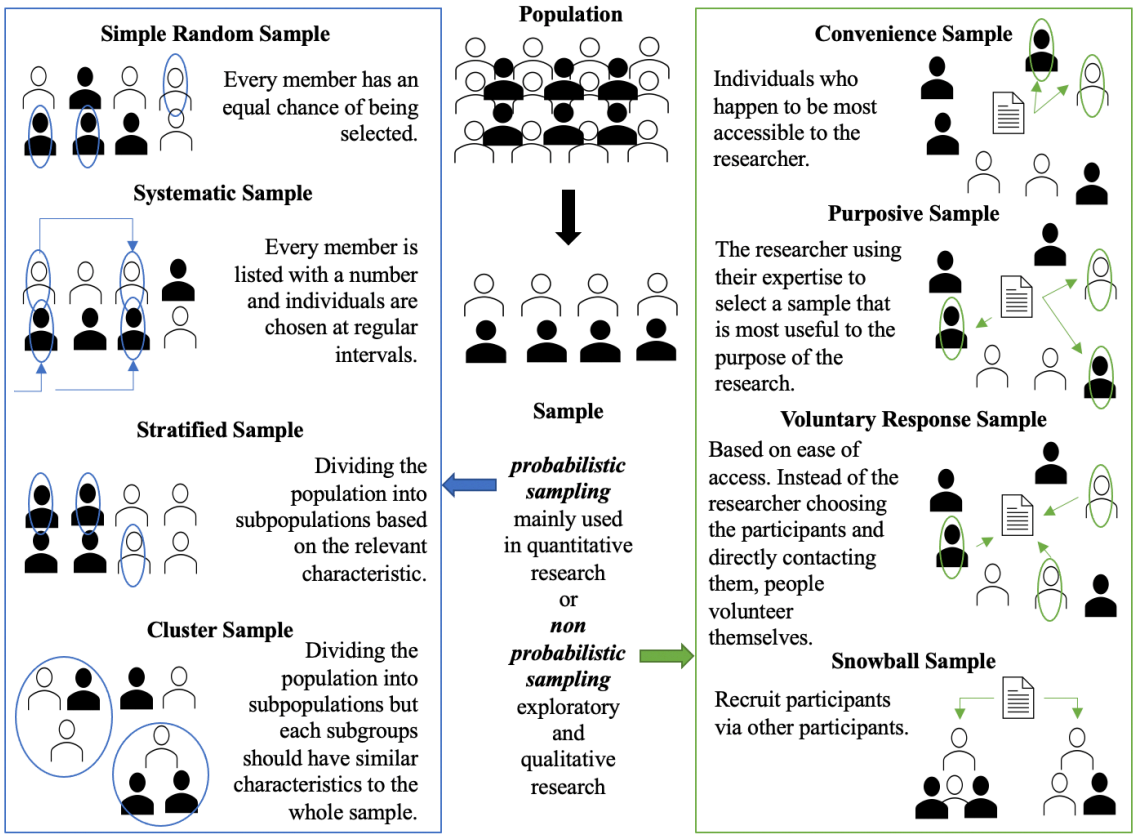

Figure 31 *– Sampling strategies. Derived from [180].*

The type of research performed influences the response format required by a question [172]. The two main popular response formats are closed-ended and open-ended questions [172], [178]. A closed question restricts the interviewee's answers to pre-defined response options. Four major structures exist for close-ended questions that are binary, ranking questions, multiple-choice, or checklist. This type of response format is suited when the researcher has a predefined set of answers in mind and when detailed narrative information is not needed. Closed questions enable comparison across individuals or groups of respondents, require less time to complete than open-ended questions, and are easy to code and process. However, they cannot capture in-depth or spontaneous responses and can sometimes unknowingly bias answers by forcing the respondent to choose between alternative responses or consider options that they had not previously considered. Moreover, misleading conclusions can be drawn because of poor questionnaire design and a limited range of options. On the other hand, open-ended questions do not provide any predetermined answers, which enables the respondent to answer the question using his or her own words. Open questions are useful when the researcher is uncertain what answers are needed or wants to conduct exploratory research. Those can be

free response, probing, and projective. As the questions require more thought and time of the interviewee, it reduces the number of questions that can be asked within a specific time span. Moreover, the researcher might misinterpret a response as it becomes difficult pooling an opinion across the sample.

5.1.3. Format The Questionnaire

Some other important points that must be considered in designing a questionnaire are the question wording and sequencing. First, the question posed must mean the same to the researcher and the respondent. Then, the choice, wording, ordering of responses, and response category can have an impact on how respondents interpret and answer the question. In addition, the design and layout of the questionnaire is an important stage in survey research since a well-designed questionnaire can simplify the tasks of the respondent, interviewer, and data processor. To this aim, attention must be paid to the length, question, and response category format (horizontally or vertically), the font size (less than 10 should be avoided), the pagination, and the instructions to fill it [178].

5.2. Questionnaire Content

The questionnaire designed for conducting this research is made up of two parts: the first part is a self-completion questionnaire followed by a face-to-face interview for those participants who provide availability for a more detailed interview. In fact, since the firms involved in the survey are not known a priori and to eliminate the risk of influencing the answers, the type selected for the first part is a self-completion questionnaire. Therefore, a proper and accurate structure of the questions is of paramount importance as they must be easily understandable and must not be open to self-interpretation by the respondents. Considering that the aim of the survey is the evaluation of the findings provided by the literature review conducted, thus it is not an exploratory type of research, closed-ended questions are preferred over open-ended ones because, considering a limited time span of the respondents, they allow more information to be collected. Moreover, those are simpler and more objective in terms of both the answering of the questionnaire by the respondent and the evaluation of the results by the researcher. Once designed, the questionnaire is translated into Italian and French to ensure culturally equivalent answers from the respondents. Before developing the survey research, the questionnaire is submitted to the supervisors of this document to authenticate its reliability, validity and to highlight any kind of problems such as excessive length, incomprehensibility, or missing questions.

The first part of the survey is dedicated to frame the respondents. The same taxonomy techniques adopted to interrogate the literature are here deployed with the aim to contextualize the answers that will be collected. In fact, as shown in the third chapter, the type of practices adopted to achieve sustainability depends on the commitment of the corporation itself, but they can also be associated with the level of the supply chain in which the companies are located and what kind of network they are in. This, in turn, allows defining the sample surveyed (cf. Paragraph 5.1).

For this purpose, what is relevant to know is:

- Job title and experience of the respondent
- Type of products handled by the company
- Size of the company
- Type of network in which the company operates (long or short) and at which stage of the supply chain they are positioned. It is worth noticing that this information is obtained by an inductive analysis considering the number of actors upstream and downstream with respect to the main stage at which a company operates.

Regarding the size of the company, the classification adopted is the one proposed by Eurostat, the statistical office of the European Union. According to them, companies can be distinguished based on their size by considering the number of headcounts (in units), either turnover (in million) or total balance sheet (in million), and the investments. By adopting the classification based on the number of employees [181], it is possible to define:

- Large enterprises: 250 or more employees.
- Small and Medium-sized Enterprises (SMEs): less than 250 employees. Of which:
  - Micro enterprises: less than 10 persons employed.
  - Small enterprises: 10 to 49 persons employed.
  - Medium-sized enterprises: 50 to 249 persons employed.

The type of network will be analyzed taking as reference the generic food supply chain model proposed by [59], already adopted for the analysis of scholarly papers.

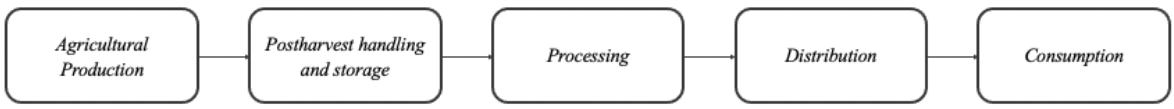

Figure 32 *– Generic Food Supply Chain. Adapted by [59].*

The second part of the questionnaire is linked to the findings of the literature review. The number of information collected is huge and the length is a key variable for a well-designed

questionnaire. Therefore, it is necessary to focus on the key points that, considering the purpose of this research, are sustainability practices. Moreover, as deeply discussed, one of the best ways to achieve sustainability is the alignment with the TBL approach and thus accounting for economic, environmental, and social impacts of the actions performed by a company. The full questionnaire submitted to the companies is reported in Appendix E.

As noticed before, all the questions are closed-ended (cf. Paragraph 5.1.4). Four major structures exist for close-ended questions that are binary, ranking questions, multiple-choice, or checklist. The one selected for this questionnaire is mostly the multiple-choice type (by means of a rating scale) because, according to Sreejesh [173], it allows to cover all significant degrees of response and perform quantitative data analysis. In rating scale questions, a question will display the answer options a range. Even if, is known that the rating scale selected can influence the results of the analysis [182], there is not a standard to define it. Therefore, this is selected considering which topic has to be evaluated i.e., practices or sustainability aspects.

According to Chardine-Baumann [183], a practice that is occasionally implemented on a few products will not have the same impact on sustainable development, as a practice that is systematically installed on all products. In this regard, [183] defines four degrees of development that are based on two properties of a practice: the stability of the practice i.e., the regularity of its implementation by the company (occasional or systematic) and the extension of the practice i.e., the activities are carried out for only a few products/services or all products/services.

The same rating scale is thus adopted in the questionnaire for the evaluation of the practices. In addition, the "0: I don't know" option is added to also consider the level of awareness with respect to the degree of implementation of practices. Therefore, the from 0 to 4 rating scale is derived as follow (cf. **Figure 33**):

- Degree 0: I don't know i.e., the respondent cannot assess the degree of implementation of the sustainable practice analyzed.
- Degree 1: the practice is not, or only to a limited extent, implemented. This means that its implementation will not significantly impact the sustainable development.
- Degree 2: this practice is rarely adopted for certain products/services in the supply chain.
- Degree 3: this practice is rarely adopted for a large number of products/services or the practice is frequently carried out for some product/services.
- Degree 4: the company implements this practice frequently for a large number of products/services.

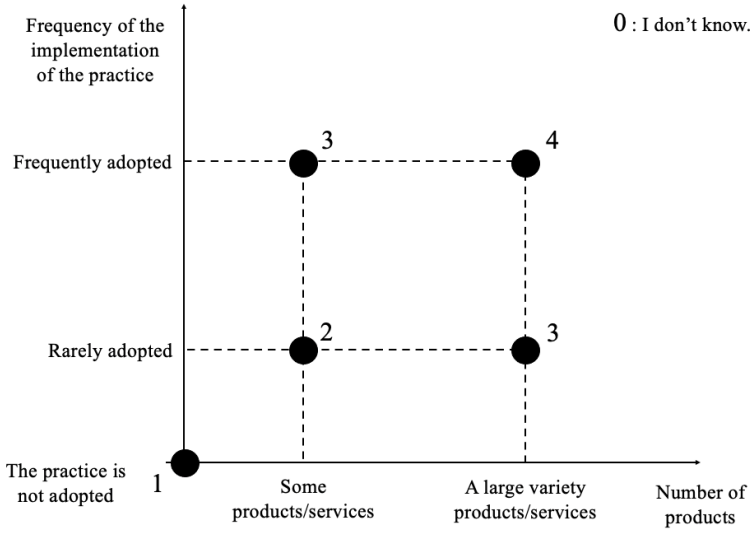

Figure 33 *– Rating scale adopted to evaluate the implementation of the practices performed. Derived by [183].*

The 1 to 4 rating scale is adopted to rank the importance given to each of the three TBL dimensions. The scores are associated as follow:

- 1: Not important at all.
- 2: Low important.
- 3: Important.
- 4: Very important.

The choice of two different types of rating scale can be risky, since the respondent has to understand the classification before answering, and this depends on what he or she is asked to evaluate. In fact, the adoption of the same scale throughout the whole questionnaire increases its readability and moreover, linear scales are widely known and adopted. Therefore they are easier to be handled by the interviewee [182]. However, this decision is taken to increase the relevance and robustness of the analysis as they are distributed considering the topic being evaluated.

6. Research Method

The empirical analysis conducted relies on statistical methodology as an approach to evaluate the data collected through the survey research carried out. Statistics is defined as the "*discipline that concerns the collection, organization, analysis, interpretation, and presentation of data*" [184]. The data are gathered on a survey-based research methodology and processed by applying descriptive and inferential statistical techniques.

A statistical variable X is defined as an entity that represents a single common aspect of the system of objects selected for analysis i.e., the target population Ω of a statistical investigation [185]. The target population in this study is all food companies based in Italy or France. It is worth noticing that a response is obtained from a company operating in Austria. Since it is not a statistically significant number, it will not be considered in the analysis conducted. A survey obtains from Ω a statistical sample S_Ω of size $|S_\Omega| = n$ ($n \in N$, $n < N$), with N statistical units. The number of the responses collected, and the number of responses collected from different companies differs by one unit. Since the two respondents belonging to the same company have attributed different values to the variables analyzed, these are processed as two separated entities. Thus, n = 123. All the variables involved in a statistical investigation must have an operational description (cf. Appendix E) i.e., a clear meaning to all those performing in the analysis itself [186]. In this context, twelve variables are deployed to characterize the respondents, three variables are intended to quantify the extent to which the TBL dimensions are considered within a company (Economic, Environmental, Social) and twenty-five variables are adopted to describe the extent of implementation of the practices (P_1, P_2, P_3, … P_{25}).

The purpose of this statistical analysis is to summarize and present the results embedded in the manifest variables (descriptive statistics) and then, to use these data to derive information about the entire population (inferential statistics) [186]. Inferential statistics results generally rely on the quantification of latent variables i.e., variables representing unobservable "social construct" [185]. It is worth noticing that some questions are conditioned based on the stage at which the company operates. Therefore, some variables are quantified for a subsect of S_Ω according to the scheme provided below (cf. **Table 6**). Numbers in brackets refers to the number of total observations for each item, out of a total of 123 responses collected.

Table 6 *– Link between the items of the questionnaire and the stage of the supply chain at which they are evaluated.*

Items	***Stage of the Supply Chain***			
	Primary Production	*Post-harvest handling*	*Processing*	*Distribution*
P1. Supplier Assessment (108)		•	•	•
P2. Supplier Collaboration (108)		•	•	•
P3. Green Purchasing (108)		•	•	•
P4. Green Design (105)			•	•
P5. Green Packaging (123)	•	•	•	•
P6. Green Production (15)	•			
P7. Green Manufacturing (91)			•	
P8. Materials and product recycling and remanufacturing (123)	•	•	•	•
P9. Protection of Animal Welfare (68)*	•	•	•	•
P10. Soil Conservation and Management (15)	•			
P11. Responsible Use of Natural Resources (123)	•	•	•	•
P12. Inventory Management (123)	•	•	•	•
P13. Green Warehousing (123)	•	•	•	•
P14. Green Shipping and distribution (123)	•	•	•	•
P15. Reverse Logistics (123)	•	•	•	•
P16. Corporate Green Image Management (123)	•	•	•	•
P17. Green Product Innovation and Design (123)	•	•	•	•
P18. Corporate Social Responsibility Programs (123)	•	•	•	•
P19. Green Human Resource Management (123)	•	•	•	•
P20. Adoption of Standard and Certifications (123)	•	•	•	•
P21. Collaborative Supply Chain: Information Planning (123)	•	•	•	•
P22. Collaborative Supply Chain: Green Targets Planning (123)	•	•	•	•
P23. Strategic Supply Chain Collaboration (123)	•	•	•	•
P24. Supply Chain Integration System (123)	•	•	•	•
P25. Adoption of ICTs (123)	•	•	•	•

*the only responses considered are the ones provided by companies handling animal-based products i.e., Milk and their products, Meat and their products, Food additives, Fish, Shellfish and their products, Fats and oils, Eggs and their products and composite dishes.

6.1. Descriptive Statistics

The first step in performing a statistical analysis relies upon summarizing the set of data S_Ω with descriptive statistics by computing the measures of central tendency i.e., mode, median, and mean and the measures of variability i.e., range, interquartile range, standard deviation, variance, and correlation. Therefore, starting from the raw set of data collected i.e., S_Ω this part tries to investigate the general trend of the statistical sample. As the extent to which the three dimensions of sustainability and the degree of implementation of the practices are considered

in a company is assessed through a Likert scale, the mean cannot be used as a measure of central tendency as it has no meaning. With Likert scale data, the most significant measures of central tendency are the mode and the median. In fact, the mean is affected by extreme values, while the median and mode are not. The median of the relative frequency distribution for any one-dimensional variable X is the middle score in an X's spectrum. The mode of the relative frequency distribution for any one-dimensional variable X is that value in an X's spectrum which is observed with the highest relative frequency in S_Ω [185]. The mode does not necessarily take a unique value and the presence of two (or more) modes within a sample could be a symptom of the non-homogeneity of the sample itself. That is, there could be two (or more) subgroups that are internally homogeneous, but distinct from each other for an additional characteristic to the one observed.

In a sample S_Ω, with ordinal data types, the variability i.e., dispersion of data, is assessed through the range, the interquartile range, and the correlation. The range expresses the difference between the largest and the smallest value in a data set. The interquartile range is defined as the difference between the third quartile and the first quartile of the relative frequency distribution of the sample. The former gives a measure of how dispersed the data are, in a given dataset while the latter indicates how distributed the middle 50% of a set of data is. The interquartile range is not sensitive to outliers.

Finally, at the ordinal scale level, the proper nonparametric statistical measure of correlation is the dimensionless Spearman sample rank correlation coefficient $-1 \leq r_s \leq 1$. The Spearman sample rank correlation coefficient is computed by means of defining rank numbers that correspond to the position of every individual observation in the ordered sequence of the original data set.

Spearman's coefficient is defined as:

$$r_s = 1 - \frac{\delta \sum_{i=1}^{n} d_i^2}{n(n^2 - 1)}$$

Where:

d = is the difference between the two ranks of each observation

n = number of total observations

It measures the strength of a rank correlation between two variables. When two variables are perfectly correlated, *d* will tend to zero and, consequently, Spearman's coefficient r_s will tend to 1; conversely, the more uncorrelated the two variables are, the more the value of r_s will tend to 0. The sign of r_s encodes the direction of a rank correlation i.e., negative or positive [185].

To interpret the strength of a correlation via the magnitude of $| r_s |$, the following rule of thumb is typically employed:

$\| r_s \| = 0$	$0 \leq \| r_s \| \leq 0.2$	$0.2 \leq \| r_s \| \leq 0.4$	$0.4 \leq \| r_s \| \leq 0.6$	$0.6 \leq \| r_s \| \leq 0.8$	$0.8 \leq \| r_s \| \leq 1$	$\| r_s \| = 1$
no rank correlation	very weak rank correlation	weak rank correlation	moderately strong rank correlation	strong rank correlation	very strong rank correlation	perfect rank correlation

Moreover, it is worth noticing that Likert scales data are subject to distortion from several causes:

• Central tendency bias i.e., the respondent avoids the use of extreme response categories.

• Acquiescence bias, the respondent agrees with statements as presented.

• Social desirability bias, the attempt to portray themselves or their organization in a more favorable light.

To determine the internal consistency i.e., reliability of the data analyzed the Cronbach's Alpha index is adopted. Measuring the internal consistency of a questionnaire consists of determining whether the answers given to the various items of the questionnaire are related to each other i.e., consistent. It is a dimensionless index $0 < \alpha < 1$. The Cronbach's Alpha is computed using sample variance, total scores, and number of items and it is defined as [187]:

$$\alpha = \frac{k^2 \, \sigma_{ij}}{\sigma_X^2}$$

Where:

X_1 = observed score for item i

k = number of items

X = sum of all items in a test consisting of k items = $X_1 + X_2 + \ldots + X_k$

σ_{ij} = covariance between item i and item j

σ^2_X = items variances and inter-item correlation

To interpret the strength of internal consistency, a benchmark value of 0.7 i.e., $\alpha > 0.7$ is commonly applied.

6.2. Inferential Statistics

Inferential statistics employs data gathered from one or more statistical samples to draw conclusions about one or more populations through two main methodologies: hypothesis testing and estimation of population parameters. A hypothesis is defined as: *"a prediction about a single population or about the relationship between two or more populations"* [188]. A research hypothesis is a general statement of what a researcher predicts, and it is restated

within the framework of two statistical hypotheses i.e., the null hypothesis or no-effect hypothesis (H_0) and the alternative hypothesis (H_1) evaluated through a statistical test. Since the statement of the research hypothesis generally predicts the presence of an effect or difference with respect to the object of study, the null hypothesis will generally be one that the researcher expects to be rejected. Conversely, since the research hypothesis typically predicts an effect or difference, the researcher will generally expect the alternative hypothesis to be accepted [188]. The result of a statistical test must be statistically significant i.e., determining whether the result obtained is due to a chance or is the result of an experimental effect. The scientific convention requires that to qualify a result as statistically significant, there can be no more than a 5% probability that the result observed is due to chance. The notation $p > .05$ is employed to indicate that the result of a test is not significant [188]. Inferential statistical tests employed with ordinal/rank-ordered data are categorized as nonparametric tests. To select the proper nonparametric test, the number of samples involved in the test of hypothesis must be considered:

• Single sample (S_Ω), i.e., the hypothesis about a population median or the distribution of data in a single population.

• Two or more independent samples (two or more subsets of S_Ω) i.e., the hypothesis about two or more independent population medians or some other characteristic of two or more independent populations.

As the primary purpose of this inferential statistical analysis is to investigate the relationship existing among the descriptive variables deployed to characterize the sample and the importance attributed to the TBL dimensions and the extent to which the identified practices are implemented within each company, the appropriate nonparametric test is the Kruskal-Wallis one-way analysis of variance by ranks. The statistical analysis is carried out using Minitab.

The Kruskal-Wallis test determines whether the medians of two or more groups are different i.e., if there is a significant difference between groups. Minitab uses the chi-square distribution to estimate the p-value. In Minitab, the following statistics are provided with Kruskal-Wallis test [189]:

- *N*: sample size, i.e., the total number of observations in each group.
- *Median*: estimation of the population median of each group (cf. Paragraph 1.1).
- *Mean rank*: average of the ranks for all observations within each sample. The mean rank is computed by combining in one set the data gathered from two or more groups. Then the data are sorted in ascending order. A rank is assigned to each of the sorted data. The average

rank is given to tied values. Tied values are those observations having the same value, which prohibits the assignment of unique rank numbers. Finally, the mean rank is computed by adding up the different ranks for each group. When a group's mean rank is higher than the overall average rank, the observation values in that group tend to be higher than those of the other groups.

- *Z-Value*: compares the average rank for each group to the average rank of all observations. If negative (positive), it indicates that the group's average rank is less (greater) than the overall average rank.
- *Null hypothesis* (H_0: all medians are equal) and *alternative hypothesis* (H_1: at least one median is different) (cf. Paragraph 1.1).
- *DF:* degree of freedom i.e., number of groups minus 1.
- *H-Value*: the test statistic for the Kruskal-Wallis test. Under the null hypothesis, the chi-square distribution approximates the distribution of H. The former is computed by finding the critical chi-square value that determines if ordinal variables are related, while the latter, assuming independent groups, is determined by

$$H = \frac{12}{n(n+1)} \sum_{j=1}^{k} \frac{R_j^2}{n_j} - 3\,(n-1)$$

Where:

k = number of groups

n_j = number of observations in the group j

R_j = sum of rank numbers for each random sample

n = total sample size i.e., sum of all n_j.

If the critical chi-square value is less than the H statistics the medians are equal. If the chi-square value is not less than the H statistic, there is not enough evidence to suggest that the medians are unequal. The H-Value test statistic is deployed to determine the p-value.

- *P-value*: the probability that measures the evidence against the null hypothesis i.e., if the differences between the medians are statistically significant. If the p-value is ≤ 0.05 the differences between some of the medians are statistically significant. The other way round to conclude that the medians are not statistically significant i.e., $p > 0.05$. A significance level of 0.05 indicated a 5% risk of concluding that a difference exists when there is no actual difference. It is worth noticing that Minitab displays two values of the p-value: p-value adjusted for ties and p-value not adjusted for ties. The former is computed by considering the ties within the data and it is usually more accurate than the latter. A tie

occurs when the same value is in more than one sample. However, it is generally lower than the p-value not adjusted for ties. Thus, the p-value not adjusted for ties is considered the more conservative estimate. When no ties exist within the data, the two p-values are equal.

7. SAMPLE CHARACTERISTICS

The statistical population in this study is all food companies based in Italy or France. The organization has been contacted via LinkedIn or via their website. 1448 organizations are contacted via e-mail or via their website (from March to May 2021). 123 responses are then received that leads to a response rate of 8.5%. This value of response rate can be considered acceptable for carrying out further analysis on the answers since it is close to those experienced in previous studies [190]. Moreover, Dörnyei [177] recommends for a study aiming to describe features of a population, a minimum of 100 participants as a rule of thumb. The main characteristics of the representative sample S_Ω are provided in the table below (cf. **Table 7**). It is worth noticing that 8 out of 17 cooperatives are part of a group while the others are individual cooperatives. Furthermore, the country of the group for each organization is described in **Figure 34**.

Table 7 *– Demographic information about the statistical sample.*

	Italian companies		**French companies**	
	Frequency	*%*	*Frequency*	*%*
Sample Size	89	72%	34	28%
Organization part of a group				
Yes	33	40%	16	47%
No	56	60%	18	53%
Cooperative				
Yes	12	13%	5	15%
No	77	87%	29	85%

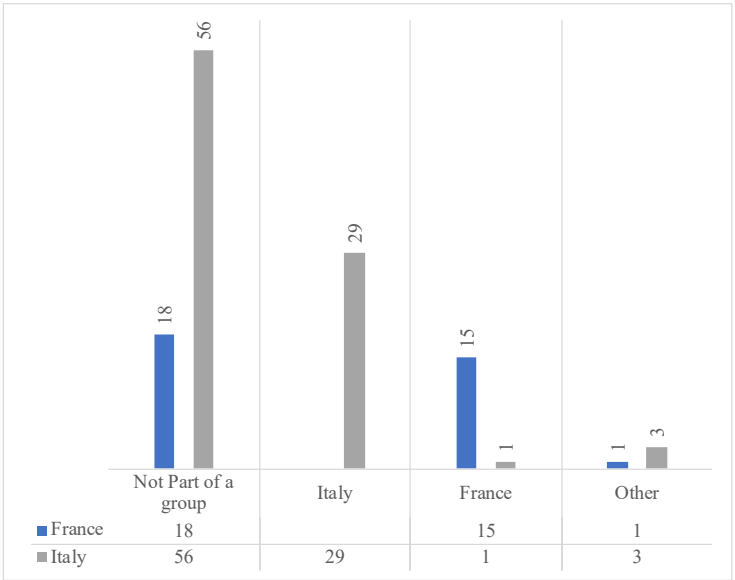

Figure 34 *– Country of the group (columns) and the country of the individual company (rows), out of a total of 123 companies.*

The same taxonomy techniques adopted in the systematic literature review performed are deployed with the aim to frame the sample. In fact, as shown in the third chapter, the type of practices adopted to achieve sustainability depend on the commitment of the corporation itself, but they may also be associated with the level of the supply chain in which the companies operate (cf. **Figure 35**) and based on the type of network they are in. It is worth noticing that the percentage of companies in the different stages of the supply chain is equally distributed among countries i.e., France and Italy (cf. **Figure 36**).

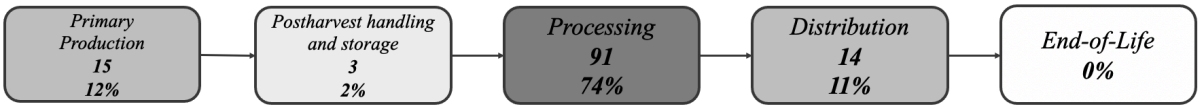

***Figure 35** – Main stage of the supply chain in which the companies operates.*

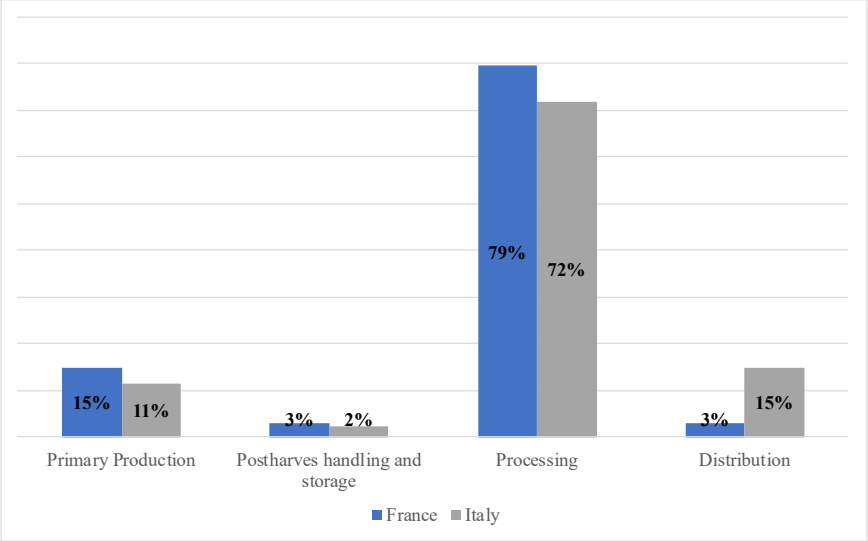

***Figure 36** – Relation between the main stage in which a company operates and the country in which the company is based.*

Concerning the subset of cooperatives, most of them operate at the primary production (4 out of 17 i.e., 24%) and processing levels (11 out of 17 i.e., 65%). The number of actors upstream and downstream with respect to the focal company allow to deduct the type of network in which the company operates. In fact, actors in a supply chain are entities, independent companies, that participate in the network to produce and deliver the products from raw materials to the final consumer. According to the model considered (cf. Figure 35), it can be assumed that a company operating at the first stage of the supply chain has no more than two upstream actors. Therefore, companies operating at the primary production that present more than two upstream actors are considered as misinterpretations of the question by the respondent and are not considered in some of the hypotheses testing of the statistical analysis. The same is true for

companies operating at the distribution stage. In fact, it can be assumed that a company operating at the distribution stage has no more than three actors downstream. Thus, distribution companies that present more than three downstream actors are considered as misinterpretations of the question by the respondent and are not considered in some of the hypotheses testing of the statistical analysis.

In addition, the type of foodstuffs offered by a company and the extent to which these foodstuffs are processed are retrieved according to the classification provided by the FAO [60] and Monteiro [61]. To perform a statistical analysis considering the product handled by a company, it is required that each class have the same size [186]. Therefore, starting from the initial classification, some of the "type of products" classes are grouped according to the nature of the products itself (cf. **Table 8**).

Table 8 *– Type of products classification: grouped classes.*

Type of products handled by a company	***Initial Classification*** *Absolute Frequency*	***Grouped Classes*** *Absolute Frequency*	***Grouped Classes*** *Relative Frequency*
Meat and their products	25	34	18.8%
Fish, shellfish and their products	5		
Eggs and their products	4		
Cereals and their product	18	28	15.5%
Pulses, seeds and nuts	10		
Sweets and sugars	22	23	12.7%
Honey	1		
Vegetables and their products	18	20	11.0%
Roots, tubers and plantains	2		
Milk and their products	20	20	11.0%
Composite dishes	11	17	9.4%
Savory snacks	6		
Fruits and their products	11	11	6.1%
Fats and oils	11	11	6.1%
Beverages	7	7	3.9%
Spices and condiments	6	6	3.3%
Food additives	4	4	2.2%

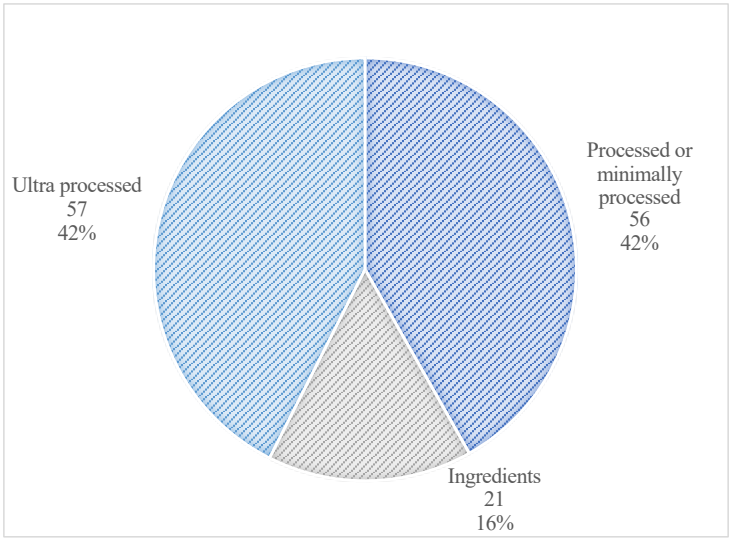

***Figure 37** – Degree of processing of the products classification.*

With reference to the portfolio composition of each company it can be observed that most of the companies (77%) handle just one family of product, while the 23% manage two or more families of foodstuffs. The relation between the portfolio composition of the companies and the stage at which they operate is reported in the figure below (cf. **Figure 38**).

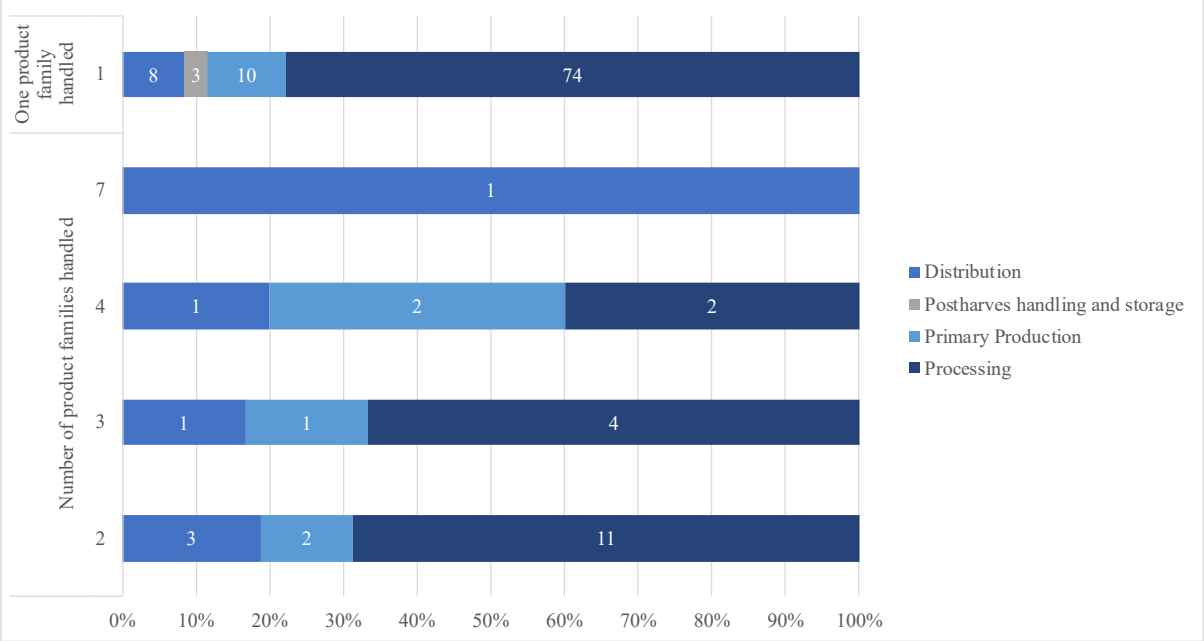

***Figure 38** – Relation between the family of products handled by a company and the stage at which it operate.*

Moreover, the statistical sample appears to be balanced according to the size of the company (cf. **Figure 39**). Large enterprises account for the 29% of the sample while SMEs are the 71% of which the 16% are micro enterprises, the 30% are small enterprises and the 25% are medium-sized enterprises, equally distributed between France and Italy (cf. **Figure 40**). It is worth

noticing that most of the cooperatives are medium-sized or large enterprises, differently from the firms (cf. **Figure 41**).

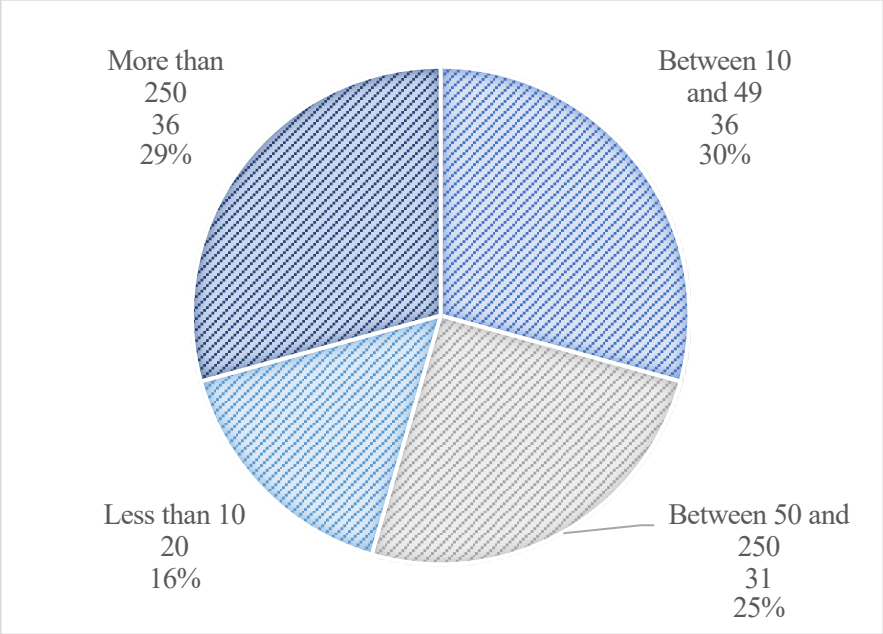

Figure 39 *– Size of the companies based on the number of employees.*

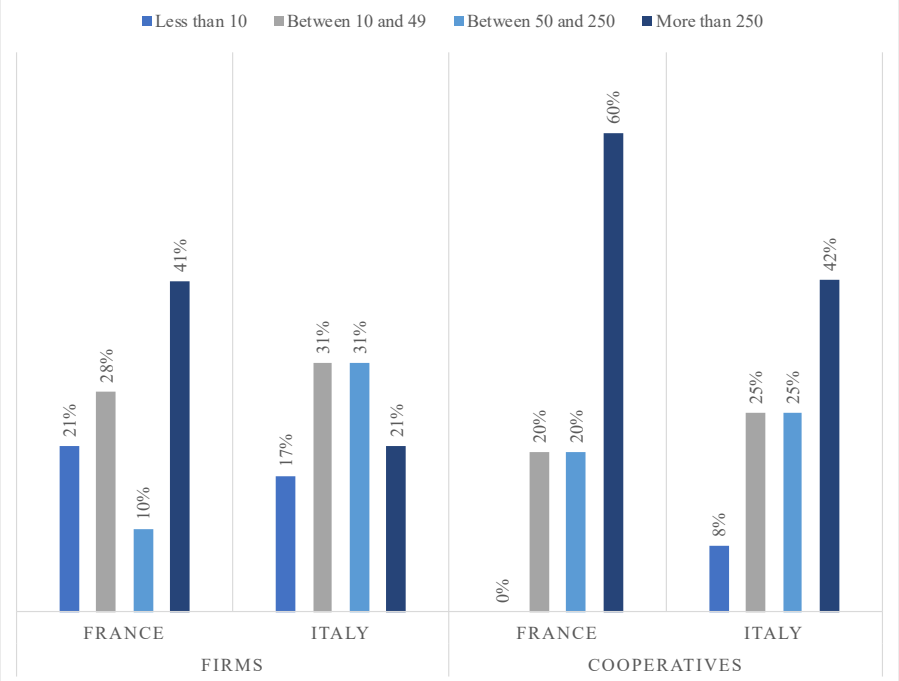

Figure 40 *– Relation between the size of the firms or cooperatives and the country.*

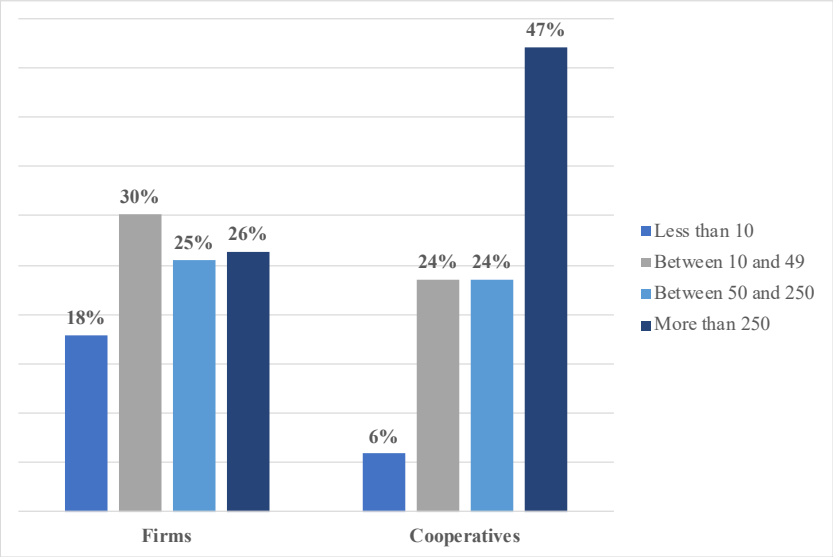

Figure 41 *– Firms vs. Cooperatives and number of employees.*

Dealing with materials and products recycling and reprocessing (P_8), 61.8% of the respondents convert food wastages into new materials, while the 48.8% of the respondents extract and efficiently recover value-added components from food wastages to produce other goods such as fertilizer and energy. The handling and collecting activities of all the returned end-of-life materials (P_{15}) are mainly carried out by a third party (74.0%) rather than by the company itself (39.8%). Results are reported in **Figure 42**.

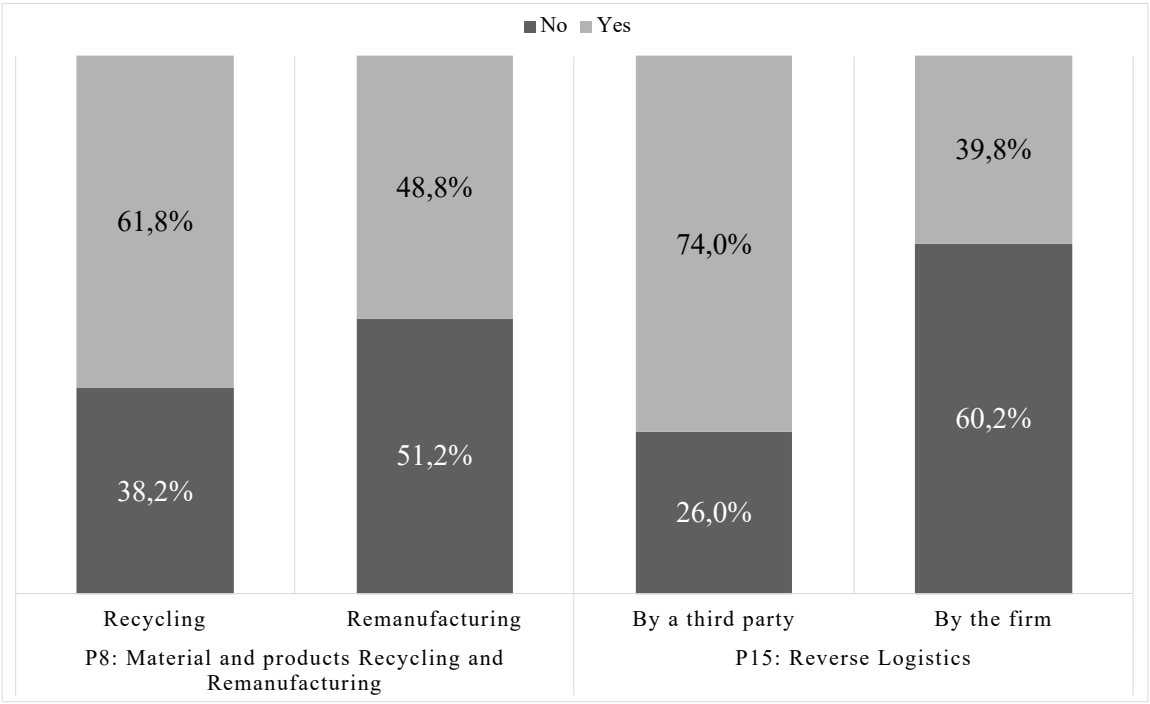

Figure 42 *– Degree of implementation of P8 and P15.*

Finally, to characterize the respondents (n=123) that are randomly selected i.e., every food company based in Italy or France has an equal chance to be selected, the department in which they operate and the years of experience within that department is considered (cf. **Figure 43**).

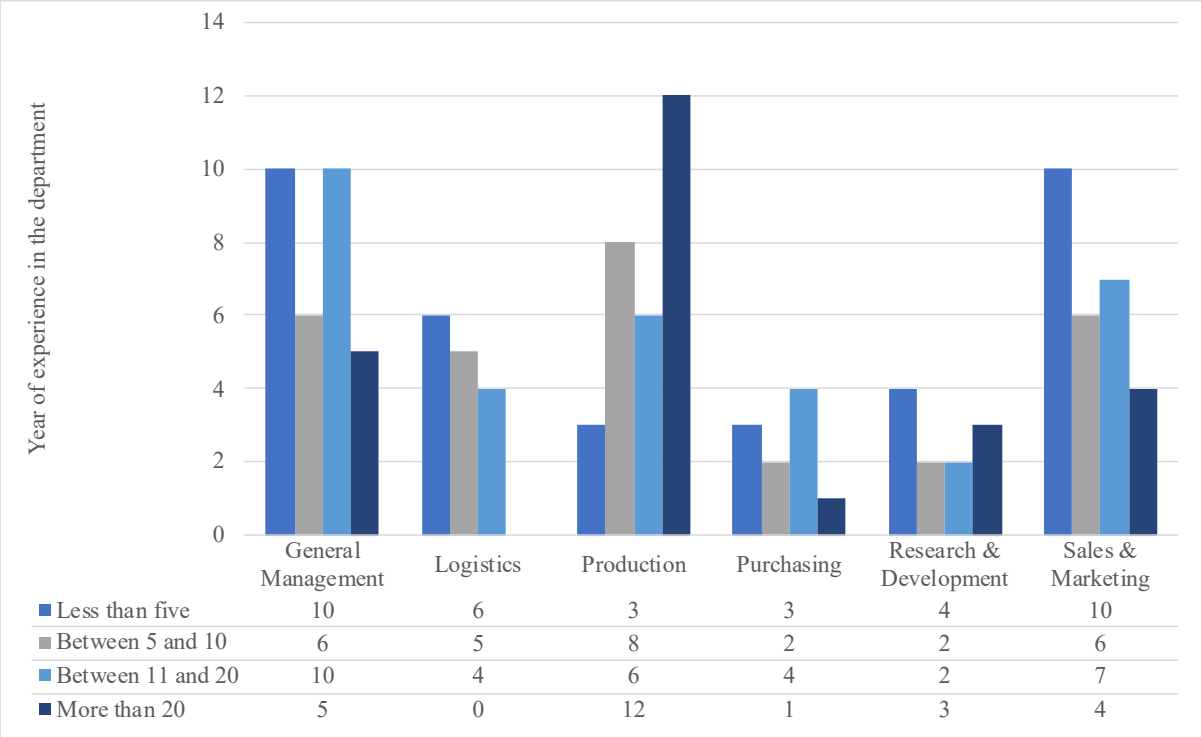

Figure 43 *– Department of the respondents and the relative year of experience.*

General management is about overseeing everything that goes on in a company and making sure that all departments are working together. It includes direction, administration, corporate social responsibility, human resource management and scientific and public affairs departments. Logistics refers to inbound and outbound logistics i.e., reception, warehousing and distribution of inputs and storage, transportation, and distribution of final products. Production department is in charge of transforming raw materials into semi-finished or finished products. Purchasing department is responsible for the procurement process of raw materials and equipment. Research & Development department is focused on the study of innovations to be used to create/improve products offered by the company or improve production processes. The sales and marketing department deals with the commercialization of foodstuffs and all activities related to the launch and sale of a product such as the definition of commercial objectives, marketing strategies and customer service.

8. Research Hypotheses Results and Discussion

With the aim to study the collected data and derive relevant conclusions, some research hypotheses are addressed (H1, H2, …, H28), considering the features of S_Ω and the items addressed in the questionnaire (cf. Appendix E). To recap, a research hypothesis is a general statement of what a researcher predicts, and it is restated within the framework of two statistical hypotheses i.e., the null hypothesis or no-effect hypothesis (H_0) and the alternative hypothesis (H_1) evaluated through a statistical test (cf. Chapter 5). In the following, the idea underpinning the research hypotheses made are discussed as well as the relevant results obtained from the statistical analysis. The details of all the hypotheses tested are reported in the Appendix F.

8.1. Importance Attributed To The TBL dimensions

The first part of this analysis aims to assess whether relevant conclusions can be traced by considering the importance given to the three dimensions of sustainability and the characteristics of a company, explained by the descriptive variables deployed in the questionnaire. Starting from the results of the literature review conducted, the first conclusion drawn is that, while the economic and environmental aspects are generally included in the studies, the social aspect remains slightly less analysed. Because of that, it can be observed if, in the operating world, the three dimensions of the TBL are considered equally important. Thus: *H1. The three dimensions of the TBL are considered equally important.*

The mode of the economic and environmental dimensions assumes the highest possible value of the Likert scale (4 = very important) while the social dimension is considered slightly less important i.e., mode = 3, important (cf. **Table 9**). This is in line with the results obtained from the literature review. In **Table 9** "N" represents number of total observations, "Sum" is the sum of the scores given to each dimension, "Minimum" is the smallest value in S_Ω, "Q1" is the first quartile, "Median" is the value separating the higher half from the lower half of a S_Ω, "Q3" is the third quartile, "Maximum" is the largest value in S_Ω, "IQR" is the interquartile range computed as Q3 – Q1, "Mode" is the score that is repeated most often in S_Ω and "N for Mode" is the number of times the mode appears. However, the sum of values given to the social dimension is slightly higher compared with the environmental one, as opposed to the relative importance of scholarly papers to these two dimensions. The same result can be observed analyzing the cumulative relative frequency distribution (cf. **Figure 44**). The social dimension has the lowest cumulative relative frequency for the first two values on the Likert scale. Moreover, it is worth noticing that the range for the three variables describing the TBL dimensions is [1, 4] and the interquartile range (IQR) is 1. Thus, the variability appears to be

the same for each dimension. Finally, only 28.5% (35 out of 123) of the respondents rated all the three sustainability axes as having the highest value of importance. Therefore, even if sustainability in the food industry appears to be a growing concern, these three dimensions are not considered equally important by industrials in the food sector.

Table 9 *– Descriptive statistics for each of the TBL dimensions.*

Variable	N	Sum	Minimum	Q1	Median	Q3	Maximum	Range	IQR	Mode	N for Mode
TBL: Economic	123	409	1	3	4	4	4	3	1	4	67
TBL: Environmental	123	388	1	3	3	4	4	3	1	4	51
TBL: Social	123	400	1	3	3	4	4	3	1	3	54

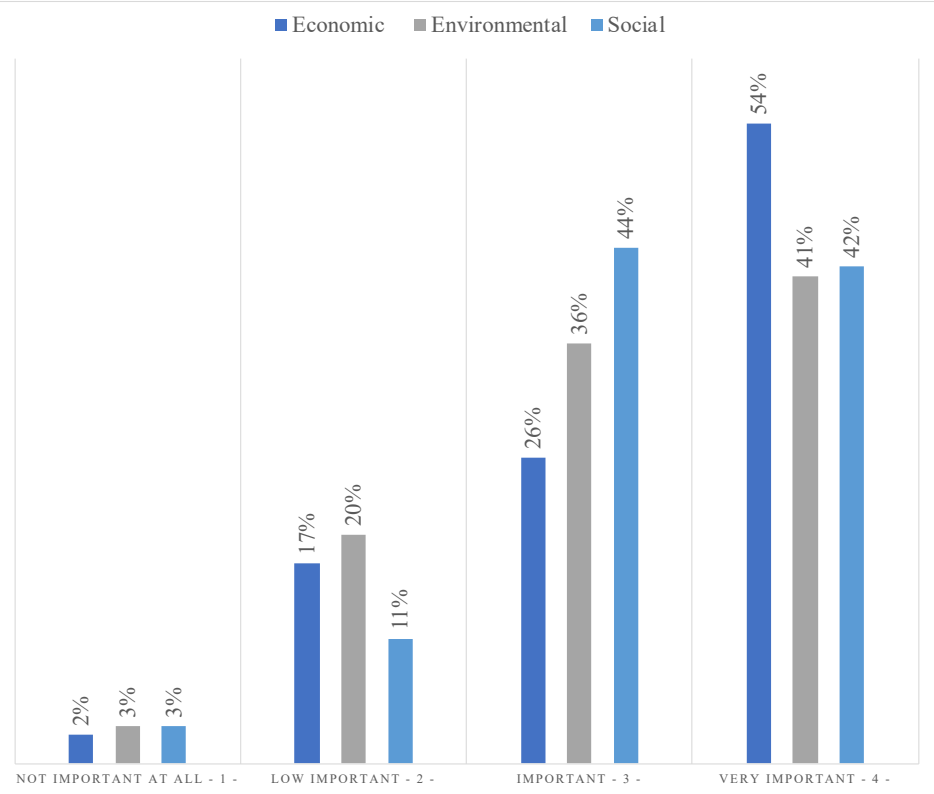

Figure 44 *– Relative frequency distribution of the three TBL dimensions.*

Moreover, the correlation coefficient analysis is carried out to determine quantitatively whether the three dimensions are correlated.

Table 10 *– Spearman correlation coefficient among the three TBL dimensions.*

	TBL: Economic	***TBL: Environmental***
TBL: Environmental	0,453	
TBL: Social	0,509	0,777

It can be observed that there is a direct strong rank correlation (i.e., $r_s = 0.777$) between the extent to which the environmental and social dimensions are considered important while there is a moderately direct strong rank correlation between the economic axe and the other two (cf**. Table 10)**. This conclusion is supported by Cronbach's alpha reliability test result i.e., Coefficient $\alpha = 0.8055$. As a reminder, in the analysis of the correlation coefficient, the relationship between these three variables can be described as a tendency to associate directly but the correlation index cannot be used to conclude on the existence of a cause-effect relationship between two or more variables [186]. Furthermore, the face-to-face interviews will provide insights concerning the maturity of the integration of sustainability issues in the food companies i.e., if sustainability is a growing concern in recent years.

8.1.1. DESCRIPTIVE VARIABLES VS. TBL DIMENSIONS

As already discussed, there are some motivating factors called drivers, that force an organization to adhere to sustainability standards. According to Yu *et al.* [62], drivers are the principal reasons for the implementation of sustainable practices in a food supply chain. Drivers can be both internal and external. Since external motivating factors are dependent on the surrounding conditions in which a company operates (e.g., influences exerted by governmental regulations, firms on which the focal firm depends), at this point of the analysis, it can be hypothesized that there is a difference between companies that are part of a group and/or companies operating in different countries. In particular:

H2. Firms that are part of a group give different importance to the TBL dimensions.

H3. There is a significant difference between companies operating in Italy and companies operating in France with respect to the importance given to the TBL dimensions.

H4. The size of a company influences the importance given to the TBL dimensions.

H5. The stage at which a company operates influences the importance given to the TBL dimensions.

The results obtained from the Kruskal-Wallis test considering the country of the firm and the importance given to each of the TBL dimensions (H3, cf. **Table 11**) allows concluding that there is a statistical significance with reference to the country in which a company operates and the importance given to the economic and social dimensions of the TBL. It can be noticed that for Italian companies the economic and social concerns are considered slightly less important (median = 3) with respect to French-based companies (median = 4). Furthermore, this result seems to confirm what had already been suggested by the literature. That is, there are external drivers (in this case the country in which a company operates) that influence companies to

consider the three dimensions of sustainability in their operations. However, as a conclusion of their study, Emamisaleh and Rahmani [8] do not support the hypothesis that external drivers have a direct influence on strategic sustainability orientation. It is worth noticing that the other variables give not the same results i.e., if the organization is part of a group and if the organization is a cooperative (cf. **Table 31**).

Table 11 *– Kruskal-Wallis test results for H3.*

TBL dimensions	***Country of the firm***	***Median***	***P-value (P-value adjusted for ties)***
Economic	France	4	**0.024**
	Italy	3	(0.012)
Environmental	France	4	0.082
	Italy	3	(0.063)
Social	France	4	**0.024**
	Italy	3	(0.014)

Concerning the statistical influence between the size of the firm and the importance given to each of the TBL dimensions (cf. **Table 12**) is found that there is a statistical significance only with reference to the importance given to the Economic dimension. Micro, and small organizations (less than 50 employees) seem to be less sensitive to the economic benefits derived from their own business as the median is lower compared to medium and large companies (more than 50 employees).

Table 12 *– Kruskal-Wallis test results for H4.*

TBL dimensions	***Number of employees***	***Median***	***P-value (P-value adjusted for ties)***
Economic	Less than 50	3	0.056
	More than 50	4	**(0.034)**
Environmental	Less than 50	3	0.399
	More than 50	3	(0.368)
Social	Less than 50	3	0.855
	More than 50	3	(0.843)

Finally, it is worth noticing the importance given to the three TBL dimensions considering the stage in which a company operates (H5). Surprisingly, companies operating at the distribution stage appear to be less sensitive to the environmental dimensions (median = 3 i.e., important

and mode = 2 i.e., low important, cf. **Table 13**) while companies operating at the primary production level seems to be strongly attentive to the environmental burden (min = 3 i.e., important) and both the median and the mode assume the highest possible value i.e., very important). In **Table 13** "N" is the number of total observations, "Min" is the smallest value in S_Ω, "Q1" is the first quartile, "Median" is the value separating the higher half from the lower half of a S_Ω, "Q3" is the third quartile, "Max" is the largest value in S_Ω, "IQR" is the Interquartile range computed as Q3 – Q1, "Mode" is the score that is repeated most often in S_Ω, and "N for Mode" is the number of times the mode appears.

This result is confirmed by the Kruskal-Wallis test (cf. **Table 14**) i.e., there is a statistical significance between the stage at which an organization operates, and the importance given to the Environmental dimension of the TBL that is higher for primary production companies with respect to organization operating at the processing and distribution levels. The results are not computed for the post-harvest handling and storage stage of the supply chain due to the little information available (cf. **Figure 35**).

Table 13 *– Descriptive statistics results considering the stage of the SC in which the company operates and the importance given to the TBL dimensions.*

Variable	Stage of the supply chain	N	Min	Q1	Median	Q3	Max	Range	IQR	Mode	N for Mode
TBL: Economic	Distribution	14	2	2.75	3	4	4	2	1.25	3	7
	Primary Production	15	1	3	4	4	4	3	1	4	10
	Processing	91	1	3	4	4	4	3	1	4	50
TBL: Environmental	Distribution	14	2	2	**3**	3.25	4	3	1.25	**2**	6
	Primary Production	15	**3**	3	**4**	4	4	1	1	**4**	9
	Processing	91	1	3	3	4	4	3	1	4	37
TBL: Social	Distribution	14	2	3	3	4	4	2	1	3	8
	Primary Production	15	3	3	4	4	4	1	1	4	10
	Processing	91	1	3	3	4	4	3	1	3	39

Table 14 *– Kruskal-Wallis test results for H5.*

TBL dimensions	*Stage of the Supply Chain*	*Median*	*P-value (P-value adjusted for ties)*
Economic	Primary production	4	0.251 (0.187)
	Processing	4	
	Distribution	3	

TBL dimensions	*Stage of the Supply Chain*	*Median*	*P-value (P-value adjusted for ties)*
Environmental	Primary production	4	**0.043**
	Processing	3	(0.027)
	Distribution	3	
Social	Primary production	3	0.140
	Processing	3	(0.068)
	Distribution	3	

Moreover, the face-to-face interviews will allow in-depth investigation of both the internal and external sustainability drivers and barriers.

According to the EU definition of a cooperative i.e., *an autonomous association of persons united to meet common economic, social, and cultural goals. They achieve their objectives through a jointly-owned and democratically-controlled enterprise*; it can be supposed that cooperatives give more importance to the Environmental and Social dimensions to traditional firms. Thus: *H6. A cooperative is not sensitive as a firm to the Environmental and Social dimensions.* The results of the Kruskal-Wallis test do not support this hypothesis. To this purpose, the face-to-face interviews will investigate this hypothesis in-depth by exploring the motivation and benefits of creating/joining a cooperative and how a cooperative can better fulfill the sustainability requirements.

8.2. Sustainable Practices Implementation

The second part of this analysis aims to investigate the degree of implementation of the practices concerning the characteristics of a company. The description of the practice is reported in the Appendix (cf. Appendix E).

First, starting from the year-wise distribution of the practices, some of them appear to be well-known within the scholarly papers, while others are a more recent field of study (cf. **Figure 29**). In this context, the maturity of implementation of a practice in the industrial world can be examined, by considering which ones are implemented for a large variety of products. Thus: *H7. Not all practices are implemented to the same extent e.g., frequently adopted for a large variety of products.* In the following, the maturity of implementation of sustainable practices is examined according to the four main dimensions already described (cf. **Figure 28**).

8.2.1. Upstream Practices

Upstream practices are broadly adopted by food companies (cf. **Figure 45**). In comparison to results from the literature which is less focused on P_2 than P_1 and P_3, in the industrial world

P_2 is almost as implemented as P_1 and P_3. In fact, the mode for three practices at issue shows the highest possible value of the rating scale as "the practice is frequently adopted for a large number of products". The median is slightly lower "the practice is rarely adopted for a large number of products or frequently adopted for certain products".

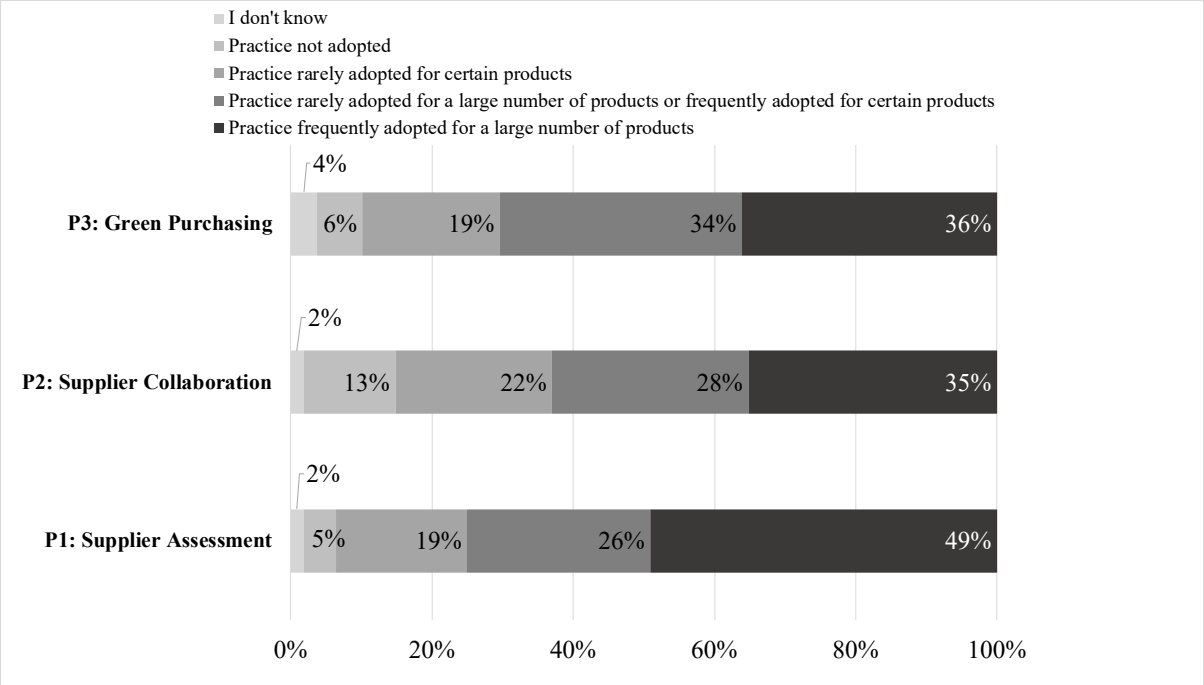

***Figure 45** – H7: Maturity of implementation of upstream practices.*

8.2.2. Sustainable Operation practices

To analyze the sustainable operations practices defined from the focal company point of view, the main stage of the SC at which each company operates is considered (cf. **Figure 46**). These results are not computed for the post-harvest handling and storage stage of the SC due to the little information available (cf. **Figure 35**). With reference to the cumulative frequency distribution, the set of activities aimed at preserving natural resources (P_{11}), protecting animal welfare (P_9), and soil conservation and management (P_{10}) are widely implemented at the primary production stage, while green packaging and production (P_5, P_6) appear to be slightly less adopted. At the processing stage, the mode of all the sustainable operations practices considered assumes the highest value, i.e., practice frequently adopted for a large number of products. Median values are different based on the sustainable operation practice considered. The median assumes the highest value for P_7 and P_{11} while for P_4, P_5, P_9 is equal to 3, i.e., practice rarely adopted for a large number of products or frequently adopted for certain products. At the distribution stage, both the mode and median for P_5 and P_9 assume the highest

possible value. The same is not true for P_4 and P_{11} that appear to be slightly less adopted. The results for sustainable operations practices are in line with the literature findings (cf. **Figure 28**). As already discussed, it is worth noticing that there is a statistical significance considering the stage of the SC in which a company operates, and the importance given to the environmental dimension, as p-value = 0.043 (cf. **Table 14**). Companies operating at the primary production stage give higher importance to the environmental dimension (median equal to 4, i.e., very important) than processing and distribution companies (median equal to 3, i.e., important). The same is not true considering economic and social dimensions.

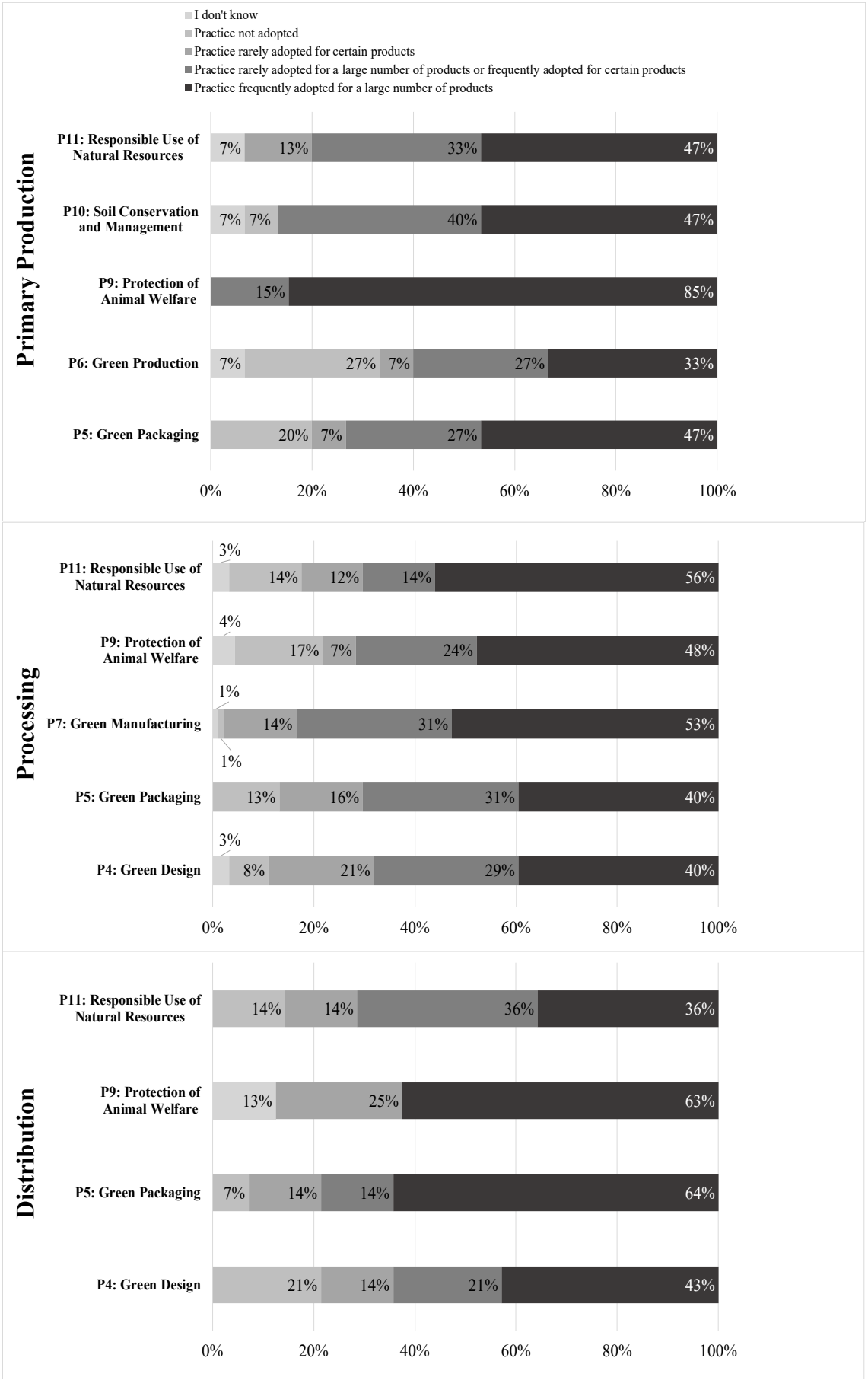

***Figure 46** – H7: Maturity of implementation of sustainable operations practices.*

8.2.3. DOWNSTREAM PRACTICES

Figure 47 describes the maturity of implementation of downstream practices. P_{14} is the least implemented practice in the operational world, despite the attention paid by the literature to this practice. Only 21% of the total respondents select less polluting methods of transport for a large number of products and for 33% the practice is not adopted. This point out the need to introduce transportation innovations in local, regional, and national food systems and in the way it is organized. Moreover, it is worth noticing that even if P_{12} appears to be widely implemented, its definition does not specifically address a "green" issue. Furthermore, the adoption of P_{12} is in line with the result obtained for P_{25} (cf. **Figure 48**).

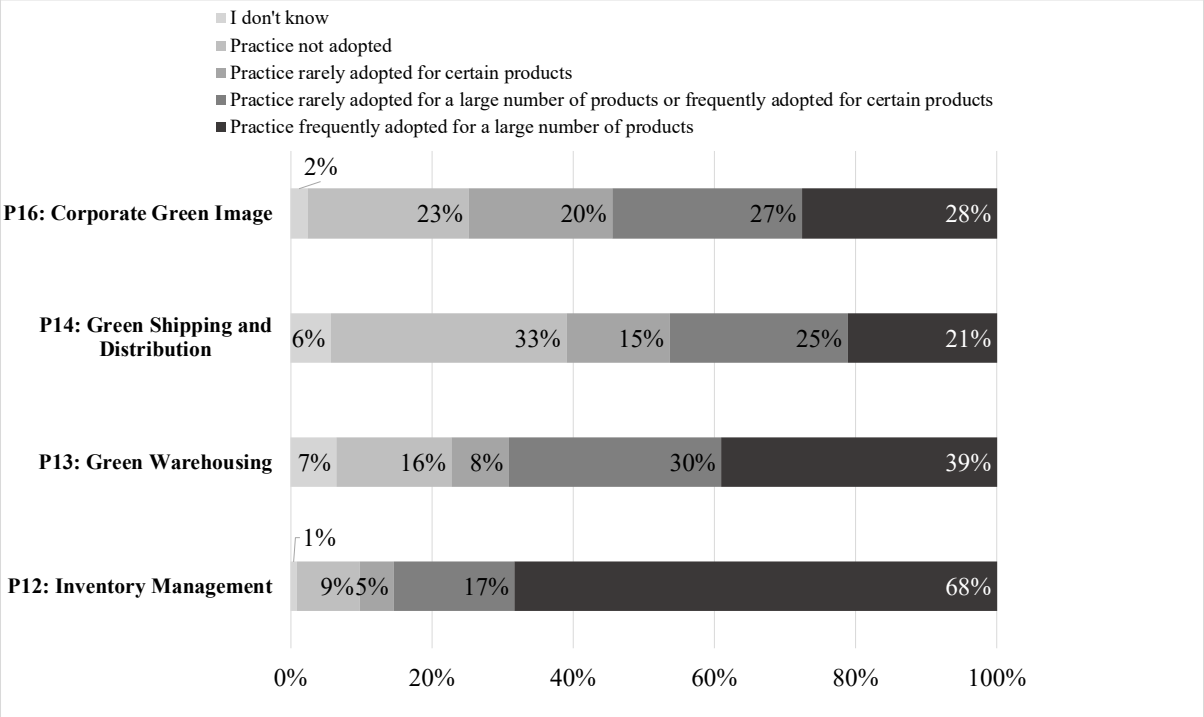

***Figure 47** – H7: Maturity of implementation of downstream practices.*

8.2.4. TRANSVERSAL PRACTICES

The maturity of implementation of transversal practices is depicted in **Figure 48**. Collaboration within a SC is recognized in literature as one of the most important practices to achieve sustainability. This aspect is not reflected in the frequency distribution of the implementation of the collaborative practices addressed in the questionnaire (P_{21} – P_{24}). Furthermore, an initial step toward achieving holistic sustainability objectives lies in a corporation's orientation toward sustainability (P_{18} and P_{19}). Even if, the concept of Corporate Social Responsibility is well-known on the academic side, in the business world P_{18} is not widely implemented. Moreover, P_{19} appears to be one of the least implemented practices.

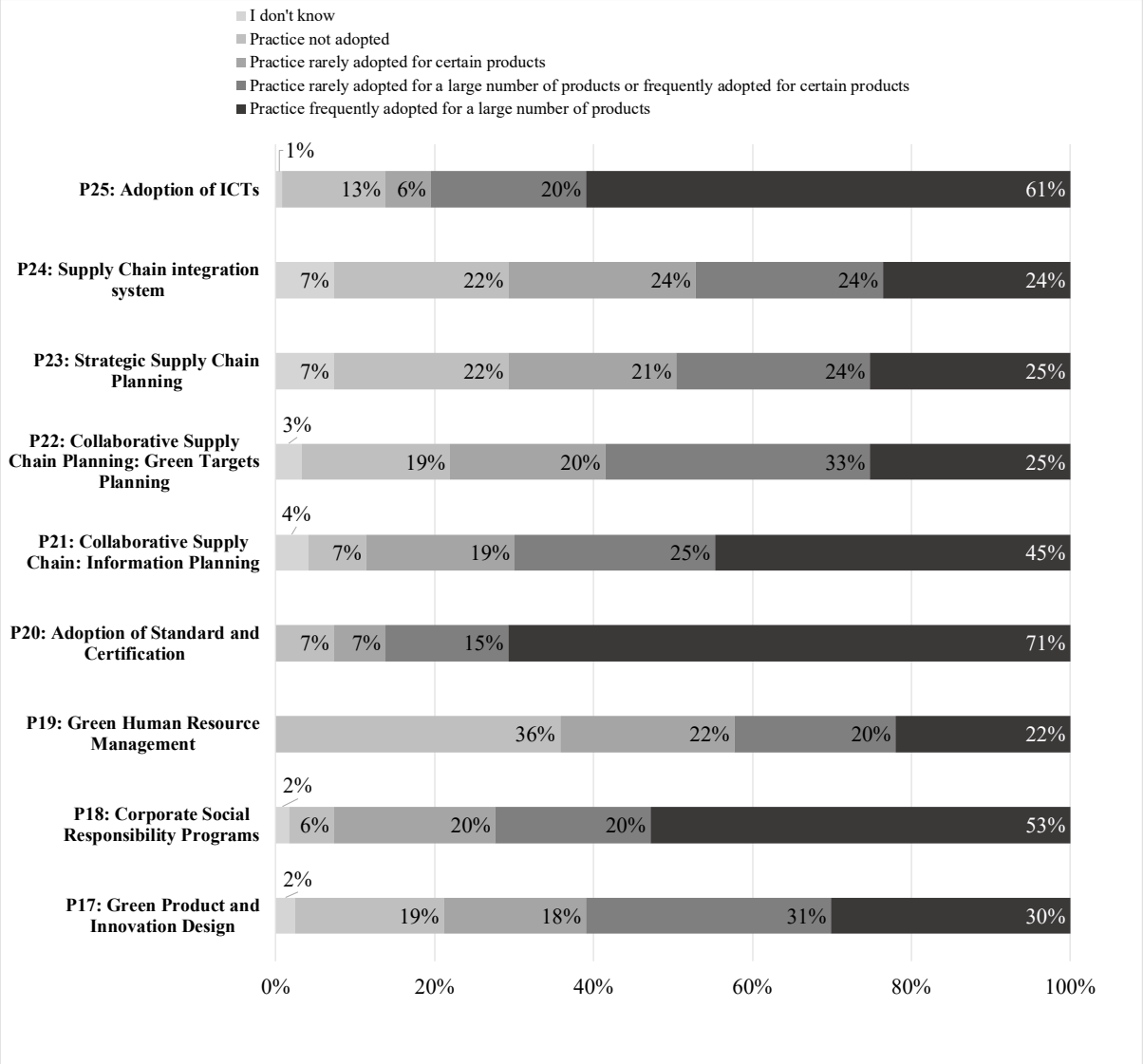

***Figure 48** – H7: Maturity of implementation of transversal practices.*

Finally, it is worth noticing that the presence of "the practice is not adopted" in almost all the practices identified, shows that even though the focus on sustainability concerns is increasing, this transition takes time. The least implemented practices are the set of collaborative supply chain practices specifically aimed at solving sustainability issues (P_{22} – P_{24}), P_{19}, P_{17} and P_{14}.

8.2.5. Descriptive Variables vs. Practices Implementation

As already discussed in the previous paragraph, external factors can force a company to adopt sustainability practices. Because of that:

H8. Firms that are part of a group show a different degree in the implementation of sustainable practices.

H9. There is a significant difference between companies operating in Italy and companies operating in France with respect to the degree of implementation of the sustainable practices.
H10. The size of the company influences the degree of implementation of sustainable practices.
By looking at the results of the statistical analysis conducted this is not true in a general way (cf. **Table 32**). In fact, the influence of external factors in the implementation of sustainable practices, depend on both the variables analyzed i.e., the practice and the external factor. In particular, firms that are part of a group show a higher degree of implementation of P_{11}, P_{19} and P_{20} (cf. **Table 15**) and the country in which a company operates influences the extent to which P_1, P_8 and P_{11} are implemented (cf. **Table 16**). This observation seems to be in contradiction with the results previously obtained. In fact, in the previous paragraph the conclusion that has been made is that Italian companies are less sensitive to the sustainability concerns with respect to French based companies. However, for sustainable practices that demonstrate a statistical influence with respect to their degree of implementation and the country of the company, the median value is always higher for Italian companies than for French companies.

Table 15 *– Kruskal-Wallis test results for H8.*

Practice	*Firm part of a group*	*Median*	*P-value (P-value adjusted for ties)*
P11: Responsible Use of Natural Resources	No	3	**0.013**
	Yes	4	(0.007)
P19: Green Human Resource Management	No	2	**0.004**
	Yes	3	(0.003)
P20: Adoption of Standard and Certifications*	No	4	0.066
	Yes	4	(**0.019**)

*The mean for firm that are part of a group is 3.755 while for firms that are not part of a group is 3.324.

Table 16 *– Kruskal-Wallis test results for H9.*

Practice	*Country of the firm*	*Median*	*P-value (P-value adjusted for ties)*
P1: Supplier Assessment	France	3	0.067
	Italy	4	**(0.047)**
P7: Green Manufacturing	France	3	**0.035**
	Italy	4	(0.019)
P11: Responsible Use of Natural Resources	France	3	0.055
	Italy	4	**(0.035)**

Similarly, the size of the company influences the implementation of sustainable practices. Numbers in the **Table 17** report the median of each sub-group. The results demonstrate that medium-sized and large organizations show a higher implementation of sustainable practices compared with micro and small organizations. Small companies systematically assume the lowest median value except for P_{20}. While it is possible to suppose that medium and large companies have more resources available to implement SSCM practices, the reason behind the values obtained for small companies is not easily deducible from the analysis performed.

***Table 17** – Kruskal-Wallis test results for H10.*

	Size of the company				***P-value***	***P-value adjusted***
Practice	*Micro*	*Small*	*Medium*	*Large*		
P1: Supplier Assessment	4	3	4	4	0.040	0.020
P11: Responsible Use of Natural Resources	3	3	4	4	0.006	0.002
P12: Inventory Management	4	3.5	4	4	0.007	0.000
P14: Green Shipping and distribution	3	1.5	1.5	3	0.032	0.023
P17: Green Product Innovation and Design	3	2	3	3	0.039	0.029
P19: Green Human Resource Management	1.5	1	2	3	0.014	0.009
P20: Adoption of Standard and Certifications	3	4	4	4	0.061	0.009
P22: Collaborative Supply Chain: Green Targets planning	3	2	3	3	0.010	0.006
P23: Strategic Supply Chain collaboration	2	2	3	3	0.003	0.002

As already discussed, the implementation of some practices could be conditioned upon the stage of the SC at which companies operate and the type of network they are in. First, it can be supposed that the higher the number of suppliers, the more difficult it is for the focal company to assess the environmental and social performances of each actor (P_1) and implement supportive activities (P_2). The same is true for companies handling different types of foodstuffs. As a part of Sustainable Supplier Management, the degree of implementation of P_3 is also considered. These practices can be extended to the request of standards and certifications (P_{20}). In fact, standards and certification are adopted as a demonstration that products or processes are carried out according to environmentally friendly methods and by respecting social criteria.

In this regard, a comparison between cooperatives and firms can be interesting. Hence, the following assumptions are made:

H11. The degree of implementation of P_1, P_2, P_3 and P_{20} is conditioned by the number of actors upstream with respect to the focal company.

H12. The degree of implementation of P_{20} is conditioned by the number of actors downstream with respect to the focal company.

H13. The degree of implementation of P_1, P_2, P_3 and P_{20} depends on the product portfolio of the company itself.

H14. Companies operating at the processing level are more sensitive to P_1, P_2 and P_3 with respect to distribution companies.

H15. The degree of implementation of P_1, P_2 and P_3 is conditioned by the fact that a company is a cooperative or a firm.

From the results obtained (cf. **Table 32**), it is possible to conclude that there is not a significant influence between the number of suppliers up- or down- stream and the degree of implementation of sustainable supplier management practices (P_1, P_2, and P_3). The same is true for P_{20}. Moreover, the number of products handled by a company has no influence on the implementation of P_1, P_2, P_3 and P_{20}. The same is true for cooperatives. With reference to H14, there is a statistical influence (p-value = 0.033) between the degree of implementation of P_1 and the main stage at which a company operates i.e., processing or distribution. Specifically, for processing companies the median value of P_1 is 3 i.e., the practice is frequently adopted for some products, or the practice is rarely adopted for a large variety of products, whilst for distribution companies, the median value is 4 i.e., the practice is frequently adopted for a large variety of product.

Next, considering the stage of the supply chain at which a company operates, the following assumptions are derived and discussed:

H16. P_6 or P_7 or P_{14} are implemented to the same extent for companies operating at the primary production or processing or distribution stage.

From the descriptive analysis conducted, it is possible to notice a difference in the degree of implementation between the three practices evaluated in the main stage of the supply chain to which the three practices are addressed (cf. **Table 18**). In Tables results, N is the number of total responses collected, "Sum" is the sum of the values of the Likert scale, "Min" is the smallest value in S_Ω, "Q1" is the first quartile, "Median" is the value separating the higher half from the lower half of a S_Ω, "Q3" is the third quartile, "Max" is largest value in S_Ω, "IQR" is the interquartile range computed as Q3 – Q1, "Mode" is the score that is repeated most often

in S_Ω and "N for Mode" is the number of times the mode appears. In fact, for processing companies, P_7 is highly implemented (both the median and the mode values achieve the highest possible score i.e., 4 = the practice is frequently adopted for a large variety of products) while P_6 and P_{14} evaluated at the primary or distribution stage shows lower values considering both the median. However, the significant difference in N (total number of observations) makes the interpretation of these results unsuitable for drawing general conclusions. Thus, the same assumption can be evaluated by considering the extent of implementation of P_7 and P_{14}, just focusing on processing companies for which N is the same (cf. **Table 19**) and with reference to companies operating at the primary production stage, evaluating respectively the extent to which P_6 and P_{14} are implemented (cf. **Table 20**).

Table 18 *– Descriptive statistics for H16.*

Variable	Stage of the SC	N	Min	Q1	Median	Q3	Max	Range	Mode	N for Mode
P6: Green Production	Primary Production	14	1	1	3	4	4	3	4	5
P7: Green Manufacturing	Processing	91	1	3	4	4	4	3	4	48
P14: Green Shipping and Distribution	Distribution	15	1	1.5	3	4	4	3	4	4

Table 19 *– Descriptive statistics for H16, evaluated for processing companies only.*

Variable	Stage of the SC	Sum	Min	Q1	Median	Q3	Max	Range	Mode	N for Mode
P7: Green Manufacturing	Processing	303	1	3	4	4	4	3	4	48
P14: Green Shipping and Distribution	Processing	194	1	1	2	3	4	3	1	35

Table 20 *– Descriptive statistics for H16, evaluated for processing companies only.*

Variable	Stage of the SC	Sum	Min	Q1	Median	Q3	Max	Range	Mode	N for Mode
P6: Green Production	Primary Production	38	1	1	3	4	4	3	4	5
P14: Green Shipping and Distribution	Primary Production	38	1	1,75	3	4	4	3	3	5

From the results of the descriptive statistical analysis carried out (cf. **Table 20**), it is interesting to notice that concerning the primary production stage, P_{14} seems to be adopted to the same

extent as P_6 (sum = 38 and median = 3 i.e., the practice is rarely adopted for a large number of products, or the practice is frequently adopted for some products/services) while for processing companies there is a significant difference with respect to the degree of implementation of P_8 and P_{13}. However, the Kruskal-Wallis test does not support this hypothesis i.e., The extent to which P_{13} is implemented is conditioned upon the stage of the supply chain. Thus, the differences in the results obtained must be interpreted with caution.

Moreover, it can be interesting to evaluate if the degree of processing of the foodstuffs has an impact on the degree of implementation of P_7, considering that unprocessed or minimally processed foods require fewer industrial processes application with respect to ingredients or ultra-processed produce. Thus: *H17. An organization handling ingredients or ultra-processed products is not sensitive as to P_7 with respect to an organization treating unprocessed or minimally processed products.* From the results of the Kruskal-Wallis test (cf. **Table 32**), this assumption is not verified. Thus, there is not a statistical significance between the degree of processing of products and the extent of implementations of P_7.

On the primary production side, the most relevant practices in terms of operations are P_9, P_{10} and P_{11}, thus: *H18. At the primary production stage, P_9, P_{10} and P_{11} are equally implemented.*

Table 21 *– Descriptive statistics results for H18.*

Variable	Sum	Min	Q1	Median	Q3	Max	Range	IQR	Mode	N for Mode
P9: Protection of Animal Welfare	50	3	4	4	4	4	1	0	4	11
P10: Soil Conservation and Management	47	1	3	4	4	4	3	1	4	7
P11: Responsible Use of Natural Resources	47	2	3	3.5	4	4	2	1	4	7

From the results obtained, both median and mode assume very high values (cf. **Table 21**). Thus, it can be concluded that the set of activities aimed at preserving the external environment are widely and equally implemented at the primary production stage. Furthermore, the most implemented one appears to be P_9, as it assumes 3 as minimum.

Sustainability practices specifically addressing the distribution stage are P_{12}, P_{13} and P_{14}. Thus: *H19. At the distribution stage, P_{12}, P_{13} and P_{14} are equally implemented.* It can be observed that, at this stage of the supply chain, the degree of implementation of both P_{12} and P_{13} is high while P_{14} is slightly less adopted. **Table 23** show that the correlation among the degree of implementation of these practices appears to be moderate.

Table 22 *– Descriptive statistics for H19.*

Variable	Sum	Min	Q1	Median	Q3	Max	Range	IQR	Mode	N for Mode
P12: Inventory Management	48	1	3	3	4	4	3	1	4	7
P13: Green Warehousing	36	1	2	3.5	4	4	3	2	4	6
P14: Green Shipping and Distribution	37	1	1.75	3	4	4	3	2.25	3; 4	4

Table 23 *– Spearman correlation coefficient results for H19. Cronbach's Alpha = 0,7904.*

	P12: InventoryManagement	P13: Green Warehousing
P13: Green Warehousing	0,713	
P14: Green Shipping and Distribution	0,572	0,554

Finally, it could be interesting to notice if cooperatives are more attentive to the external environment and the use of natural resources. Thus: *H20. A firm is not sensitive as a cooperative to the environmental burden (P_{11}).* The Kruskal-Wallis test result shows that there is not a statistical significance of firms vs. cooperatives considering the extent to which activities to preserve the natural environment are implemented (cf. **Table 32**).

Collaboration within a SC is recognized as one of the most important practices to achieve sustainability. Trust and cooperation are at the base of all supply chain activities implemented in collaboration. In this regard, it can be assumed that collaborative practices i.e., P_{21}, P_{22}, P_{23} and P_{24} are easily implemented in supply chains in which few actors are involved. Thus:

H21. The number of actors upstream influences the importance given to collaborative practices P_{21}, P_{22}, P_{23} and P_{24}.

H22. The number of actors downstream influences the importance given to collaborative practices P_{21}, P_{22}, P_{23} and P_{24}.

Kruskal-Wallis test results (cf. **Table 32**) show that there is not a statistical significance between the extent of implementation of collaborative practices and the number of actors in the supply chain. Following the definition of a cooperative, it is possible to investigate if: *H23. Cooperatives show a different degree of implementation to collaborative practices $P_{20,1}$, $P_{20,2}$, P_{21} and P_{22} with respect to firms.*

Table 24 *– Kruskal-Wallis test results for H23.*

Cooperative	***Median***	***Mean***	***P-value (P-value adjusted for ties)***
No	3	2.58	0.025
Yes	3	3.25	(0.020)

This assumption is verified for P_{22} i.e., sustainability targets are shared with the other actors in the supply chain i.e., suppliers and/or customers (cf. **Table 24**). Thus, it can be observed that cooperatives show a higher degree of implementation of P_{22} than firms. Anyway, it is worth noticing that sustainable collaborative practices are widely discussed in the literature. In the analysis carried out the attention has been limited to P_{21}, P_{22}, P_{23} and P_{24}.

An initial step toward achieving holistic sustainability objectives lies in a corporation's orientation toward sustainability (P_{18}). Under this light, Green Human Resource Management (P_{19}) can be adopted as a support to spread green values and culture that in turn can enhance the implementation of sustainable practices. Considering the internal and/or external drivers, the organization environment and according to the definition of a cooperative, it is possible to hypothesize that: *H24. A firm is not sensitive as a cooperative to its social impact (P_{18} and P_{19}).* From the analysis carried out this assumption is not verified thus, there is not a statistical influence considering firm vs. cooperatives and the extent of implementation P_{18} and P_{19} (cf. **Table 32**).

Finally, the positive impacts related to P_{25} at the environmental dimension can be ascribed to lower the consumption of resources, reducing emissions and food losses and wastages. Concerning the social aspect, P_{25} improves traceability, food safety, transparency, communication, and coordination among actors. Thus:

H25. The degree of implementation of P_{25} depends on the number of actors upstream.

H26. The degree of implementation of P_{25} depends on the number of actors downstream.

H27. The degree of implementation of P_{25} is conditioned upon the product portfolio of a company.

From the results obtained (cf. **Table 32**), there is not a statistical significance between the degree of the implementation of P_{25} and both the number of actors within the supply chain or the product portfolio of the company.

8.3. TBL DIMENSIONS VS. PRACTICES IMPLEMENTATION

Following the definition of each practice (cf. Appendix E), it is possible to hypothesize that the extent to which the three dimensions of the Triple Bottom Line (TBL) are considered important influences the degree of implementation of sustainable practices. This will be evaluated considering the pairs "degree of implementation of a practice" and "importance given to the three dimensions of the Triple Bottom Line". The underlying assumption is that a company that gives higher importance to each one of the TBL dimensions also implements practices devoted to lowering the impact at the environmental and social level and enhancing the economic dimension. The correlation between the importance given to each of the three TBL dimensions and the degree of implementation of sustainable practices is assessed through the Spearman correlation coefficient (cf. **Table 25**) while the Kruskal-Wallis test is deployed to verify the influence of the importance given to the three TBL dimensions on the degree of implementation of sustainable practices (cf. **Table 26**, **Table 27**, **Table 28**).

Table 25 *– Spearman rank correlation coefficient TBL dimensions vs. Sustainable practices. Cronbach's alpha = 0.9153.*

	Economic	***Environmental***	***Social***
P1	0,036	**0,268**	0,131
P2	-0,018	**0,211**	0,109
P3	0,086	**0,382**	0,166
P4	0,069	**0,395**	**0,224**
P5	0,030	0,144	0,057
P6	-0,185	**0,213**	-0,164
P7	**0,224**	**0,409**	**0,309**
P9	-0,146	0,077	-0,004
P10	**-0,221**	**0,340**	0,083
P11	0,019	0,196	0,168
P12	0,152	-0,050	-0,015
P13	0,060	0,164	0,056
P14	0,033	**0,275**	0,154
P16	0,112	**0,346**	0,169
P17	0,029	0,180	0,090
P18	0,058	**0,291**	**0,249**
P19	0,156	**0,287**	0,182
P20	0,164	0,015	0,022
P21	0,010	0,018	0,022
P22	0,106	**0,297**	0,189
P23	0,111	**0,223**	0,085

	Economic	*Environmental*	*Social*
P24	0,049	**0,216**	0,134
P25	0,091	0,112	0,039

From the results of the correlation analysis, there is a weak positive rank correlation between the degree of implementation and the importance given to the economic dimension of the TBL ($r_s = 0.224$) and a weak negative correlation between the degree of implementation of P10 and the importance given to this TBL dimension ($r_s = -0.221$). From the environmental point of view, the extent of implementation of many practices appears to be correlated with the importance given to the environmental dimension of the TBL. In the specific, the extent to which sustainable supplier management practices (cf. **Table 25**) i.e., P_1, P_2 and P_3 are implemented show a weak positive rank correlation with the importance given to the environmental dimension ($r_s(P_1) = 0.268$, $r_s(P_2) = 0.211$, and $r_s(P_1) = 0.382$). Considering sustainable operation and risk management practices, P_4 ($r_s = 3.95$), P_6 ($r_s = 213$), P_{10} ($r_s = 340$), and P_{14} ($r_s = 0.275$) show a weak rank positive correlation with respect to the importance given to the environmental dimension while there is a moderately strong correlation between the degree of implementation of P_7 ($r_s = 0.409$) and the environmental dimension. Moreover, there is a weak rank positive correlation between the degree of implementation of P_{16}, P_{18}, P_{19}, P_{22}, P_{23} and P_{24} and the importance given to the environmental dimension of the TBL. Finally, sustainable practices that appear to be weak rank positively correlated with the importance given to the social dimension are P_4 ($r_s = 0.224$), P_7 ($r_s = 0.309$) and P_{18} ($r_s = 0.249$). Even if a greater influence was expected considering the importance given to the economic dimension and the degree of implementation of sustainable practices (cf. **Table 26**), the results obtained are in line with the description adopted for the practices themselves. Indeed, the Kruskal-Wallis analysis shows that the greater the importance given to the economic dimension, the greater the implementation of P_{16}. That is, to obtain a competitive advantage in the market, environmentally friendly processes and products are developed or improved. In line with this, Kruskal-Wallis test results show a significant influence between the importance given to the Economic dimension and P_7 that is, the more the economic dimension is considered important, the more technologies to reduce the environmental impact are deployed in manufacturing activities. From the perspective of the environmental dimension, the Kruskal-Wallis test showed that there is a statistically significant difference between the importance given to the environmental dimension itself and several of the practices considered (cf. **Table 27**). In all cases where the statistically significant difference is verified, it can be

observed that as the importance given to the environmental dimension increases, the degree of implementation of the practices increases as well. Finally, considering the social dimension, some results are in line with the expected ones (cf. **Table 28**).

That is, from the description of P_{18} and P_{19} it is possible to deduce that the more the social dimension is considered important, the more the company implements practices in this regard. In fact, this is confirmed by the Kruskal-Wallis analysis. Whereas, surprisingly, there is not a significant difference considering both sustainable supplier management practices (P_1, P_2) and collaborative practices (P_{21}, P_{23} and P_{24}) and the importance give to the social dimension. This is true, except for P_3 and P_{22} i.e., the more the social dimensions is considered important, the more the purchase of a product is based on cost, quality and performance together with its impact on the environment (P_3) and the more sustainable targets are shared with the other actors in the supply chain such as suppliers or customers (P_{22}).

It is important to emphasize that the environmental dimension is undoubtedly the easiest to assess in terms of importance because the way it is defined is clear and precise and not subject to free interpretation. On the contrary, the importance of the economic dimension could be due to a difference in assessment by the respondent, i.e., whether the short or long term is considered. Similarly, the definition of the social dimension is more subject to free interpretation by the respondent. This consideration should be kept in mind, when interpreting the results obtained.

Moreover, the in-depth part of the questionnaire will determine if the implementation of each practice has a positive, neutral, or negative impact on each of the TBL dimensions. Furthermore, a discussion on the sustainable practices that require the biggest investment and/or social efforts to be implemented, will be addressed. Finally, a comparison between the most established and most recent ones is discussed.

Table 26 *– Kruscal-Wallis test results TBL:Economic vs. sustainable practices. Likert scale data for Economic dimension columns contain the median value of the degree of implementation of each practice, compared to the value attributed to the Economic dimension. SS = Statistical Significance.*

	Likert Scale for Economic dimension				***Kruskal-Wallis test***	
Practices	*Not important at all*	*Low important*	*Important*	*Very important*	***SS****	***p-value***
P1	3.5	3	4	3.5	*No*	*0.757*
P2	2	3	3	3	*No*	*0.658*
P3	3.5	3	3	3	*No*	*0.606*
P4	2	3	4	3	*No*	*0.267*
P5	2	3	4	3	*No*	*0.110*
P6	4	-	2.5	3	*No*	*0.535*
P7	**3**	**2.5**	**4**	**4**	***Yes***	***0.002***
P9	4	4	4	4	*No*	*0.667*
P10	4	-	3.5	3	*No*	*0.656*
P11	3	3	4	4	*No*	*0.389*
P12	1	4	4	4	*No*	*0.356*
P13	1	3	4	3	*No*	*0.153*
P14	1	1.5	3	3	*No*	*0.467*
P16	**1**	**2**	**3**	**3**	***Yes***	***0.015***
P17	2	2	3	3	*No*	*0.624*
P18	2	3	4	4	*No*	*0.424*
P19	1	2	2	3	*No*	*0.152*
P20	4	4	4	4	*No*	*0.378*
P21	2	3	3	3	*No*	*0.314*
P22	1	2	3	3	*No*	*0.122*
P23	2	2	3	3	*No*	*0.726*
P24	2	2	3	2.5	*No*	*0.485*
P25	1	4	4	4	*No*	*0.553*

* As the p-value is less than the significance level 0.05, we can conclude that there are significant differences according to the text of the hypothesis.

Table 27 *– Kruscal-Wallis test results TBL: Environmental vs. practices. Likert scale data for Environmental dimension columns contain the median value of the degree of implementation of each practice, compared to the value attributed to the Environmental dimension. SS = Statistical Significance.*

	Likert Scale for Environmental dimension				***Kruskal-Wallis test***	
Practices	*Not important at all*	*Low important*	*Important*	*Very important*	***SS****	***p-value***
P1	**2.5**	**3**	**3**	**4**	***Yes***	*0.070* ***(0.040)***
P2	2	3	3	3	*No*	*0.086*
P3	**2**	**2**	**3**	**4**	***Yes***	***0.001***
P4	**2**	**2**	**3**	**4**	***Yes***	***0.002***
P5	2	3	3.5	3	*No*	*0.130*
P6	-	-	3	3	*No*	*0.463*
P7	**2**	**3**	**3**	**4**	***Yes***	***0.002***
P9	2.5	4	3	4	*No*	*0.156*
P10	-	-	3	4	*No*	*0.272*
P11	2.5	3	3	4	*No*	*0.275*
P12	3.5	4	4	4	*No*	*0.891*
P13	**1**	**3**	**3**	**3**	***Yes***	***0.014***
P14	**1**	**2**	**2**	**3**	***Yes***	***0.007***
P16	**1**	**2**	**3**	**3**	***Yes***	***0.001***
P17	2	3	3	3	*No*	*0.096*
P18	**1**	**2.5**	**4**	**4**	***Yes***	***0.003***
P19	**1**	**2**	**2**	**3**	***Yes***	***0.002***
P20	4	4	4	4	*No*	*0.907*
P21	2	3	4	3	*No*	*0.674*
P22	**1**	**3**	**3**	**3**	***Yes***	***0.002***
P23	**1.5**	**3**	**2**	**3**	***Yes***	***0.043***
P24	**1**	**2**	**3**	**3**	***Yes***	*0.053* ***(0.043)***
P25	4	4	4	4	*No*	*0.808*

* As the p-value is less than the significance level 0.05, we can conclude that there are significant differences according to the text of the hypothesis.

Table 28 *– Kruscal-Wallis test results TBL: Social vs. practices. Likert scale data for Social dimension columns contain the median value of the degree of implementation of each practice, compared to the value attributed to the Social dimension. SS = Statistical Significance.*

	Likert Scale for Social dimension				***Kruskal-Wallis test***	
Practices	*Not important at all*	*Low important*	*Important*	*Very important*	***SS****	***p-value***
P1	2	3	3	4	*No*	*0.589*
P2	2	3	3	3	*No*	*0.457*
P3	2	3	3	3	*No*	*0.146*
P4	**1.5**	**2.5**	**3**	**3**	***Yes***	***0.048***
P5	2.5	3	4	3	*No*	*0.364*
P6	-	-	3.5	3	*No*	*0.572*
P7	**2**	**3**	**4**	**4**	***Yes***	***0.030***
P9	2.5	4	4	4	*No*	*0.362*
P10	-	-	3	4	*No*	*0.790*
P11	3	3.5	3.5	4	*No*	*0.382*
P12	3	4	4	4	*No*	*0.564*
P13	1	4	3	3	*Yes*	*0.099*
P14	1	2	2	3	*No*	*0.290*
P16	1	2	3	3	*No*	*0.105*
P17	2	3	3	3	*No*	*0.409*
P18	**1**	**4**	**3**	**4**	***Yes***	***0.013***
P19	**1**	**2**	**2**	**3**	***Yes***	***0.028***
P20	3.5	4	4	4	*No*	*0.594*
P21	4	3	3	3	*No*	*0.804*
P22	1.5	2.5	3	3	*Yes*	*0.092 (0.074)*
P23	2.5	3	2	3	*No*	*0.310*
P24	1	2	2	3	*No*	*0.247*
P25	3.5	4	4	4	*No*	*0.950*

* As the p-value is less than the significance level 0.05, we can conclude that there are significant differences according to the text of the hypothesis.

9. CRITICAL ANALYSIS OF THE RESULTS

The Triple Bottom Line approach is one of the fundamental pillars that is adopted when trying to link the operational world to sustainability requirements. It is based on the economic, environmental, and social aspects that a business should be accountable for. The first axe refers to the economic benefits of an organization, the environmental axe is intended as a coexistence with the external environment and responsible use of resources while the social axe stress out the importance of fair and beneficial business practices toward labor, the community, and the region in which a corporation conduct its business. The increasing attention paid to the Sustainable Development and Sustainable Supply Chain Management concepts and the most recent scientific papers allow to figure out the well-known or best practices that companies should pursue to "green" their operations. However, studies across these topics frequently fail in taking into consideration the whole FSC. A best practice is defined as: "*Any practice or experience which has proved its value or which is used in an efficient way in an organization, and can be applied in other organizations*"[1]. A best practice has three characteristics: it is formalized, reusable and effective . The third criteria include the relevance, coherence, effectiveness, efficiency, robustness and sustainability of the value created by the implementation of a practice [24]. The final aim of the empirical research performed is twofold. First, it is used to validate the model derived from the literature review concerning the practices that a food industry should implement to meet the Sustainable Development requirements. Next, a comparison between Italian and French companies is carried out to analyze the external factors that influence the importance attributed to the three TBL dimensions and the degree of implementation practices as well. Moreover, the analysis carried out allow to investigate which are the best practices currently implemented in the food industry to achieve sustainability considering separately its three dimensions of sustainability.

First, the three dimensions of sustainability are not considered equally important in the operational world. In the specific, the environmental and the social dimensions are considered slightly less important than the economic. Under this light, it is worth noticing that only 28.5% (35 out of 123) of the respondents rated all the three sustainability axes as having the highest value of importance. However, the variability of the importance given to the three dimensions appears to be the same. Furthermore, it has been shown that the country in which a company operates has an influence on the economic and social dimensions but not on the environmental one. For French companies, the economic and social dimensions appear to be more important than the Italian ones. Concerning the size of the organization, micro, and small enterprises i.e.,

less than 50 employees seem to be less sensitive to the economic benefits derived from their own business than medium or large enterprises i.e., more than 50 employees. The same is not true considering the environmental and social impact. Finally, there is a significant influence between the stage at which a company operates, and the importance given to the environmental dimension. For companies operating at the primary production level, the environmental dimension is considered very important i.e., the highest value of the Likert scale adopted, while processing and distribution companies are less sensitive to the environmental burden derived from their operations. There is not greater importance given to the environmental and social axes by cooperatives with respect to traditional firms, as it might be assumed. However, cooperatives count for 13.8% of the sample size (17 out of 123 responses collected) thus, this result may be confirmed or contradicted by enlarging the analysis. In the end, it is worth noticing that while the definition of the environmental dimension is more delineated and therefore less prone to misinterpretation or difference in judgments, when addressing the economic and social dimensions, free interpretation can be a crucial component in conditioning the outcome of the analysis carried out, even if the definition was reported in the questionnaire submitted.

Next, the maturity of implementation of the sustainable practices is analyzed. First, it is worth noticing that the lowest value of the adopted Likert scale is present in all practices i.e., the practice is not adopted. This is surprising since it has been shown that sustainability concerns are an increasing field of study of the scientific arena and deemed very important in the operational world. However, even if the lowest value of the Likert scale is present in all practices, the percentage of responses that have obtained the minimum value represents a small fraction compared to the total. Consequently, it is possible to conclude that even though the focus on sustainability concerns is increasing dramatically, this transition takes time. Furthermore, it is important to notice that all the practices are for more than 50% frequently implemented for many products or rarely adopted for a large variety of products or are largely implemented for all the products. This consideration does not hold for Green Shipping and Distribution and Green Human Resource Management, which are the least implemented among the sustainable practices identified. Moreover, there is a statistical significance between the external factors considered i.e., if the firm is part of a group, the country in which a company operates, and the dimensions, and the degree of implementation of some sustainable practices. Among the practices for which this assumption holds, if the company is part of a group, it demonstrates a higher median in the degree of implementation of the practices. Therefore, it can be concluded that being part of a group positively influences the adoption of sustainable

practices. The same is true considering Italian-based companies with respect to French-based ones. In fact, if the country in which the company has a significant influence on the degree of implementation of sustainable practices, the median values are higher for Italian companies than for French companies. Although this result may seem to contradict those previously obtained with respect to the importance given to the economic and social dimensions of sustainability, which were greater for French companies, it should be considered that the practices for which this hypothesis is verified are specifically focused on the environmental axe. Finally, medium-sized and large organizations show a higher implementation of sustainable practices with respect to micro and small organizations. Surprisingly, small companies systematically assume the lowest median value. This consideration does not hold for P19: Adoption of standard and Certifications. In fact, in this case, the lowest median value is showed by micro-companies. This can be due to the expenditures required to comply with the standard and/or certifications requirements.

The implementation of some practices could be conditioned upon the stage of the SC at which the companies operate and the type of network they are in. It has been shown that there is not a significant influence between the number of suppliers up- or down- stream and the degree of implementation of sustainable supplier management practices (P_1, P_2, and P_3). The same is true for P_{19}. Moreover, the number of products handled by a company has no influence on the implementation of P_1, P_2, P_3 and P_{19}. The same is true for cooperatives. Considering the main stage of the supply chain in which a company operates, the set of activities aimed at preserving natural resources, animal welfare and soil are equally implemented at the primary production stage (P_9, P_{10}, P_{11}). From the data gathered, it has been shown that at the primary production stage, environmentally friendly methods are adopted to lower the environmental burden both for the productive (P_6) and distributing activities (P_{14}) while for processing companies there is a significant difference with respect to the degree of implementation of P_7 i.e., the introduction of green technologies in manufacturing activities, and P_{14}. There is no evidence that an organization handling unprocessed or minimally processed products is not sensitive to P_7 as an organization treating ultra-processed products. Moreover, distribution companies are more prone to consider the environmental performances of their supplier than processing companies. At the distribution stage, P_{12} and P_{13} are implemented to the same extent while P_{14} is slightly less adopted. In this regard, it is worth noticing that there is a statistical significance considering the stage of the supply chain in which a company operates, and the importance given to the environmental dimension. In fact, companies operating at the primary production stage give higher importance to the environmental burden than processing or distributing organizations.

Finally, there is not a statistical significance that a firm is not sensitive as a cooperative, by considering the extent to which activities to preserve the natural environment are implemented. Building on the TBL paradigm, the findings reveal which sustainable practices have a significant influence on economic, environmental, and social dimensions. The underpinning assumption is that a company that gives higher importance to each one of the TBL dimensions also implements practices devoted to lowering the impacts at the environmental and social levels and enhancing the economic dimension. Concerning the economic dimension, it is possible to conclude that environmentally friendly processes and products are developed or improved to obtain a competitive advantage in the market. In line with this, the more the economic dimension is considered important, the more technologies to reduce the environmental impact are deployed in manufacturing activities. To lower the environmental impact and to conserve natural resources suppliers are selected by considering their sustainability performances (P_1), products are purchased based on cost, quality, and performance together with its impact on the environment (P_3) and/or these are conceived by enhancing their quality and by reducing their adverse impact on the environment throughout its life cycle (P_5). In this regard, a set of actions or technologies are deployed in manufacturing activities with the intent to reduce emissions, energy, or water consumption (P_8). The implementation of P_5 and P_8 are effective also on lowering the social impacts. Surprisingly, the selection and use of the proper type of packaging to prevent the waste of food and to lower the environmental burden (P_6), the adoption of environmentally friendly methods deployed at the primary stage (P_7), and the deployment of environmental management systems specifically focused on the use of natural resources, animal welfare and soil management (P_9, P_{10}, P_{11}), seem not to have a statistical significance on the importance given to the environmental dimension. Furthermore, designing warehouses by considering both the point of view of the location of the facilities and internal design of the warehouse itself (P_{13}), selecting less polluting modes of transportation such as eco-friendly refrigerant, intermodal way of transport (P_{14}), and developing or improving environmentally friendly processes and products to enhance the green image of a company and in turn, as a lever of competitive advantage in the market (P_{16}) also helps to improve the environmental dimension. However, there is no evidence that settling Research & Development activities for introducing or obtaining environmentally friendly products or packaging (P_{17}) has a direct impact on the environmental dimension. Moreover, the implementation of corporate social responsibility programs (P_{18}) coupled with the spreading of green values and culture (P_{19}) within a company are effective in enhancing both the environmental dimension and social dimensions. The sustainable collaborative practices

that specifically address environmental issues have a statistical influence on the environmental dimension, but not on the social one. Thus, the sharing of sustainable targets with suppliers and/or customers (P_{22}), the creation of strategic alliances with other actors in the supply chain to achieve mutually relevant benefits (P_{23}) and performing collaborative sustainable activities such as collaborative waste reduction and environmental innovations, the introduction of adoption of environmental technologies, and the joint development of recyclable products (P_{24}) are effective on lowering the environmental burden

PART 3 – SUSTAINABLE FOOD SUPPLY CHAIN: FACE-TO-FACE INTERVIEWS

The aim of this research project is to discuss the integration of sustainable practices into supply chain management in the food industry. To this end, properest sustainable supply chain management practices targeting the food industry are identified through a systematic literature review and discussed in the first part of this research project. The second part of this document addresses the maturity of implementation of the identified practices by companies operating in this sector. In addition, the discussion examines the importance attributed to the three sustainability dimensions and their relationship with the implementation of sustainable practice through statistical analysis. Finally, the third part of the document is devoted to enlarging the conclusion already observed. The third part should therefore be intended as an extension of the empirical analysis previously presented. The third part of this document is structured as follow:

- *Chapter 10 – Sample description*, to contextualize the obtained results and the related outcomes, the set of respondents who participated in the face-to-face interviews is presented.

- *Chapter 11 – Face-to-face interview outcomes*, the questions addressed during the interview are discussed one by one, thus creating a link between what has been observed in the literature and what has been statistically analyzed.

10. Sample Description

The sample involved in this second part of the study is a subset of the statistical sample from which the presented empirical analysis is conducted. 11 out of 124 of the total respondents agreed to participate to the face-to-face interview. Given the limited number of respondents, the proposed analysis is mainly qualitative. In the following, the same variables discussed in the first part of the empirical analysis are reported, considering the subset of respondents participating in the face-to-face interview. To preserve the anonymity of respondents, companies are distinguished by considering the nature of the business, i.e., firms "F" or cooperatives "C" and the number of employees, i.e., small "S", medium "M" or large "L" organizations, as follows:

• SF1: Italian company that processes semi-finished products for bakery. The company is not part of a group. Number of employees: between 10 and 49. Department of the respondent and number of years of experience in that department: Research and Development, 10 years.

• SF2: Italian dairy company that directly manages every phase of its supply chain, from the cultivation of forage to the production of milk and cheese. The company is not part of a group. Number of employees: between 10 and 49. Department of the respondent and number of years of experience in that department: Sales & Marketing, 1 year.

• SF3: Italian company that distributes oils and the related vegetable fuel obtained as residuals from oils. The company is part of a group based in Italy. Number of employees: between 10 and 49. Department of the respondent and number of years of experience in that department: Sales & Marketing, 20 years.

• MF1: Italian dairy company that handles the milk coming from flocks from all over the region in which the company operates and processed it to obtain cheeses and related products. 65% of its turnover is realized in Italy and 35% in international markets. The company is not part of a group. Number of employees: between 50 and 250. Department of the respondent and number of years of experience in that department: Research & Development, 21 years.

• MF2: French company processing the industrial production of bread and fresh pastries. The company is not part of a group. Number of employees: between 50 and 250. Department of the respondent and number of years of experience in that department: General Management, 15 years.

• MF3: Italian company specialized in the production of chocolate, milk chocolate, and hazelnut creams. The company is not part of a group. Number of employees: between 50 and

250. Department of the respondent and number of years of experience in that department: General Management, 13 years.

• LF1: Italian company world leader in plant-based products. It processes over 500 varieties of vegetables, divided into four categories: canned, fresh, frozen, and ready-to-eat meals. The company is part of a group based in France. Number of employees: more than 250. Department of the respondent and number of years of experience in that department: Logistics, 15 years.

• LF2: Italian company, operating in the sector of cold cuts, snacks, finger foods and gastronomic specialties for large retail chains, supermarkets, discount stores and specialty stores. Active in more than 50 countries with its brands and products. The company is part of a group based in Italy. Number of employees: more than 250. Department of the respondent and number of years of experience in that department: General Management, 5 years.

• LF3: Italian company that is the leading producer in Europe of preserved pulses, chopped and peeled tomatoes in the retail segment, the first producer in Europe of private labels pasta sauces, and one of the main producers in Italy of fruit juices and beverages. The company is part of a group based in Italy. Number of employees: more than 250. Department of the respondent and number of years of experience in that department: Research & Development, 30 years.

• SC1: Italian dairy cooperative operating at the primary production stage (breeding). The cooperative is part of a group based in Italy. Number of employees: between 10 and 49. Department of the respondent and number of years of experience in that department: Production, 6 years.

• MC1: Italian dairy cooperative. It is the reference company in the dairy chain of the region in which it operates, and all its members are located within the region and surrounding territories. The cooperative is not part of a group. Number of employees: between 50 and 250. Department of the respondent and number of years of experience in that department: General Management, 4 years.

Most of the organizations operate at the processing level (9 out of 11), while one cooperative operates at the primary production stage and one firm is a distribution company. Thus, for all companies surveyed, the type of business transactions carried out is B2B.

11. FACE-TO-FACE INTERVIEWS OUTCOMES

The questionnaire designed to conduct the face-to-face interviews consists of two main parts: first, an introduction to sustainability concerns, the main drivers that motivate companies to adopt sustainable practices, and the difficulties that arise in implementing these practices are addressed. Second, the impacts (positive, neutral, or negative) of the identified twenty-five practices are evaluated. This is discussion is addressed in the next chapter. Then, an in-depth discussion about sustainable practices is proposed. The interview is designed to last one hour. However, based on the availability of the interviewees some interviews lasted less, thus not all the questions are covered by all the respondents.

11.1. SUSTAINABILITY: INDUSTRIALS' PERSPECTIVE

The first conclusion that derives from the systematic literature review performed is that sustainability in the food industry is a recent field of study and that the general interest on this subject might be expected to increase in the future. Therefore, the first objective of the interview is to investigate whether the same is true for industrials working in this sector. Thus, the question that arises is: *Is the attention towards sustainable development increasing in your company (with reference to the last 5 years)?*

10 of the 11 respondents, confirmed this assumption, i.e., the focus on sustainability concerns is an increasing trend nowadays. For some companies, the concept of sustainable development applied to day-to-day operations is more deep-rooted and sustainability projects have been implemented for more than five years, while others have confirmed that companies are increasingly sensitive to environmental and social issues deriving from their own businesses. Examples of projects implemented by the interviewed companies are listed in Appendix G. It is worth noticing that most of the sustainability projects concern the environmental dimension, while the social dimension is rarely cited.

Finally, MF3 points out that "*No, the focus on sustainable development in our company is the same. We are not a very "eco-friendly" company, and the increased efficiency of our machines or plants is more due to the evolution of engineering than to the propensity to have something more environmentally friendly. In recent years we have invested in a cogeneration plant to produce electricity, we try to reduce water consumption as much as possible, for example we have installed a compression cooling system that uses air instead of water, and then we focus a lot on separate collection of both materials and packaging waste*".

11.1.1. Sustainability Drivers

Drivers or motivating factors are the main reasons for implementing sustainable practices in a food supply chain. The literature review led to the identification of internal and external drivers, presented in paragraph 3.1. The same question is posed to industrials working in the food sector. With the aim of understanding why the focus on sustainability has increased significantly in recent years, the question that arises is: *What are the main drivers that lead your company to implement sustainable practices?*

Responses collected are fully reported in Appendix G. The major sustainability internal driver is the attitude and the support of senior management to the issue of sustainability, regardless of the size of the company: "*The attention towards sustainability issues starts from the guidelines of the group (SC1)", "the consistency with the message we bring to the market and the final consumer (MC1)", "the company direction that annually sets a budget for a set of sustainable goals that have to be achieved (MF1)", "is the owners of the company who pay special attention to these environmental needs (MF3)", "the company mission (LF1)", "the attitude and support of senior management in performing sustainability activities (LF3)"*. The most prominent external drivers are the influences exerted by important clients and the governmental regulations, regardless of the size of the company or the type of products handled: *"more visibility on the market (SC1)", "the sustainability actions adopted are the result of requests from our customers (SF1)", "the requirements imposed by the local government must be followed very strictly (SF3)", "first of all, the markets (MC1)" "our clients ask us to comply with certain certifications (MF3)", "greater sensitivity by the market […] local and national policies that go in this direction (LF2)", "producing for large clients, certain actions are implemented because they are required by the contract (LF3)".*

11.1.2. Sustainability Barriers

Paragraph 3.2. shows that waste is considered the biggest barrier to FSC sustainability. The aim is to find out whether there are other internal or external barriers to sustainable practices implementation. Thus, the question that arises is: *Up to you, what are the main barriers to implement sustainable practices?*

Responses collected are fully reported in Appendix G. As first, it is worth noting that none of the respondents mentioned waste as the biggest barrier to aligning the company with sustainability requirements. Although the main internal driver to implement sustainable practices is the attitude and support of senior management to the issue of sustainability, one of the main barriers is the need to change employee attitudes to implement sustainability projects.

As noticed by SF2: "*[…] changing a process has a lower cost than investing in new systems and machineries. It is a different type of cost that mostly involve changing the comfort zone of people. Forcing people to change their way of working, costs effort, commitment and training. And then certainly one barrier is the economic cost of investment".* In this regard, all respondents emphasized that fulfilling the sustainable development requirements is a challenge from an economic point of view. Indeed, the cost of investment in either new machinery, plant or process changes and the related return on the investments appear to be the main barrier: "*sustainability has a cost, which cannot be transferred to the market (LF2)".* In addition, the market structure, consumers' eco-literacy and product price are pointed out as external barriers. An important role is played by the suppliers: "*The main barrier has been and still is […] getting farmers to adhere to the importance of having an environmental and social strategy (LF3)", "some suppliers are not certified, or, in the case of palm oil, they do not have the facilities to handle segregation of palm oil (MF3)".*

It is worth noticing that also insufficient guidance from local or national authorities to environmental, or social regulation can represent a barrier as noticed by SF3: *"The problem is that certain regulations sometimes follow certain beliefs, which are not always applicable in the right way or for all situations or companies".*

11.2. Sustainable Practices: The Impacts On The TBL Dimensions

According to Chardine-Baumann [183] the assessment of economic, environmental, and social impacts simultaneously deriving from the implementation of sustainable practices can be very complicated as they require the deployment of very different rating scales, and they are impossible to compare. Because of this, Chardine-Baumann [183] proposes to assess the impacts of each sustainable practice on a scale of three qualitative values: positive, neutral, and negative per each one of the three TBL dimensions. In the interview, the economic dimension is defined as the economic benefit of an organization, the environmental dimension is described as the coexistence with the environment and the responsible use of natural resources while the social dimension is defined as fair and beneficial business practices toward labor, the community, and region in which the company conducts its business. The value "Not Applicable" is attributed if the practice is not implemented in the company. Moreover, none of the organizations surveyed handle plant-based products at the primary production stage thus, the assessment of the impacts deriving from the implementation of P_6 and P_{10} is not discussed. In this regard, none of the questions specifically address the impact of P_{15} that is discussed along with the impact derived by the adoption of P_8.

11.2.1. Upstream Practices: Evaluation Of The Impacts

Selecting suppliers taking into account their attention to the environment (P_1), the implementation of supportive activities that seek to improve the relationship between the buyer and the supplier (P_2), and the purchase of a product based on its cost, quality, and performance together with its impact on the environment (P_3) have a positive impact on the environmental and social dimensions (cf. **Figure 49**). It is worth noticing that according to their definition, upstream practices are evaluated for processing and distribution companies, thus, for 10 out of 11 respondents. P_2 is not adopted by SF1 and SF2. In this regard, most of the respondents recognize that the implementation of sustainable supplier management practices requires economic and physical resources expenditures thereby explaining the reason why it can be more difficult for small companies to implement P_2. Moreover, by looking at the results obtained for the economic dimension, most of the respondents recognize that the implementation of P_1 has a negative impact. In fact, as underlined by LF3: "*Suppliers are selected based on a series of criteria, including the focus they have on environmental and social aspects. If you have knowledge of your supply chain, you can also select what is in line with the strategy of your company. The environmental and social impacts deriving from the implementation of assessment activities are positive, while performing all these activities requires economic and physical resources, and not performing them would cost less to our company. However, the risk involved in not assessing our suppliers' commitment to the environmental and social dimensions would be much greater. The subsequent environmental and social problems* [arising from selecting suppliers without focusing on environmental and social aspects] *would be much more important in terms of cost*." The same consideration holds for P_2. According to MF1 the reason why the economic impact deriving from the implementation of P1 is negative is that "*Some suppliers offer raw materials or products that are environmentally friendly but obviously they have higher prices."*

Even if, the economic impact deriving from the implementation of P_1 appears to be negative in the short run, in the long run, it is recognized to become neutral or positive. As explained by SF2 *"At the beginning, the economic impact is definitely negative. In the sense that, it generally involves higher costs. Over time, it can generate value that can be communicated to customers and stakeholders. From the environmental point of view, it certainly has a positive impact both regarding our company and products and in absolute terms, that is giving importance to suppliers who have a strong environmental commitment. From a social point of view, it depends. The impact can be positive if you succeed in effectively communicating your choices to the markets and clients and if you succeed in collaborating with your suppliers. Otherwise,*

it does not create any kind of advantage. On the other hand, the economic impact of implementing P_2 is positive for most of the interviewees. In fact, according to LF1: "*It is very difficult to find a supplier who will not accept to participate in sustainability projects, and if he does, this means selecting a different supplier, because every supplier must be in line with our company mission".* Results are different for P_3. The economic impact that derives from the adoption of P_3 is considered positive for 50% the respondents and neutral or negative for the other 50%. MF1 recognizes that *"at the economical level the impact is positive because the quality of the product purchased is higher"* while LF1 underline that *"often the use of recycled materials such as recycled plastics compared to fossil-based ones cost more",* thus it is evaluated as negative for the economic dimension. According to LF3 "*everything you do in terms of sustainability comes at a cost. Thus, the economic impact would always be negative because you need more resources and more investments. However, if we want to evaluate the economic aspect by also considering the return on investment, such as the reduction of risk or as an increase in business because it means to propose to the customers a product that is more valuable thus increasing the competitiveness of the company, the economic impact is no longer negative, but it can be considered as positive".* The same consideration holds for SF2: "*From an economic point of view, I don't know, in the sense that attention to the quality of the product and its environmental impact is something that costs money. Thus, selecting suppliers who offer high-quality raw materials and who also are sensitive to their environmental impact certainly costs more. Subsequently, if these values are transmitted to the market and the consumer is willing to spend more for this type of product, then it certainly has a positive economic impact, otherwise, the risk is to lose market share because changes in price are still an important variable. From the environmental point of view, there is a positive impact. From the social point of view, if the customer perceives the value of the product offered, then the impact is positive. Otherwise, it is neutral."*

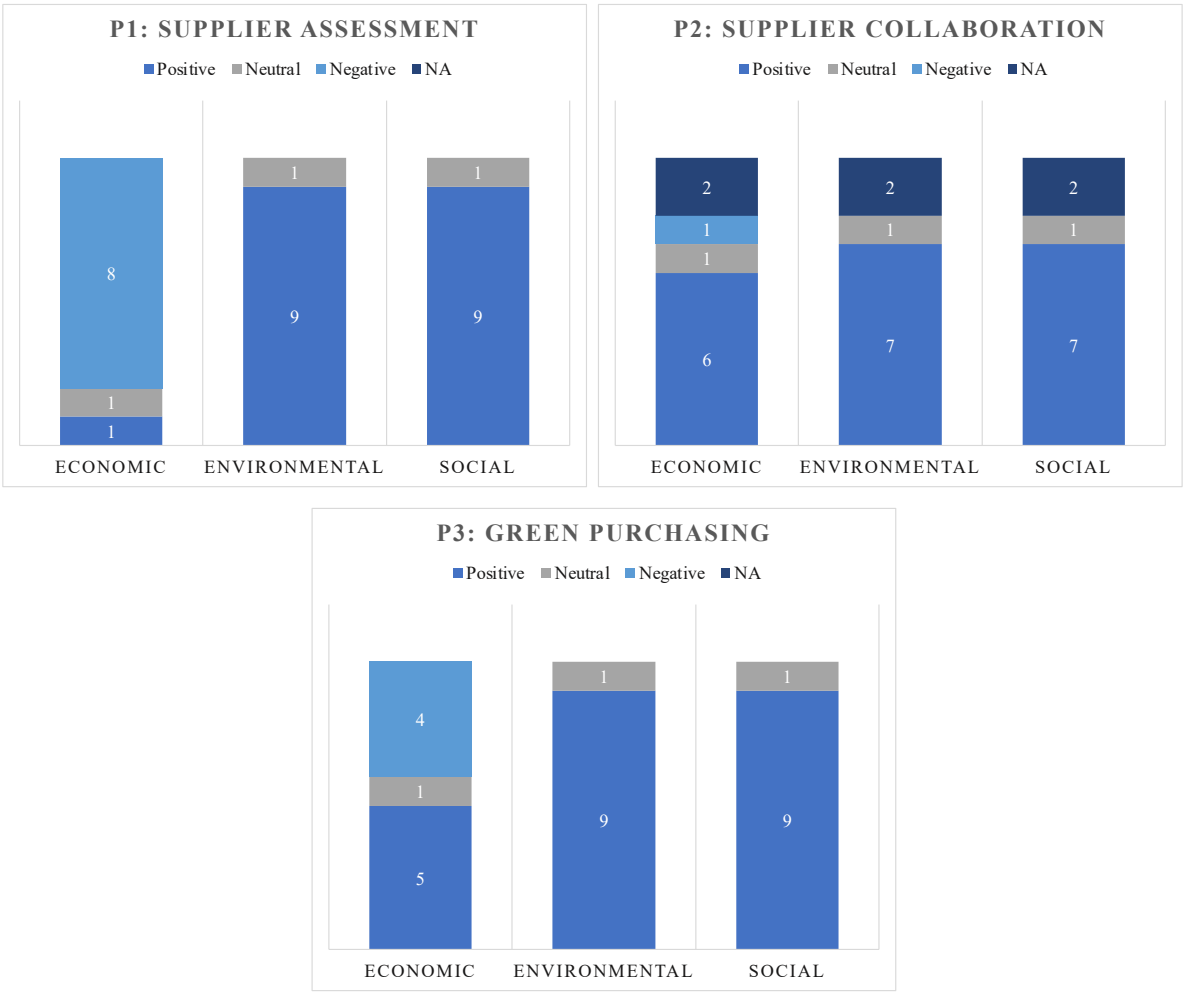

Figure 49 *– Upstream practices: impact assessment results.*

11.2.2. Sustainable Operations Practices: Evaluation Of The Impacts

Sustainable practices analyzed specifically addressing the single product are Green Design (P_4) and Green Packaging (P_5). It is worth noticing that P_4 is not evaluated for SC1 that operates at the primary production stage. P_4 is not adopted by SF1, SF2, SF3, and MF3 while P_5 is not adopted by SF1, SF2, SC1, and MF3. Although the reasons why these practices are not implemented are not investigated in-depth as they are outside the boundaries of the face-to-face interview, it can be observed that for small companies it is more difficult to implement sustainable practices considering the single product, while for large companies P_4 and P_5 are implemented and show positive impacts for the environmental and social dimensions (cf. **Figure 50**). This consideration suffers from the size of the sample analyzed. Examining a larger sample of responses could enrich the results obtained. As underlined by MC1 concerning P_5 *"the environmental and social impacts are certainly positive. The economic impact could be negative because we spend more on packaging to make it reusable or recyclable. However, it is part of our social and environmental commitments to consider the choice of sustainable*

packaging". Moreover, concerning the packaging choice, a consideration is proposed by LF1: "*I know that there is a study on the implementation of a plastic tax, and it depends on how it will be structured because if the plastic tax will affect fossil-based plastics then the impact in economic terms will be negative and this could be an incentive to switch to recyclable/recycled plastics. It depends on how the legislation evolves"*. Thus, confirming that the influences exerted by governmental regulations can be a driver in the implementation of sustainable practices.

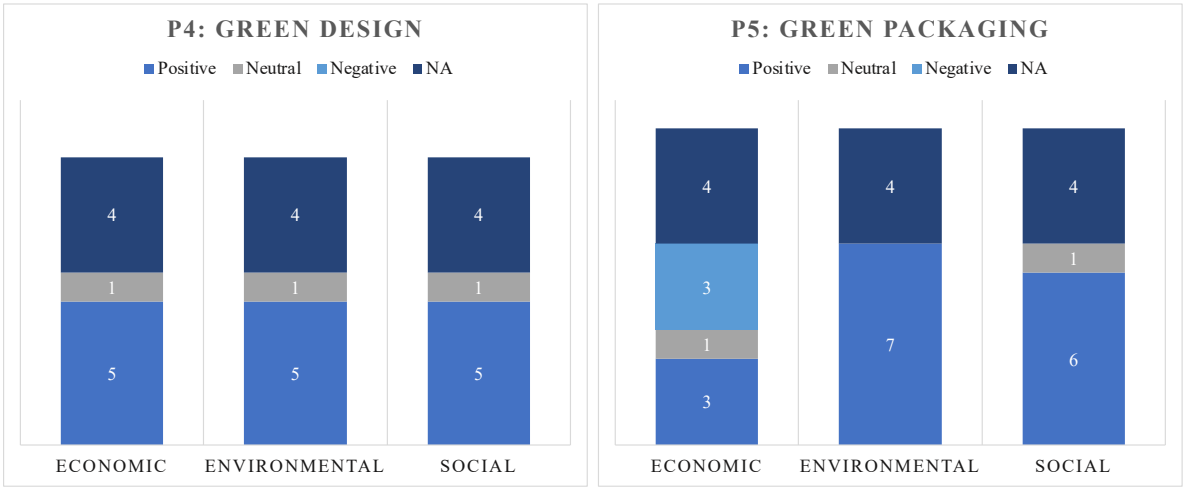

***Figure 50** – P4 and P5: impact assessment results.*

Green Manufacturing (P_7) includes the set of actions or technologies deployed in manufacturing activities with the intent to reduce the environmental burden, e.g., to reduce the emissions, the energy or water consumption. P_7 is not evaluated for SC1 operating at the primary production stage and SF3 operating at the distribution stage. Responsible Use of Natural Resources (P_{11}) is the set of actions aimed to reduce the consumption of natural resources currently implemented in the company. The results of the impacts deriving from the adoption of P_7 and P_{11} are reported in **Figure 51**. For both practices, the impacts are positive on the environmental dimension and positive or neutral considering the social dimension. The economic impact derived from the implementation of P_7 and P_{11} is considered positive, especially in the long run: "*I would say* [the impact] *is also positive in economic terms, not in the very short term, but certainly in the medium/long term (MC1)", "Concerning the economic dimension, in the early stages the impact is certainly negative, but in the long run the impact can only be positive. From the Environmental and social point of view it is positive (MF1)", "Concerning the energy consumption, nowadays there is a combination of sustainability and economy. We are investing in tri-generation plants, photovoltaic panels and they have a positive impact on the environment and from the economic point of view (LF2)", "From an*

economic point of view it depends. For example, we have installed a photovoltaic system thus we have a self-consumption of the energy we produce. Whereas all the water wastages go through a purification plant to release it into the environment with zero impact. In this case, we do not have an economic return, but only the protection of the environment (SF2)". As noticed by LF1 "*From an economic point of view, investments are necessary which may have a negative impact or offset the advantage of reducing the waste of water, energy and CO2 emissions […] the involvement of people, it is also an important aspect to reduce the consumption of water, energy and sort the wastages".*

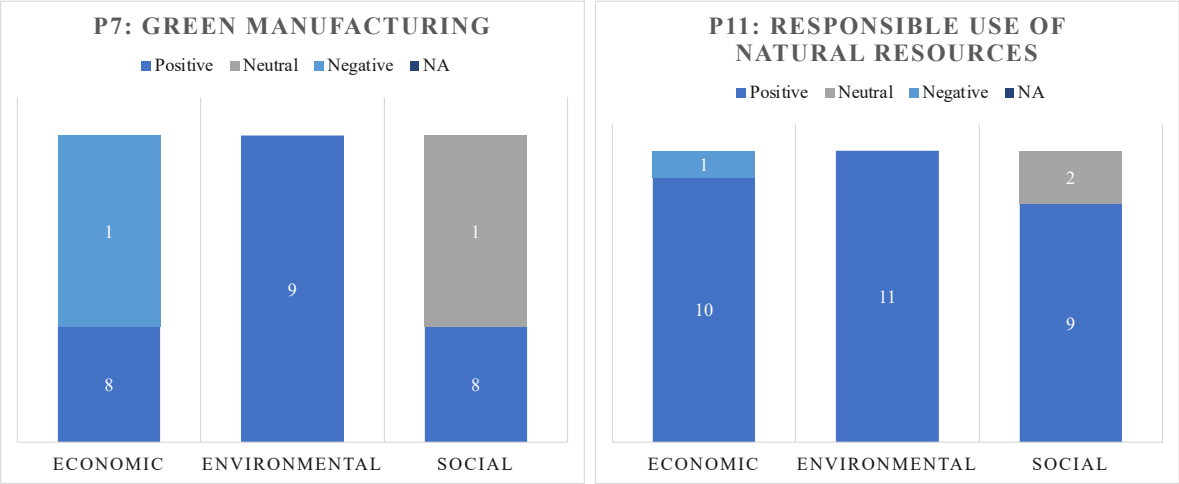

***Figure 51** – P7 and P11: impact assessment results.*

The results obtained by the assessment of the impact of Material and Products Recycling and Reprocessing practice (P_8) reveal that P_8 has a positive or neutral impact on the environmental and social dimensions while on the economic dimension the impact can be negative, due to the disposal costs. However, most of the respondents point out that the main component of waste are not raw materials, by-products, or finished products, those are mainly recycled by the company during the production process or transferred to a third party in order to be reprocessed, but rather the packaging: "*As company, we have very little waste from semi-finished or finished products. The waste or scrap that we have to deal with is mainly plastic and paper, which is sorted in the separate waste collection (MF3)*", "*The main component of waste is those that derive from packaging (plastic or cardboard) and it is given to recyclers. While the by-products that derive from milk processing become raw materials for other companies. The impacts are however positive on the three dimensions (MF1)".*

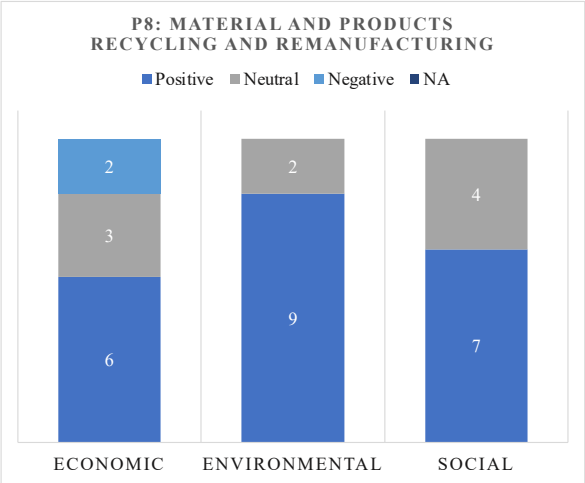

Figure 52 *– P8: impact assessment results.*

The impact resulting from the implementation of Protection of Animal Welfare (P_9) is assessed for companies handling animal-based products thus for a subset of the total respondents i.e., 6 out of 11 interviewees. Results are reported in **Figure 53**. From the obtained outcomes it is worth noticing that the implementation of P_9 has a positive impact on the environmental and social dimensions while considering the economic ax, the impacts can be both positive and negative. LF2 explains that "*The economic impact is negative because the protection of animal welfare increases the cost of production. That is, a raw material purchased by suppliers that implement sustainable breeding practices costs more than the others".* The same is considered by LF3: *"We make sauces with meat, and we buy meat from certified supply chain to be sure that the animal welfare is taken into account. But all these certifications clearly have a cost".* However, SF2 points out that *"The protection of animal welfare has an extremely positive impact on all the three dimensions, especially for the economic dimension, leaving aside the ethical point of view. Appropriate levels of animal welfare increase the level of productivity and reduce the risks of diseases that in turn, increase the life of the animal itself. Thus, the investment in this regard is definitely profitable".* The same consideration is underlined by SC1. Another aspect is emphasized by MF1: "*This practice is carried out regardless of the environmental concerns. Most of our suppliers are obliged to follow certified environmental programs, also because of the market, especially the American market start to ask for guarantees in this regard. In addition, there are specific EU directives to follow".*

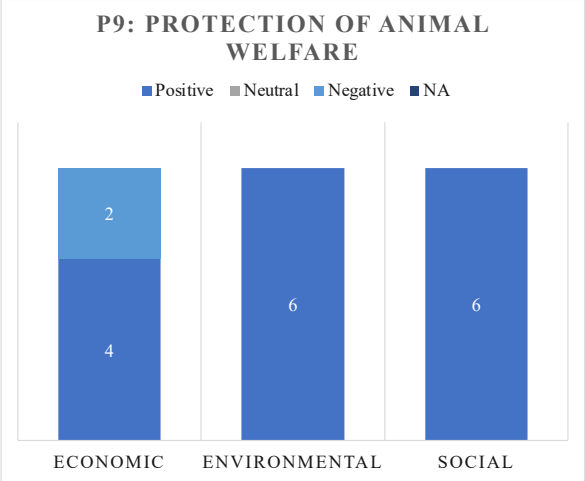

***Figure 53** – P9: impact assessment results.*

11.2.3. Downstream Practices: Evaluation Of The Impacts

From the downstream perspective, the impact assessment results for Inventory Management (P_{12}) and Green Warehousing (P_{13}) are reported in **Figure 54**. P_{12} is not adopted by SF2 and P_{13} is not adopted by SF2 and MF1. P_{12} and P_{13} show a positive or in some cases neutral impact on the three TBL dimensions. Inventory management practice is effective in lowering the products wastages and improve the traceability of the products when it is combined with information and communication technologies such as tags, barcodes, and QR codes.

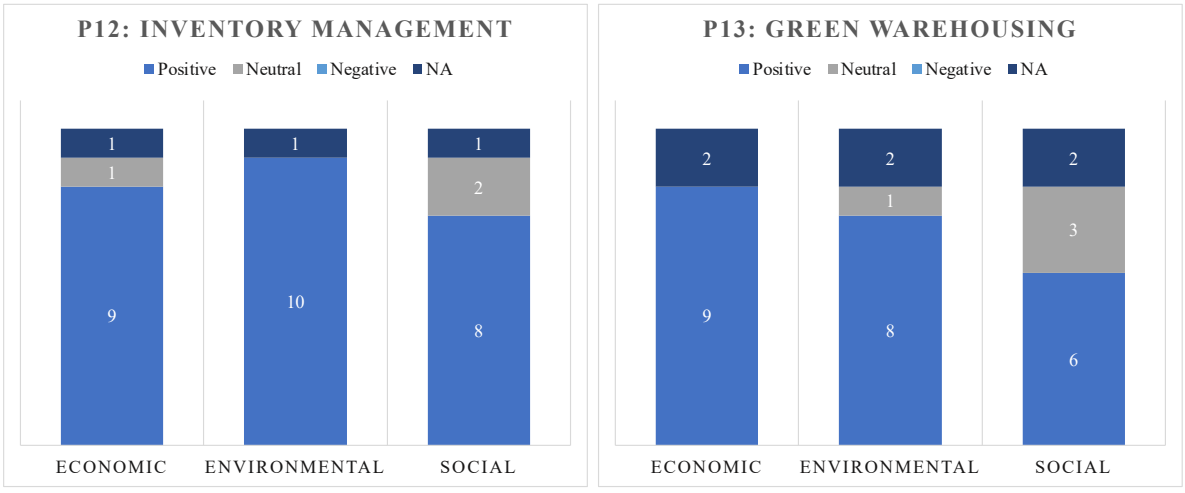

***Figure 54** – P12 and P13: impact assessment results.*

From the empirical analysis carried out, Green Shipping and Distribution (P_{14}) appears to be one of the least implemented practices. The face-to-face interviews outcomes confirm this result (cf. **Figure 55**). The limited number of responses collected does not allow general conclusions to be drawn. However, it is important to notice that P_{14} is only adopted by the large

companies surveyed i.e., LF1, LF2, and LF3. The assessment of impacts resulting from the implementation of P_{14} is positive on the environmental dimension, positive or neutral on the social dimension, and may be negative on the economic dimension. In this regard, LF3 underline that *"We try as much as possible to reduce road transport in favor of using the railways and ports. This is possible thanks to the region in which the company is located"* while LF1 points out that *"The use of liquid methane or e-trucks today definitely has a significant cost differential"*. These results confirm the need to introduce transportation innovations in local, regional, and national food systems and in the way it is organized, as already observed as a conclusion of the empirical analysis carried out. Moreover, innovative opportunities in sustainable transport are required. As noticed by MC1: "*At present, the local transport system does not allow us to opt for alternatives other than road transport. Since we have no alternatives, we are trying to reduce the environmental impact by optimizing the logistics of the transport that is carried out. For example, by avoiding the overlapping of trucks on the road and by using the hubs in our territory that allow us to reduce the kilometers traveled. To date, this is certainly an aspect that needs to be improved, but there is no possibility of investing in alternative solutions. […] With the aim to improve the outbound logistic of our company, we try to cooperate with other companies at the regional level, in order to share problems and needs. That is, for example, encouraging the shipment of fully loaded trucks by combining the transport of products from several companies. This, in turn, saves fuel consumption, emissions, and workers".*

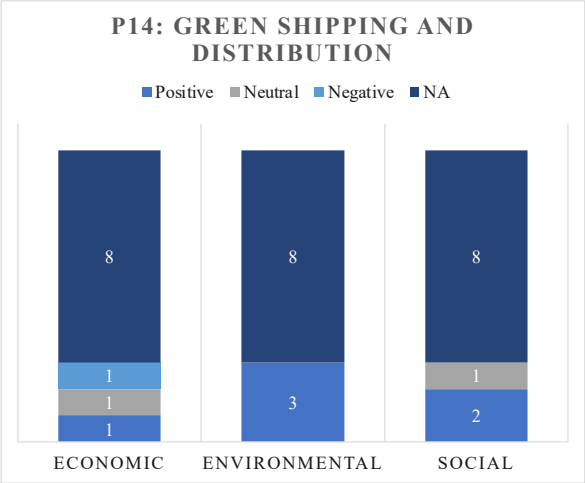

Figure 55 *– P14: Impact assessment results.*

The development or improvement of environmentally friendly processes and products to enhance the green image of a company and in turn, as a lever of competitive advantage in the market (P_{16}) has a positive impact on the environmental dimension, and a positive or neutral

impact on the economic and social dimensions (cf. **Figure 56**). P_{16} is not adopted by MF1, MF2, MF3, and SF1. With reference to the experiences encountered by small companies, positions regarding the implementation of P_{16} are divided: according to SF2, P_{16} is effective in enhancing the competitivity of the company *"Absolutely, this is one of the most important levers for us. One of the key factors that can support us to convey the values of our small company"*, SC1 points out that "*being a zero-emissions company still does not pay off on the market"* while SF3 underline that the effectiveness of P_{16} and the related impacts are subject to the sensitivity of the final customer. The same is pointed out by LF1: *"The environmental impact deriving from the implementation of sustainability projects is positive. However, it is not used as leverage. Thus, the impact on the economic dimension is neutral. On the social ax, it depends a lot on the awareness of the society you are addressing. I am thinking for example of the younger generation who will certainly not be impressed by the fact that a company is committed to lowering its environmental burden, they will take it for granted, fortunately"*.

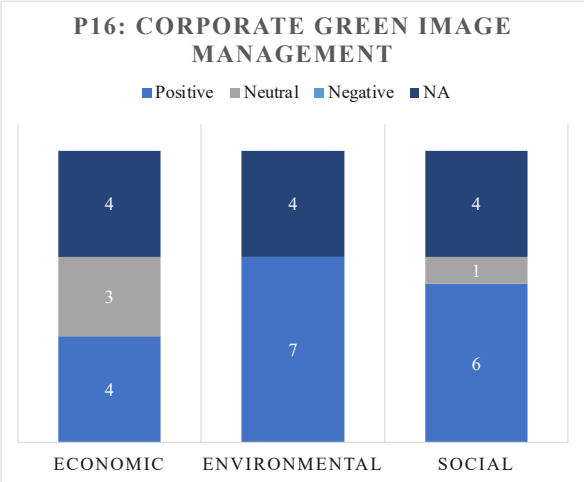

Figure 56 *– P16: impact assessment results.*

11.2.4. Transversal Practices: Evaluation Of The Impacts

Research & Development activities aiming at introducing or obtaining environmentally friendly products or packaging (P_{17}) have a positive impact on the environmental and social dimensions, while it can be positive, neutral, or negative on the economic dimension (cf. **Figure 57**). As pointed out by LF2: "*When a product is designed ex-ante and sustainability criteria are taken into account, the economic aspect is positive in the sense that it is very easy to sell it at the correct price on the market. Conversely, when a product is modified according to sustainable principles, this can involve for example the change in one or more suppliers and the economic impact is probably negative"*.

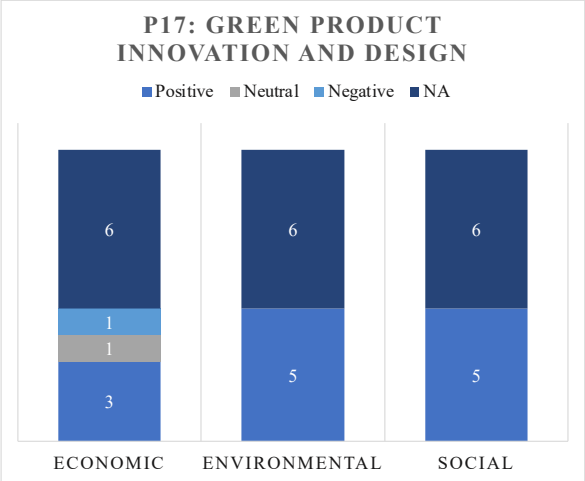

***Figure 57** – P17: impact assessment results.*

Sustainable practices specifically addressing the commitment of a company towards sustainable development are Corporate Social Responsibility Programs (P_{18}) and Green Human Resource Management (P_{19}). At a first glance appear that while P_{18} is widely implemented, P_{19} has not the same result. This consideration is in line with the results obtained from the empirical analysis carried out. P_{19} is not adopted by SF1, SF2, and MF2. By looking at the results obtained for P_{18} the impacts are positive on the environmental and social dimensions, while on the economic dimension impact can be negative. As underlined by LF2 the impact can be negative in the short run and turning into positive in the long run or, as pointed out by LF1 the impact on the economic dimension can vary according to the initiative that is proposed. Other than donations, which appear to be a common activity among the respondents' other projects implemented by companies are for example *"granting to the employees working hours dedicated to voluntary work, financed by the company (LF1)", "For our employees, we have created a kind of "small village". These are independent houses dedicated to our employees and their families. In addition, we have set up a school bus service for children who have to go to school from the farm. We try to be very careful by considering the workers' working day, which starts very early, so having the house close to the farm can help them, beyond the economic benefits. And this is also a small contribution to reduce gas emissions. We don't have a written code of conduct, but it's more of a code of ethics that is transferred to the farm from generation to generation (SF2)".* P_{19} takes the form of individual or teams training activities, or it is implemented through the establishment of an environmental and social committee that ensures that all operations comply with the company's vision and mission.

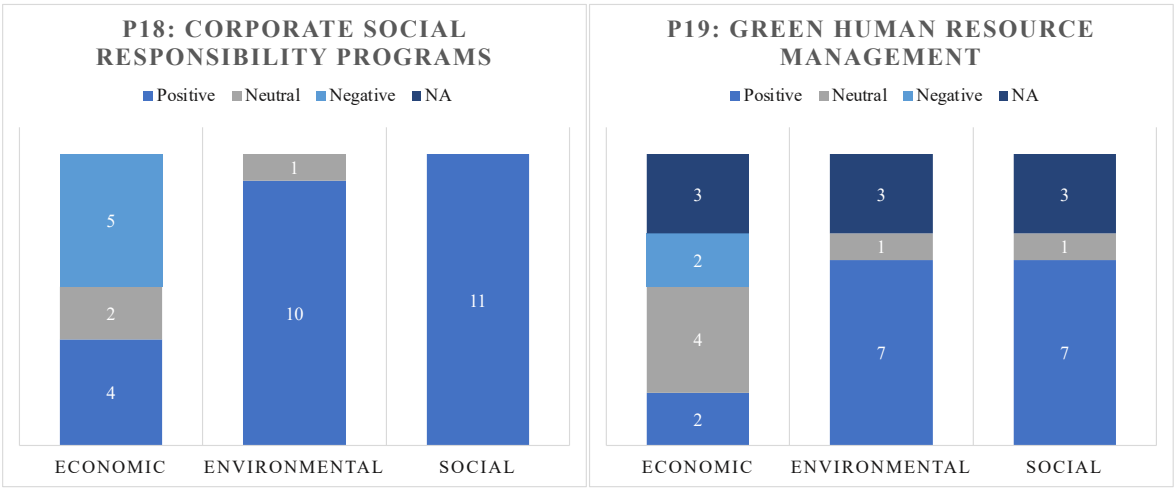

Figure 58 *– P18 and P19: impact assessment results.*

From the results of the empirical analysis carried out, Standard and Certifications (P_{20}) practice appears to be widely adopted as a demonstration that processes are performed or that products are compliant with their requirements. The same is evident by looking at the results obtained from the face-to-face interview (cf. **Figure 59**). The impacts of the implementation of P20 are positive on the environmental and social dimensions, while on the economic dimension the impact can be negative. The experiences collected from small, medium and large underline the fact that certifications require tests that are costly, but in the long term the economic impact can also be positive. In the specific, as pointed out by SF2: "*From an economic point of view, the impact can be positive or negative. Negative because certifications require an initial investment, but if you succeed in conveying the value of your products and the market accepts to pay a bit more as a guarantee of the whole series of values, it can become a positive aspect. From an environmental and social point of view, the impact is certainly positive, both in terms of the image of your company and from the consumer protection perspective*".

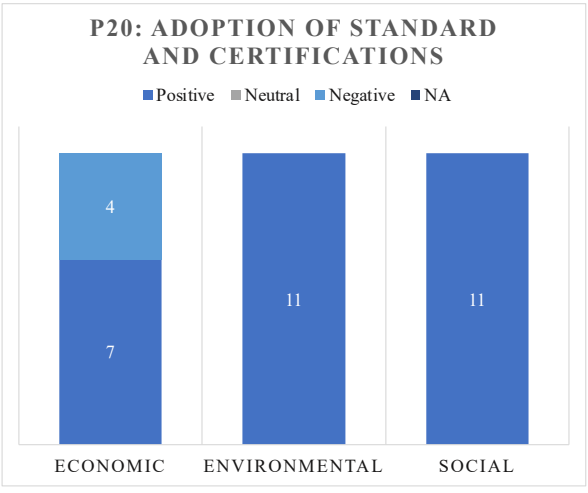

Figure 59 *– P20: impact assessment results.*

Figure 60 depicts the impacts deriving from the implementation of collaborative practices. As already underlined in the discussion of the empirical analysis carried out, P_{21} is widely implemented while other collaborative practices specifically dealing with sustainability concerns show a lower degree of implementation. P_{22} is not adopted by SF1, SF3, MF1, and MF3. P_{23} is not adopted by SF1, SF2, MF1, MF3, and LF1. P_{24} is not adopted by SF2, MF1, and MF3. Therefore, sustainable collaborative practices appear to be more difficult to implement for small and medium-sized companies. Nevertheless, considering the size of the sample interviewed, this cannot be considered as a general conclusion.

Involving upstream and downstream partners to share planning information (P_{21}) show positive or neutral impacts on the economic and environmental dimensions, while considering the social dimension, the impact assessment results vary among the respondents. SC1 points out that "*At the social level, the implementation of P_{21} could raise some problems because in our operations we are very conditioned by events, so planning the production can damage our company".* Considering the environmental dimension, MF1 and LF1 emphasize production planning as a good practice to avoid wastages of raw materials. Moreover, SF1 and SF2 underline that P_{21} is mostly carried out in collaboration with clients rather than suppliers. However, they point out two different perspectives by assessing the impacts: "*there is an increasing requirement of a just-in-time production performance that could reach chaotic levels (demands from today for tomorrow) raising problems (SF1)", "We produce exclusively according to the needs of our clients, both for fresh and frozen products. From the economic dimension, this has an important impact because it means being able to work in just-in-time, thus reducing warehouse stocks to the minimum, which would otherwise have a high cost. From a social dimension, being able to plan production based on the clients' needs certainly has a positive impact because it means giving customers a product that is always fresh (SF2)".* Involving upstream and downstream partners to share green targets (P_{22}) has a positive impact on the environmental and social dimensions. Concerning the economic dimension, the impact is recognized to be positive in the long run. Finally, the establishment of strategic alliances to achieve mutually relevant benefits through the exchange, sharing, and co-development of resources and capabilities with partners (P_{23}) and the implementation of sustainable practices with other actors involved in the SC such as collaborative waste reduction, sharing of environmental innovations and technologies, and joint development of recyclable products (P_{24}) show a positive impact on the three sustainability dimensions.

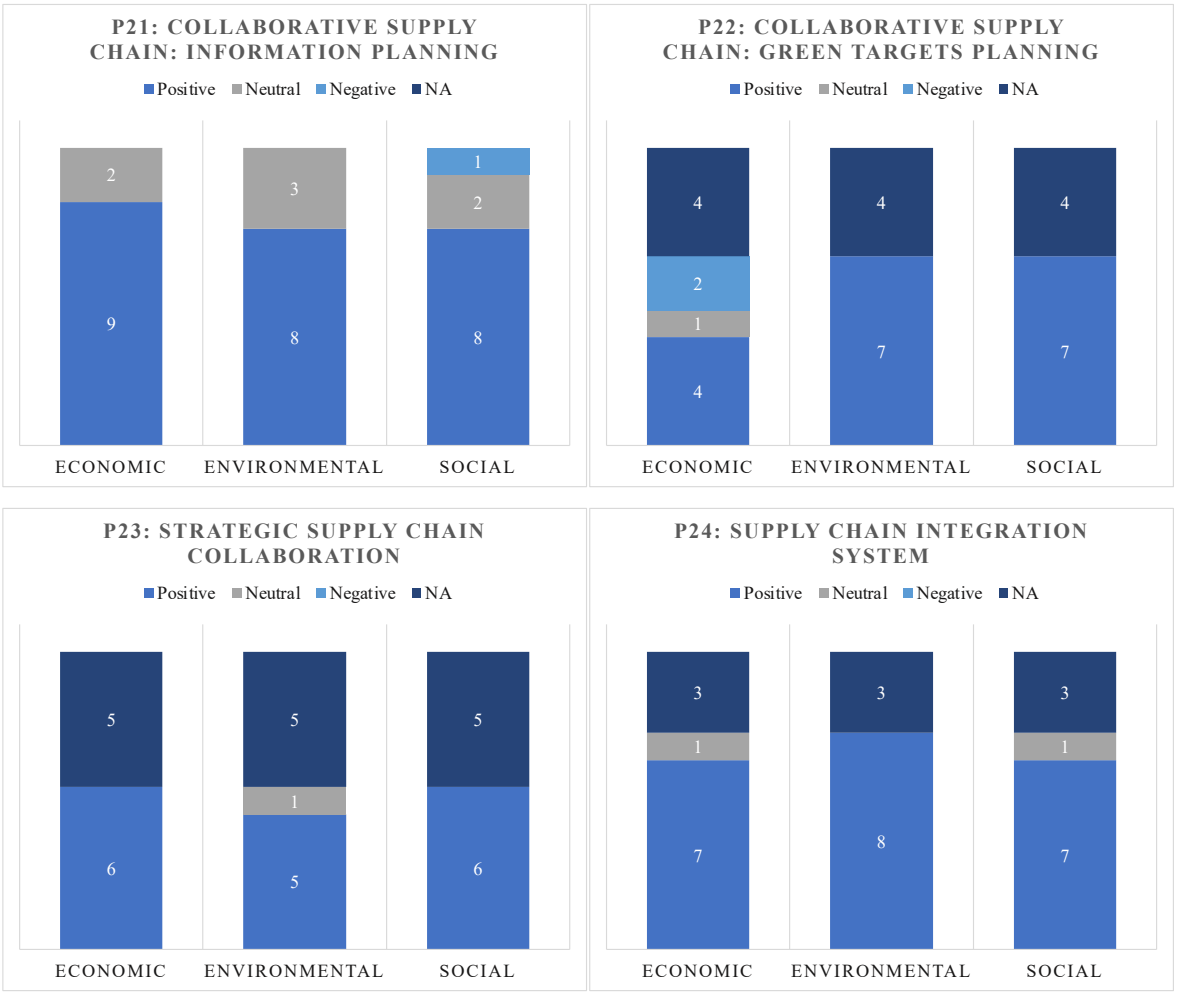

Figure 60 *– P21-P24: impact assessment results.*

Furthermore, as already underlined, collaboration within a supply chain is recognized as one of the most important practices to achieve sustainability. Plenty of practices are found in the scientific literature. In the study carried out the attention is limited to P_{20} – P_{24}. To complete this analysis, respondents are asked if there are other sustainable collaborative practices they implement. LF3 underline the importance of the collaboration activities carried out with certification bodies while MC1 point out the need to integrate the transport systems in collaboration with other companies, in turn improving the Green Shipping and Distribution (P_{14}) practice, as already discussed in the previous paragraph (cf. Paragraph 11.2.3).

Adoption of Information and Communication Technologies (P_{25}) is recognized in literature to reduce costs, increase productivity, lower the consumption of resources, food losses, and waste. Accordingly, the impact results assessment shows that the implementation of this practice can have a positive or neutral impact on the three TBL dimensions (cf. **Figure 61***)*. P_{25} is not adopted by MF2.

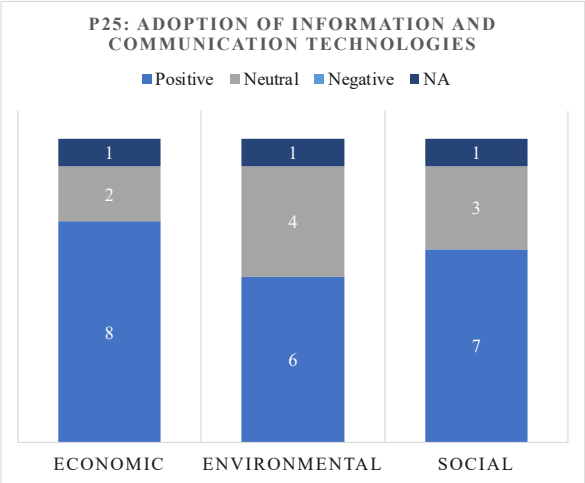

Figure 61 *– P25: impact assessment results.*

11.3. SUSTAINABLE PRACTICES: PRESENT VS. FUTURE DIRECTIONS

The third part of the face-to-face interview focuses on sustainable practices. The questions designed investigate in detail the effectiveness of the identified sustainable practices in fulfilling sustainability requirements versus the practices that will disappear. Finally, attention is paid to emerging practices that may appear in the future. Due to time constraints, and based on the availability of the respondents, this part was not explored for the totality of the interviewees.

First, considering the effectiveness of sustainable practices in achieving the sustainable development target, LF3 emphasizes that: "*the environmental and social sustainability projects carried out within our plants are more effective because you have daily contact and direct control. When you implement external projects, for example in collaboration with clients and suppliers, it is more difficult. However, given the partnerships that are then created, the process is more challenging but still effective"*. The importance of creating alliances and partnerships with customers and/or suppliers is also stressed out by LF2: "*I would definitely mention partnerships and the alliance with suppliers and stakeholders in general. Then, also having a national supply chain, the circular economy so the use of by-products for example, the animal welfare, clean labels and communication to the end-consumer, the transition to sustainable packaging and the transition to sustainable energy and a more social approach in terms of training of the employees and charity activities"*. This last point is strongly underlined by LF1: *"raising employee awareness on waste reduction, employee involvement in open day initiatives and donations have been in place for some time but are among the most effective activities. In addition, there are benefits (e.g., yoga, nutritionist) provided by the company that employees can take advantage of, and all this leads to greater employee involvement in*

voluntary activities and collaborations with external bodies. Furthermore, employee involvement facilitates the transition to sustainable development when new projects are proposed within the company". Finally, SF1 notice that: "*the attention is increasingly focused on both the environmental and social impact, especially because for some types of crops they give rise to problems. I am thinking for example of palm trees in Malaysia and Indonesia, and especially for what concerns the social impact, focused specifically on the exploitation of child labor, or in general, on the relationship between the farmer and/or the worker and the employer. The request of environmental certifications is also increasing, which have an impact on the cost of the product but are used as a guarantee for the quality of the product itself".* Other than investments implemented to lower the environmental burden, such as the adoption of systems to reduce energy or water consumption, among the most effective practices appear to be those that focus on the social dimension, in addition to the environmental dimension. Furthermore, SC1 underline: "*the products traceability is fundamental in our sector both for the environmental impact, the animal welfare and as a guarantee of an high-quality finished product. From an economic point of view, it may be a problem immediately because it leads companies to invest, but there is a return at market level. What is underdeveloped is certainly the agricultural machineries and the transport system, which cause a lot of pollution, but it is still the most difficult part to change".*

The general perception regarding the adoption of sustainable practices is that none of the twenty-five practices identified will disappear in the future; on the contrary, their implementation will be increasingly required, and new practices may emerge: "*None of the cited practices will disappear in my opinion. On the contrary, I think that in the future we have to expect more demands and requirements to be met by the market (SC*1)", "*among these that we have mentioned none will disappear in the future. In my opinion they will go to increase. The point of improvement in my opinion will have to be more and more on logistics and transportation processes (MC1*)", "*It's difficult to answer because I've never really thought about it. I see some products or processes that will no longer be produced as more problematic than some practices (SF1)".*

Emerging practices include switching from an animal-based to a plant-based diet, "What can be interesting is the shift from animal to plant-based products (SF1)", "I think that the focus on a vegetarian and vegan diet will grow considerably. An in general, I think that when we talk about sustainability the focus will be more and more on the nutritional point of view (LF3)" and all the improvement related to the products, "*All research paths on product improvements, such as improving the shelf life of products. Moreover, the education of the final consumer is*

also important. We are doing this for example with schools, we are starting to talk about nutrition education, about the consumption of dairy products and I think it is important. (MC1)", "*In recent years I have seen the shift from certain additives towards more environmentally friendly raw materials, aimed at safeguarding the wellbeing of consumers and this trend will continue in the future. Both because technology is evolving and because consumers are demanding it (e.g., products without colorings, additives) (SF1)"*, "*there is already an increase in the control of the use of antibiotics. By 2022, companies will have to be monitored and restricted for the use of antibiotics. The problem is that there are no viable alternatives to antibiotics. The demand is to produce a product that has a low environmental impact, that is controlled in terms of animal welfare, that is not produced with antibiotics, but one excludes the other. To date, attempts are being made to replace antibiotics with natural products, but they do not work. Economically, it will just cost us a lot of money, without a return. Socially, it's a big problem for us, however environmentally it would be an improvement (SC1)".* In this regard, SF3 stressed out the increasing focus on local products that will in turn limit the imports, that is a practice already carried out by some companies such as LF1 "*Undoubtedly also the use of local products. But in our company, there is already a lot of attention to the local, in fact we guarantee that the timespan from harvesting to the finished product is about 24h".* Finally, as already underlined, innovations in logistics and transport system seem to be one of the practices that needs to be developed more intensively. Based on this and reflecting on emerging practices, MF1 points out: *"I live 50km from my workplace, as do other colleagues, and each of us travels by car. We have 40 trucks that go around the region every day to pick up the milk and we tend to make sure that they travel as fully loaded as possible, but it is not always possible, especially considering the milk production cycle. One thing that we have never thought of, but that I have heard in other companies, is to improve the so-called "hidden" impacts that are apparently outside our production cycle. For example, road transport, we are 120 employees, therefore 120 cars, without considering the transport of products that enter our company and those that leave. I would like to adopt means of transport with gas systems, gas that is produced by the manure of the stables from which we take milk. And this would be a fundamental message for our workers as well".*

11.4. Observations and Takeaways

The third and final part of this research project allows us to compare the results obtained in the previous chapters and the vision that industrialists working in the food sector have about sustainability and sustainable development. As already pointed out, sustainability and the focus on sustainable development is a growing concern and it may be expected that the attention on these topics will increase in the future. The main internal drivers for companies to adopt sustainable practices are the attitude and support of senior management to the issue of sustainability, regardless of the size of the company. While the most prominent external drivers are the influences exerted by clients and government regulations. Despite the evidence collected through the systematic literature review, product wastage does not appear to be the main barrier for achieving sustainability requirements. From the interviews carried out, one of the biggest internal barriers is represented by the need to change employee attitudes to implement sustainability projects. Moreover, all respondents emphasized that fulfilling the sustainable development requirements is a challenge from an economic point of view. Therefore, the costs required to implement sustainable practices represent an internal and external barrier to the company. As one interviewee pointed out, sustainability has a cost that cannot be bear by the market. In addition, the market structure, consumers' eco-literacy and the relationship with the company suppliers also play a role. Building on the TBL approach, the impact (positive, neutral or negative) derived by the implementation of the twenty-five sustainable practices identified is assessed. Sustainable supplier management practices have a positive impact on the environmental and social dimensions, while the implementation of these practices can have a negative impact on the economic dimension, at least in the short run. The same consideration can be extended to all the practices analyzed. Sustainable practices analyzed specifically addressing the single product appear to be less implemented than sustainable practices dealing with the processes. However, the impacts are positive on the three TBL dimensions. One of the findings of the empirical analysis is that Green Shipping and Distribution is among the least adopted practices, despite the attention of the literature on it. The results of the face-to-face interviews support this finding, partially explain the reasons behind these results such as *"the use of alternative road transport than traditional ones has a significant cost differential"* or *"at present the local transport system does not allow us to opt for alternatives other than road transport"*. Finally, the focus is on practices that best fulfill sustainability requirements and sustainable practices that may emerge in the future. Even though only eleven respondents participate to the face-to-face interview, thus general

conclusions cannot be drawn due to the limited size of the sample, numerous inputs are provided. Respondents shared various details about how the practices are implemented in their companies, and analysis of their responses revealed some practices relevant to successful sustainable supply chain management such as the Adoption of Standard and Certification, the Protection of the Animal Welfare, a Responsible Use of Natural Resources, and Collaboration with suppliers, clients and stakeholders by highlighting key points where there is the need to intervene.

Since the focus on sustainability and Sustainable Development is becoming more and more relevant nowadays, the objective of the present empirical research is to analyze how companies in the food sector cope with this requirement. The main objective of this research project is to analyze the integration of sustainable practices into supply chain management in the food industry and the related results. To this end, the first part of this research project is devoted to present the theoretical foundation underpinning sustainability concept and the systematic literature review carried out to define sustainable best management practices that companies operating in the food sector should implement to reach the Sustainable Development target. All the practices identified have been introduced as a conceptualization of a general model, which is then empirically validated in the second part of this research project. In particular, the most relevant practices, from both the academic and industrial sides, are sustainable supplier management practices that include Supplier Assessment and Collaboration practices and Green Purchasing practice that embraces everything sourced from a supplier, according to which the purchase of a product is based on cost, quality, and performance together with its impact on the environment. In addition, from the point of view of the focal company, sustainable operations practices are considered as crucial because call for the commitment of the company toward the TBL issues, such as Green Design, Green Packaging, Green Production and Manufacturing, Material and Product Recycling and Remanufacturing and the integration of environmental management systems. Furthermore, focusing on 123 companies operating in Italy or France, this work provides the opportunity to statistically analyze how external factors such as the number of actors involved in the SC and the main stage of the SC in which a company operates, or the status of a company itself can influence the adoption of sustainable practices. Building on the TBL paradigm, the findings reveal which sustainable practices have a significant influence on economic, environmental, and social dimensions. Environmentally friendly processes and products are developed or improved to obtain a competitive advantage in the market, thus enhancing the economic benefits of an organization. Similarly, technologies aimed at reducing their environmental impacts are deployed in manufacturing activities. In addition, they are effective in preserving the natural environment. The selection of suppliers based on their sustainability performances, and the purchase of products based on cost, quality, and performance together with its impact on the environment have a statistical significance on the environmental dimension. Green design, green warehousing, green shipping, and

distribution play also a role to reduce the environmental burden. The implementation of corporate social responsibility programs coupled with the spreading of green values and culture within a company are effective in enhancing both the environmental and social dimensions. However, the last one appears to be one of the less implemented practices. This demonstrates that companies still have to deal with important difficulties in developing social programs. Finally, the third part of this research project offers the possibility to enlarge the results obtained through the statistical analysis carried out by focusing on the impact that derives from the implementation of sustainable practices on the three TBL dimensions. Eleven face-to-face interviews are performed with industrialists working in the food industry. Although the size of the sample analyzed does not allow to draw general conclusions, the third part of this research project offers interesting takeaways regarding the implementation of sustainable practices in companies and their impacts, i.e., positive, neutral, or negative on the economic, environmental and social perspective.

This work originates several theoretical and practical implications. From a theoretical perspective, it enlarges the body of knowledge on sustainable supply chain management practices and highlights key points where there is the need to investigate further. Furthermore, the proposed study enlarges the existing scientific literature on this topic by proposing an empirical analysis about the maturity of implementation of sustainable practices. In particular, by exploiting the established and rigorous systematic literature review methodology, and a survey questionnaire, the developed analysis represents a contribution that includes the point of view of professionals that in their daily professional life are increasingly dealing with the sustainability issue. As a matter of fact, literature is mostly focused on studying sustainable practices in the manufacturing SCs, and it often evaluates these practices singularly. Also, this research project offers an updated and comprehensive study on the implementation of the practices that foster the sustainability in the food industry. From a practical point of view, this study proposes an overview of the most common and adopted practices that can be implemented in order to achieve Sustainable Development in the food industry. This research project provides a novel sustainable supply chain management practices model obtained via a systematic literature review as a precise approach methodology able to identify the most important research trends. In this sense, this work might support food companies in the identification of the most promising practices that might be carried out for promoting sustainability programs in their supply chain. At the same time, public policy makers might be supported in undertaking their strategies in driving the sustainability adoption patterns. On the contrary, this work allows capturing the less mature practices that may require some additional

time for more effective implementation. The analysis is carried out by focusing on two of the major European countries in the food sector. In order to enlarge the obtained takeaways, future work will be addressed in considering more companies operating in other geographical areas. Moreover, a preliminary analysis of the difference between firms and cooperatives is presented considering the degree of implementation of SSCM practices. Nevertheless, expanding the sample of cooperatives included in the study could reveal interesting results.

APPENDIX A – TAXONOMY: SOME DETAILS

The purpose of this appendix is to provide the details of some classifications discussed in the second chapter. The publisher and journals distribution as well as the geographical positioning of authors and studies carried out are depicted in the following charts.

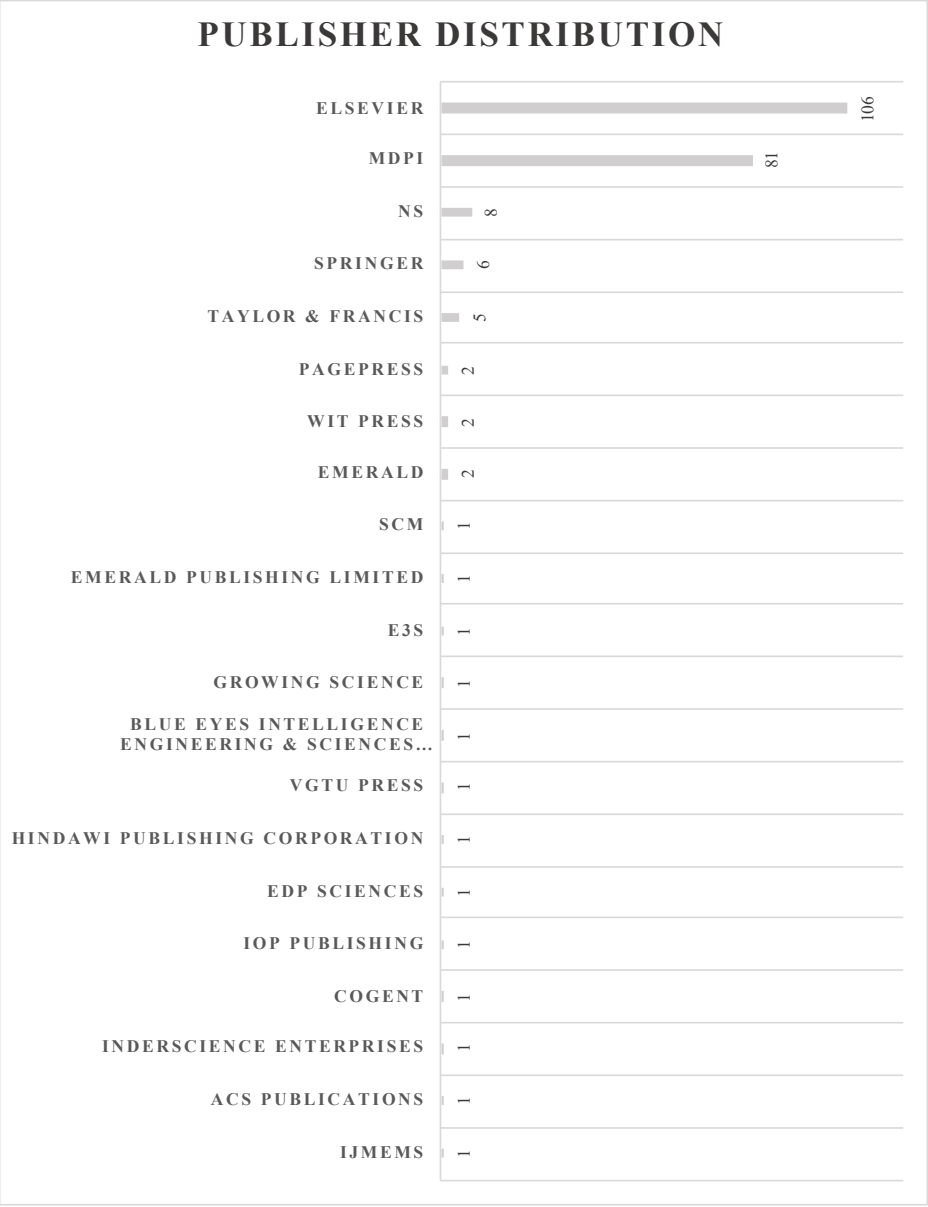

Figure 62 *– Publisher distribution. Total of 224 selected documents.*

Figure 63 *– Journal distribution. Total of 224 selected documents.*

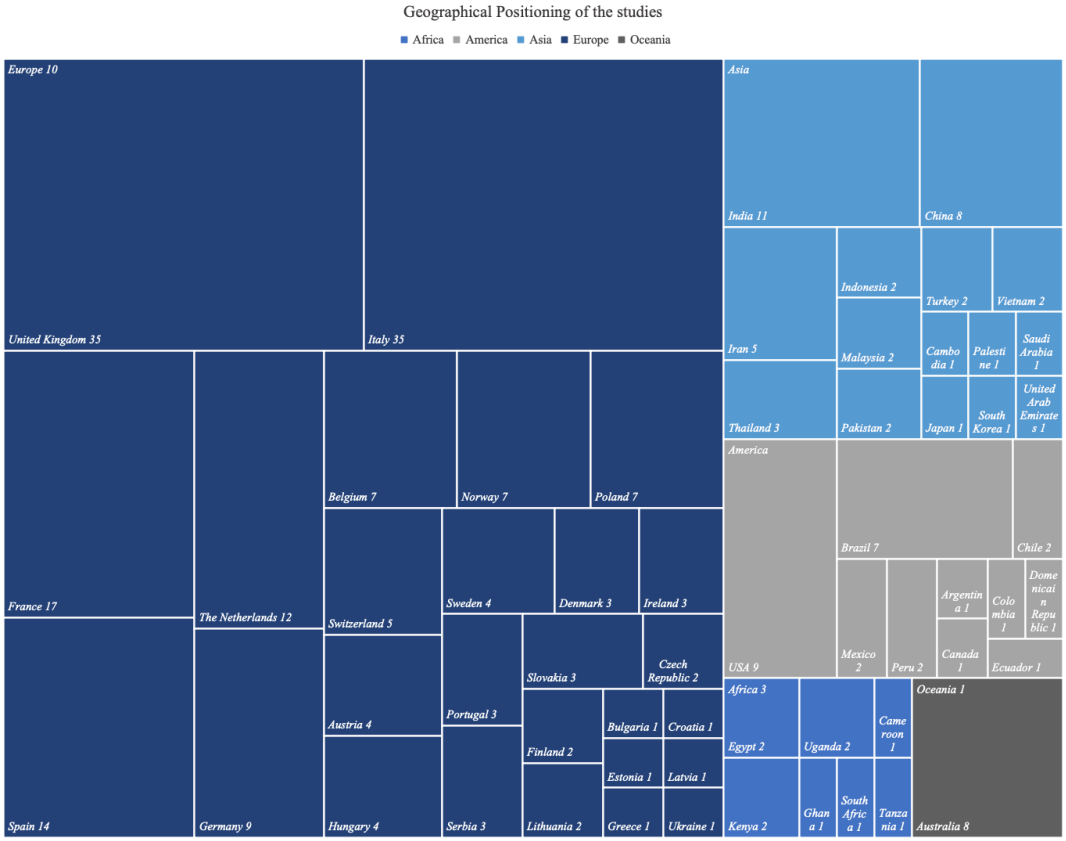

Figure 64 *– Geographical positioning of the studies. Over a total of 224 selected documents. 70 documents are not located in one or more country.*

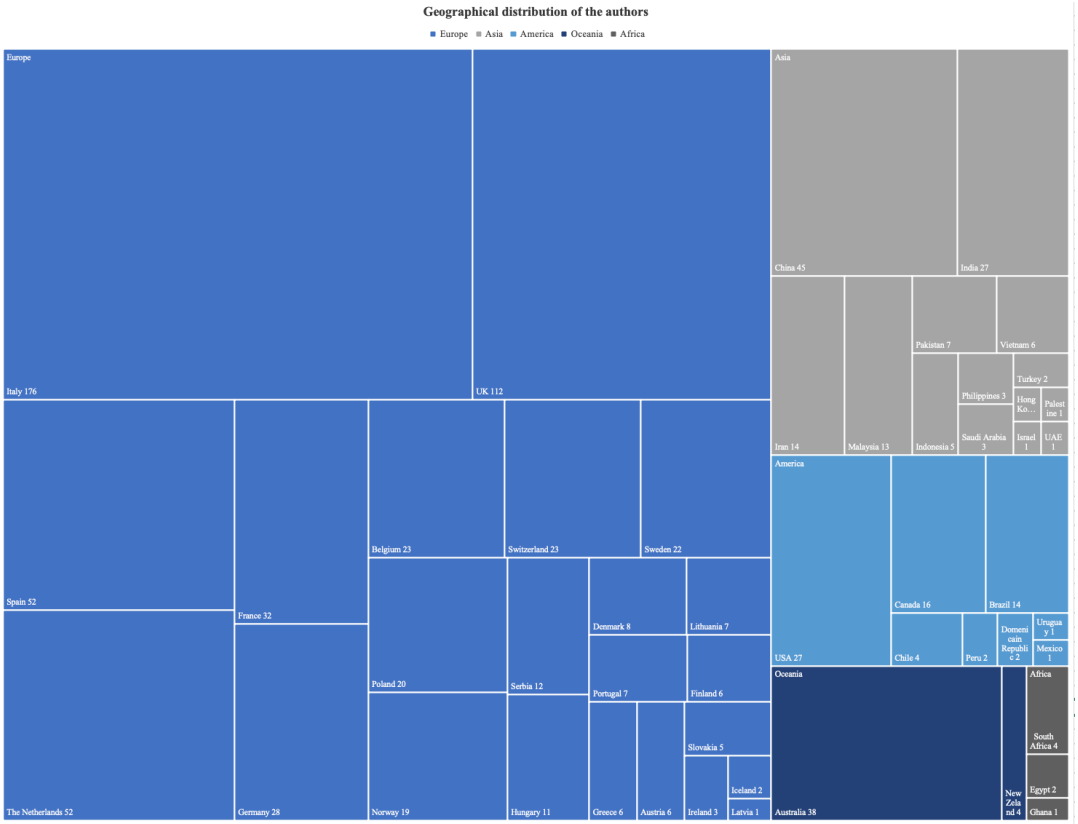

Figure 65 *– Geographical positioning of the authors. Over a total of 224 selected documents.*

APPENDIX B – DEFINITIONS

The most relevant definitions found in literature are provided in the following tables, classified according to the main topics.

Authors	Supply Chain [SC] and Supply Chain Management [SCM]
[191]	*[SC] "a conglomerate of facilities that are responsible for the: (i) ordering and purchase of raw materials, (ii) conversion of raw materials into semi-finished and finished products, and (iii) delivery of high-quality finished products to the customers using a well-defined distribution system."*
[1]	*[SC] "the process of back-and-forth ex- change of materials, information and finances amongst suppliers, manufacturers, distributors, retailers and consumers at various levels."*
[8]	*[SCM] "the management of exchange of information and materials in logistics process that continues from raw materials procurement to delivery to the customer."*
[192]	*[SCM] "a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service-level requirements."*
[193]	*[SCM] "a set of approaches to integrate supply chain participants so that products are produced and distributed at the right quantities, to the right locations and at the right time to ensure the total cost is minimized and the service level is maximized."*
[194]	*[SCM] "includes planning for procurement, manufacturing, transportation and reverse logistics with a focus on integration, transparency and cycle time."*

Authors	Agro- or Food- Supply Chain [FSC] and Food Supply Chain Management [FSCM]
[90]	*[FSC] "A food supply chain is a grid used to move the final food product from the manufacturer through pre- and post-production activities to the customers under quality and time-conscious work."*
[195]	*[FSC] "a set of interdependent companies that work closely together to manage the flow of goods and services along the value-added chain of agricultural and food products, in order to realize superior customer value at the lowest possible costs."*
[42]	*[AFSC] "an activity from production to distribution that provides an agricultural or horticultural commodity."*
[86]	*[AFSC] "all the activities, which are involved in the movement of agricultural food produce from the producers/farmers to customers."*

[36]	*[FSCM] In simple terms, the FSCM is described as all the conventional processes from 'farm to fork' or from 'plough to plate'.*
[196]	*[AFSCM] agri-food supply chain management (AFSCM) involve a series of activities from the production (farm) to the kitchen table (fork)*

Authors	**Sustainable Supply Chain [SSC] and Sustainable/Green Supply Chain Management [SSCM] [GSCM]**
[197]	*[SSC] "as a set of supply chain practices aimed at **reducing environmental impact** (measured in terms of carbon dioxide emissions, waste reduction, water consumption, etc.), as well as at **improving the social condition** of different stakeholders while contributing to the long-term **economic development** of the chain."*
[198]	*[SSC] "augment value for customers as well as other stakeholders while ensuring the attainment of a **closed-loop or circular economy**."*
[25]	*[SSCM] "the management of material and information flows, as well as cooperation among companies, along the supply chain, while taking goals from all **three dimensions of sustainable development (i.e., economic, environmental and social)** and **stakeholder requirements** into account".*
[199]	*[SSCM] "the strategic achievement of a firm's **economic, environmental, and social goals** in the **systematic coordination** of key inter-firm processes for enhancing financial growth and/or performance."*
[200]	*[SSCM] "a sophisticated process by which firms organize their **CSR (corporate social responsibility)** activities across dislocated manufacturing processes spanning organizational and geographical boundaries."*
[201]	*[SSCM] "means **producer collaborates** with its SC members and **collaboratively** manages inter-and intra-firm processes for sustainable development."*
[202]	*[SSCM] "attention brought to the **environment** in relation to supply chain management is called sustainable supply chain management".*
[203]	*[SSCM] "is the addition of sustainability to traditional SCM processes, taking **financial, environmental, and social impacts** of firm activities into consideration."*
[204]	*[SSCM] "is the management of SCs, where all the **3Ds of sustainability** are taken into account."*
[205]	*[SSCM] "the effective **actions** were **taken by senior management** to make the supply chain more sustainable."*
[206]	*[SSCM] "an extension to the existing ideology of SCM by adding **social and environmental aspects."***

[207]	*"SSCM and/or GSCM is referred to the management of raw materials and reduction of waste from upstream to downstream, and after shelf life back to the upstream with the improvement of the **environmental and social impact**."*
[208]	*[GSCM] "as the process of purchasing, producing, marketing, and performing various packaging and logistic activities while considering the **ecological balance**."*
[209]	*[GSCM] "the integration of **environmental thinking** into supply chain management activities: from product design, to delivery of the final product, to end-of-life treatments."*
[26]	*[GSCM] "an integrating **environmental thinking** into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumer as well as end-of-life management of the product after its useful life."*
[15]	*[GSCM] "the integration **of environmental thinking** applied to an industrial context that involves suppliers in the environmental management process."*

Authors	**Corporate Social Responsibility (CSR)**
[135]	*[CSR] "a concept whereby companies integrate social and environmental concerns in their business operations and their interaction with their stakeholders **voluntarily.**"*
[210]	*[CSR] "a concept whereby companies decide **voluntarily** to contribute to a better society and a cleaner environment."*
[211]	*[CRS] "a response to perceived failures or limitations of governmental regulation following privatization, globalization and reforms of welfare state."*
[136]	*[CRS] "an umbrella term for a variety of theories and practices, all of which recognize the following: (a) that companies have a responsibility for their impact upon society and the natural environment, sometimes beyond legal compliance and the liability of individuals; (b) that companies have a responsibility for the behavior of others with whom they do business (e.g., within value chains); and (c) that business needs to manage its relationship with wider society, whether for reasons of commercial viability, or to add value to society".*

Authors	**FW: Food Waste, FL: Food Loss, FS: Food Surplus, FA: Food Availability**
[212]	*[FW] "Include all the food streams, encompassing edible and inedible fractions, leaving the food supply chain, at any stage"*
[213]	*[FW] The surplus of food that is not recovered to feed people, to feed animals, to produce new product, new materials or energy.*
[79]	*[FW] "Discarding of food products that are fit for consumption or fit to proceed in the food supply chain. Mostly occurs at the later stages of the food supply chain, such as retail and consumer households"*

[214]	*[FW] Food originally produced for human consumption that was discarded or was not consumed by humans. Including still edible food that is deliberately discarded.*
[79]	*[FL]"Decrease in food quantity or quality in the early stages of the food supply chain, reducing the amount of food suitable for human consumption. Often related to post-harvest activities with lacking system or infrastructural capacities."*
[214]	*[FL] The unintentional decrease in edible food quantity or quality before consumption, including postharvest losses.*
[213]	*[FS] The edible food that is produced, manufactured, retailed or served but for various reasons is not sold to or consumed by the intended customer.*
[214]	*[FS] The edible food produced, manufactured, retailed or served that has not been consumed by humans (mainly due to socio-economic reasons), including food produced beyond nutritional needs.*
[213]	*[FA] Food produced throughout the food supply chain and of different types (raw materials, semi-processed food and finished products).*

APPENDIX C – SUSTAINABLE DEVELOPMENT GOALS

To promote human well-being and protect the environment, in September 2015, the United Nations partners endorsed the 2030 Agenda for Sustainable Development, of which the essential elements are the 17 Sustainable Development Goals (SDGs) and 169 sub-goals, which aim to end poverty, combat inequality and achieve social and economic development. They also take up aspects of fundamental importance for sustainable development such as tackling climate change and building peaceful societies before 2030. The 17 SDGs are summarized in **Figure 66**.

Figure 66 *– Sustainable Development Goals. Adapted by [215].*

APPENDIX D – IS LCA THE RIGHT TOOL TO QUANTIFY SUSTAINABILITY?

One of the first results of this literature review is that nowadays there exists a wide variety of different approaches that are applied to assess the impact of sustainability, both qualitative and/or quantitative. According to Genovese *et al.* [13], the methodologies that can be used to evaluate the environmental impacts of a production system are generally based on the principles of life cycle assessment (LCA).

Defined by the standard ISO 14040:2006, the life cycle assessment LCA addresses the environmental aspects and potential environmental impacts e.g., use of resources and the environmental consequences of releases, throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling, and final disposal [216]. By applying LCA methodology, two modeling techniques can be followed: bottom-up approach or top-down. The former is a process life cycle assessment methodology, working by creating a system boundary that depends on the aim of the study, and accounting for individual impacts assessment (e.g. carbon equivalent emissions), the latter is an Environmental Input–Output (EIO) approach that uses country and/or regional input–output trade data coupled with sector-level emissions to calculate environmental impacts, yielding an all-encompassing result within an extended system boundary [13]. The information generated by LCA has also received growing attention from policymakers for setting objectives and monitoring the impact of policies [217]. As noted by Segura *et al.* [218], even if LCA is a common approach in the scientific literature, it is not an appropriate tool to support decision-making in SSCM.

Some extension of the LCA methodologies seems to be more appropriate. Sala *et al.* [219], recognize Life Cycle Thinking (LCT) as fundamental for addressing current challenges faced by the food industry. Indeed, LCT and the different life cycle-based methodologies such as Life Cycle Assessment (LCA), Life Cycle Costing (LCC), Social Life Cycle Assessment (sLCA) and the overall Life Cycle Sustainability Assessment (LCSA) support the transition toward the sustainability of production and consumption systems. However, for an in-deep evaluation, LCT methodologies require to be implemented with quantitative methodologies or other integrated approaches because the current LCA method is incomplete and does not comprehensively assess some aspects that are critical for long-term sustainable food production [219]. To conclude, they enhance that some challenges have to be addressed to ensure that LCA delivers robust results. The same consideration is made by Gala *et al.* [220] that recognize the strengthen of this assessment tool but underline a series of improvement that has to be

made, like study harmonization (ISO do not strictly define the functional units, reference flows, system boundaries, how to select rules for quantifying the impact associated with processes of how to establish the environmentally relevant impact categories), data issues, and the inclusion of economic and social aspects.

Despite the critics of adopting this method, in the literature there are many examples of the application of the LCA approach to assessing FSC sustainability, as discussed in the second chapter.

APPENDIX E – THE QUESTIONNAIRE: VARIABLES AND PRACTICES DESCRIPTION

Sustainability is defined as the economic-environmental-social impacts i.e., the three dimensions of the TBL, a business should be accountable for. Where, Economic is intended as the economic benefits of an organization, Environmental means the coexistence with the environment and responsible use of resources and Social intends fair and beneficial business practices toward employees, the community and region in which a corporation conducts its business.

Table 29 – Manifest variable description.

Variable	*Operational Description*	*Type and Values*
Department	Job title of the respondent	Nominal Variable
Year of experience	Years of experience of the respondent within that department	Ordinal Variable
Country of the group	Country of the group if the firm is part of a group	Nominal Variable
Country of the firm	–	Nominal Variable
Cooperative	Distinction between cooperative and non-cooperative companies	Dichotomous Variable Yes = the company is a cooperative No = the company is not a cooperative
Type of products	Type of products offered by the company	Nominal Variable • Cereals and their product • Roots, tubers and plantains • Pulses, seeds and nuts • Milk and milk products • Eggs and their products • Fish, shellfish and their products • Meat and their products • Vegetables and their products • Fruits and their products • Fats and oils (oils, butters and margarines, etc.) • Sweets and sugars • Spices and condiments • Beverages • Food additives • Composite dishes • Savory snacks • Other
Product Portfolio	Number of products handled by a company.	Ordinal Variable Range = [1, >1]
Degree of processing	Degree of processing of the products.	Nominal Variable • Processed or minimally processed • Ingredients • Ultra-processed
Number of employees	Number of employees of the company used to characterize the size of the company.	Ordinal Variable • Less than 10 • Between 10 and 49

Variable	*Operational Description*	*Type and Values*
		• Between 50 and 250 • More than 250
Stage of the supply chain	The most important stage at which a company operates.	Nominal variable • Agricultural production (including breeding and fisheries activities) • Post-harvest handling and storage • Processing • Distribution • End-of-life
Actors upstream	Number of actors between the company and the agricultural production.	Range = [1; 5]
Actors downstream	Number of actors between the company and the final consumer.	Range = [1; 5]
Economic	The extent to which the Economic dimension of the TBL is considered in a company.	Likert scale data Range = [1; 4] 1: not at all important 2: low important 3: important 4: very important
Environmental	The extent to which the Environmental dimension of the TBL is considered in a company.	
Social	The extent to which the Social dimension of the TBL is considered in a company.	
P_1	Supplier Assessment	Likert scale data Range = [0; 4] 0: I don't know 1: The practice is not adopted 2: The practice is rarely adopted for some products/services 3: The practice is rarely adopted for a large number of products or the practice is frequently adopted for some products/services 4: The practice is frequently adopted for a large number of products/services
P_2	Supplier Collaboration	
P_3	Green Purchasing	
P_4	Green Design	
P_5	Green Packaging	
P_6	Green Production	
P_7	Green Manufacturing	Likert scale data Range = [0; 4] 0: I don't know 1: The practice is not adopted 2: The practice is rarely adopted for some products/services 3: The practice is rarely adopted for a large number of products or the practice is frequently adopted for some products/services 4: The practice is frequently adopted for a large number of products/services
P_8	Material and product recycled or reprocessed by the company or by a third party	Dichotomous: Y/N
P_9	Protection of Animal Welfare	Likert scale data

Variable	*Operational Description*	*Type and Values*
P_{10}	Soil Conservation and Management	Range = [0; 4] 0: I don't know 1: The practice is not adopted 2: The practice is rarely adopted for some products/services 3: The practice is rarely adopted for a large number of products or the practice is frequently adopted for some products/services 4: The practice is frequently adopted for a large number of products/services
P_{11}	Responsible Use of Natural Resources	
P_{12}	Inventory management	
P_{13}	Green Warehousing	
P_{14}	Green Shipping and Distribution	
P_{15}	Reverse logistic – by the firm or by third party	Dichotomous: Y/N
P_{16}	Corporate Green Image Management	Likert scale data Range = [0; 4] 0: I don't know 1: The practice is not adopted 2: The practice is rarely adopted for some products/services 3: The practice is rarely adopted for a large number of products or the practice is frequently adopted for some products/services 4: The practice is frequently adopted for a large number of products/services
P_{17}	Green Product Innovation and Design	
P_{18}	Corporate Social Responsibility Programs	
P_{19}	Green Human Resource Management	
P_{20}	Adoption of Standard and certification	
P_{21}	Collaborative Supply Chain: Information Planning	
P_{22}	Collaborative Supply Chain: Green Targets Planning	
P_{23}	Strategic Supply Chain Collaboration	
P_{24}	Supply Chain Integration System	
P_{25}	Adoption of ICTs	

Table 30 *– Link between the practice and the description adopted in the questionnaire to evaluate the practice itself.*

Practice	*Description*
P1. Supplier Assessment	Suppliers are selected considering their environmental performances (e.g., certifications provided, monitoring of suppliers).
P2. Supplier Collaboration	Implementation of supportive activities and development programs that seek to improve relationship with suppliers.
P3. Green Purchasing	The purchase of a product is based on cost, quality, and performance together with its impact on the environment.
P4. Green Design	The products are designed with a given quality objective but also to reduce their negative impact on the environment throughout its life cycle.
P5. Green Packaging	The packaging choice is carried out to prevent food wastages and to lower the environmental burden (e.g., selection of the proper material, size and shape, biodegradable packaging is preferred to the traditionally used plastics).

Practice	*Description*
P6. Green Production	Environmentally friendly methods are adopted at the primary stage of the supply chain to reduce the environmental burden (e.g., grass-fed beef, free-range poultry, organic production, agroforestry, selection of pesticides according to their impact on the environment or on health aspects).
P7. Green Manufacturing	Technologies to reduce the environmental impact (e.g., to reduce the emissions, the energy or water consumption, to control on the microbial formation) are deployed in manufacturing activities.
P8. Product Recycling	Materials or products that cannot be used or sold are recycled or remanufactured by the company or by third party.
P9. Protection of Animal Welfare	Animal welfare is strongly considered in all your company's activities (elimination of cruelty, safe handling, housing, processing and transport).
P10. Soil Conservation and Management	Actions aimed to increase the soil conservation are settled (e.g., conservation of forest and species, prevent soil erosion and pollution, prevent loss of arable land and biodiversity, responsible farming methods).
P11. Responsible Use of Natural Resources	Actions aimed to reduce the consumption of natural resources are currently implemented in the company. (e.g., use of energy collected from renewable sources, micro-irrigation for agricultural production).
P12. Inventory Management	Inventory tracking systems are adopted not only with the aim of aligning supply with demand, but also to reduce food wastages.
P13. Green Warehousing	Warehouses are designed in order to lower the environmental burden by taking into account both the point of view of the location of the facilities and internal design of the warehouse itself.
P14. Green Shipping and distribution	Less polluting modes of transportation are selected in order to lower the impact on the environment (e.g., consumption of fuel, eco-friendly refrigerant, intermodal way of transport).
P15. Reverse Logistics	Materials or products that cannot be used or sold are recycled or remanufactured by the company or by a third party.
P16. Corporate Green Image Management	Aiming at enhancing the green image of the company, development or improvement of environmental-friendly processes and products are settled as a lever of competitive advantage in the market.
P17. Green Product Innovation and Design	Research & Development activities are settled for introducing or obtaining environmentally friendly products or packaging.
P18. Corporate Social Responsibility Programs	Voluntary activities addressing social or environmental challenges are performed by my company such as, food donations, written environmental targets objectives, code of conduct, acts for workers' rights.
P19. Green Human Resource Management	Green attention is spread in my company. For example, teams are in charge of solving environmental problems, managers are held accountable for environmental performances and rewarded for their environmental performances, ecological training is planned for workers, workers are hired based on their environmental commitment.

Practice	*Description*
P20. Adoption of Standard and Certifications	Standards and/or certifications are adopted to demonstrate that processes are performed, or that products are compliant with their requirements.
P1. Collaborative Supply Chain: Information Planning	Planning information (i.e., exchange relevant, complete, accurate and up-to-date Supply Chain information and knowledge) are shared with other actors in the supply chain.
P22. Collaborative Supply Chain: Green Targets Planning	Sustainable targets are shared with suppliers and/or customers.
P23. Strategic Supply Chain Collaboration	Strategic alliances with other actors in the supply chain are intended to achieve mutually relevant benefits.
P24. Supply Chain Integration System	Collaborative sustainable activities are carried out with other actors involved in the supply chain such as collaborative waste reduction, environmental innovations, adoption of environmental technologies and joint development of recyclable products.
P23. Adoption of ICTs	Information and communication technologies (labels, barcode, RFID tag, blockchain) are adopted to increase the product traceability.

APPENDIX F – KRUSKAL-WALLIS TEST RESULTS SUMMARY

In the following the statistical results are reported considering the research methodologies described in the first chapter (cf. **Chapter 6**). Kruskal-Wallis one-way analysis of variance by ranks test results are synthetized in the following tables (cf. **Table 31**, **Table 32**) grouped considering the first and second set of research hypotheses.

Table 31 *– Kruskal-Wallis test results for the first set of hypotheses.*

Hypotheses	***Statistical Significance****	***p-value***
*H1. The three dimensions of the TBL are considered equally important***.*		
*H2. Firms that are part of a group give a higher importance to the TBL dimensions****.*		
Economic dimension.	No	0.197
Environmental dimension.	No	0.358
Social dimension.	No	0.891
***The same results hold by considering the subset of cooperatives.		
H3. There is a significant difference between companies operating in Italy and companies operating in France considering the importance given to the TBL dimensions.		
Economic dimension.	**Yes**	**0.024**
Environmental dimension.	No	0.082
Social dimension.	**Yes**	**0.024**
*H4. The size of a company influences the importance given to the TBL dimensions*****.*		
Economic dimension.	No	0.198
Environmental dimension.	No	0.347
Social dimension.	No	0.830
*****The same hypothesis is evaluated by grouping Micro and Small enterprises (i.e., less than 50 employees) and Medium and Large enterprises (i.e., more than 50 employees).		
Economic dimension.	**Yes**	**0.056**
Environmental dimension.	No	0.304
Social dimension.	No	0.761
H5. The stage at which a company operates influences the importance given to the TBL dimensions.		
Economic dimension.	No	0.197
Environmental dimension.	No	0.093
Social dimension.	No	0.207
*H5[sub-group]. The stage at which a company operates influences the importance given to the TBL dimensions, according to the following model: Primary Production + Post-harvest Handling and Storage; Processing & Distribution***.*		
Economic dimension.	No	0.251
Environmental dimension.	**Yes**	**0.043**

Hypotheses	***Statistical Significance****	***p-value***
Social dimension.	No	0.104
H6. A cooperative is not sensitive as a firm to the TBL dimensions.		
Economic dimension.	No	0.912
Environmental dimension.	No	0.393
Social dimension.	No	0.354
**The analysis is performed relying on descriptive statistics methodology. The results are discussed in the corpus of the document.		
* As the p-value is less than the significance level 0.05, we can conclude that there are significant differences according to the text of the hypothesis.		

Table 32 *– Kruskal-Wallis test results for the second set of hypotheses.*

Hypotheses	***Statistical Significance****	***p-value***
*H7. Not all practices are implemented to the same extent e.g., frequently adopted for a large variety of products***.*		
H8. Firms that are part of a group show a different degree in the implementation of sustainable practices (P1, P2, … P25).		
P1: Supplier Assessment	No	0.595
P2: Supplier Collaboration	No	0.378
P3: Green Purchasing	No	0.717
P4: Green Design	No	0.750
P5: Green Packaging	No	0.733
P6: Green Production	No	0.655
P7: Green Manufacturing	No	0.180
P9: Protection of Animal Welfare	No	0.362
P10: Soil Conservation and Management	No	0.307
P11: Responsible Use of Natural Resources	**Yes**	**0.013**
P12: Inventory Management	No	0.579
P13: Green Warehousing	No	0.237
P14: Green Shipping and Distribution	No	0.502
P16: Corporate Green Image Management	No	0.168
P17: Green Product Innovation and Design	No	0.260
P18: Corporate Social Responsibility Programs	No	0.077
P19: Green Human Resource Management	**Yes**	**0.004**
P20: Adoption of Standard and Certification	**Yes**	0.066 (**0.019°**)
P21: Collaborative Supply Chain: Information Planning	No	0.843
P22: Collaborative Supply Chain: Green Targets Planning	No	0.073

Hypotheses	***Statistical Significance****	***p-value***
P23: Strategic SC collaboration	No	0.357
P24: SC integration system	No	0.393
P25: Adoption of ICTs	No	0.757
H9. There is a significant difference between companies operating in Italy and companies operating in France considering the degree of implementation of the sustainable practices (P1, P2, … P25).		
P1: Supplier Assessment	**Yes**	0.067 (**0.047**°)
P2: Supplier Collaboration	No	0.812
P3: Green Purchasing	No	0.105
P4: Green Design	No	0.614
P5: Green Packaging	No	0.230
P6: Green Production	No	0.124
P7: Green Manufacturing	**Yes**	**0.035**
P9: Protection of Animal Welfare	No	0.702
P10: Soil Conservation and Management	No	0.790
P11: Responsible Use of Natural Resources	**Yes**	0.055 **(0.035°)**
P12: Inventory Management	No	0.403
P13: Green Warehousing	No	0.917
P14: Green Shipping and Distribution	No	0.133
P16: Corporate Green Image Management	No	0.161
P17: Green Product Innovation and Design	No	0.292
P18: Corporate Social Responsibility Programs	No	0.604
P19: Green Human Resource Management	No	0.295
P20: Adoption of Standard and Certification	No	0.117
P21: Collaborative Supply Chain: Information Planning	No	0.092
P22: Collaborative Supply Chain: Green Targets Planning	No	0.140
P23: Strategic SC collaboration	No	0.583
P24: SC integration system	No	0.729
P25: Adoption of ICTs	No	0.420
H10. The size of the company influences the degree of implementation of sustainable practices (P1, P2, … P25).		
P1: Supplier Assessment	**Yes**	**0.040**
P2: Supplier Collaboration	No	0.123
P3: Green Purchasing	No	0.816
P4: Green Design	No	0.297
P5: Green Packaging	No	0.245
P6: Green Production	No	0.592

Hypotheses	*Statistical Significance**	*p-value*
P7: Green Manufacturing	No	0.293
P9: Protection of Animal Welfare	No	0.517
P10: Soil Conservation and Management	No	0.384
P11: Responsible Use of Natural Resources	**Yes**	**0.006**
P12: Inventory Management	**Yes**	**0.007**
P13: Green Warehousing	No	0.723
P14: Green Shipping and Distribution	**Yes**	**0.032**
P16: Corporate Green Image Management	No	0.520
P17: Green Product Innovation and Design	**Yes**	**0.039**
P18: Corporate Social Responsibility Programs	No	0.372
P19: Green Human Resource Management	**Yes**	**0.014**
P20: Adoption of Standard and Certification	No	0.061 (**0.009**°)
P21: Collaborative Supply Chain: Information Planning	No	0.554
P22: Collaborative Supply Chain: Green Targets Planning	**Yes**	**0.010**
P23: Strategic SC collaboration	**Yes**	**0.003**
P24: SC integration system	No	0.084
P25: Adoption of ICTs	No	0.210
H10[subset]. The size of the company (less or more than 50 employees) influences the degree of implementation of sustainable practices (P1, P2, … P25).		
P1: Supplier Assessment	No	0.137
P2: Supplier Collaboration	No	0.193
P3: Green Purchasing	No	0.610
P4: Green Design	No	0.071
P5: Green Packaging	No	0.146
P6: Green Production	No	0.655
P7: Green Manufacturing	No	0.177
P9: Protection of Animal Welfare	No	0.228
P10: Soil Conservation and Management	No	0.138
P11: Responsible Use of Natural Resources	**Yes**	**0.000**
P12: Inventory Management	**Yes**	**0.001**
P13: Green Warehousing	No	0.426
P14: Green Shipping and Distribution	No	0.268
P16: Corporate Green Image Management	No	0.160
P17: Green Product Innovation and Design	**Yes**	**0.029**
P18: Corporate Social Responsibility Programs	No	0.095
P19: Green Human Resource Management	**Yes**	**0.002**

Hypotheses	***Statistical Significance****	***p-value***
P20: Adoption of Standard and Certification	**Yes**	**0.019**
P21: Collaborative Supply Chain: Information Planning	No	0.164
P22: Collaborative Supply Chain: Green Targets Planning	**Yes**	**0.009**
P23: Strategic SC collaboration	**Yes**	**0.000**
P24: SC integration system	**Yes**	**0.010**
P25: Adoption of ICTs	No	0.304
*H11. The degree of implementation of P_1, P_2, P_3 and P_{20} is conditioned by the number of actors upstream with respect to the focal company****.*		
P1: Supplier Assessment.	No	0.386
P2: Supplier Collaboration.	No	0.102
P3: Green Purchasing.	No	0.226
P20: Adoption of Standard and Certifications.	No	0.894
***The same results are obtained by considering the distinction between direct supplier and sub-suppliers i.e., one actor upstream (direct supplier) and more than one actor (sub-suppliers).		
H12. The degree of implementation of P_{19} is conditioned by the number of actors downstream with respect to the focal company.	No	0.550
*H13. The degree of implementation of P_1, P_2, P_3 and P_{20} depends on the product portfolio of the company itself*****.*		
P1: Supplier Assessment.	No	0.105
P2: Supplier Collaboration.	No	0.311
P3: Green Purchasing.	No	0.156
P20: Adoption of Standard and Certifications.	No	0.945
**** The same results hold by considering the cluster of products as "one type of product family handled" and "more than one type of product family handled".		
H14. Companies operating at the processing stage are more sensitive to P_1, P_2 and P_3 with respect to distribution companies.		
P1: Supplier Assessment.	**Yes**	**0.033**
P2: Supplier Collaboration.	No	0.223
P3: Green Purchasing.	No	0.495
H15. The degree of implementation of P_1, P_2 and P_3 is conditioned by the fact that a company is a cooperative or a firm.		
P1: Supplier Assessment.	No	0.127
P2: Supplier Collaboration.	No	0.317
P3: Green Purchasing.	No	0.291
*H16. P_6 or P_7 or P_{14} are implemented to the same extent for companies operating at the primary production or processing or distribution stage***.*		

Hypotheses	***Statistical Significance****	***p-value***
H17. An organization handling ingredients or ultra-processed products is not sensitive as to P_7 with respect to an organization treating unprocessed or minimally processed products.	No	0.939
*H18. At the primary production stage, P_9, P_{10} and P_{11} are equally implemented***.*		
*H19. At the distribution stage, P_{12}, P_{13} and P_{14} are equally implemented***.*		
H20. A firm is not sensitive as a cooperative to the environmental burden (P_{11})	No	0.926
*H21. The number of actors upstream influences the importance given to collaborative practices P_{21}, P_{22}, P_{23} and P_{24}*****.*		
P21: Collaborative Supply Chain: Information Planning	No	0.413
P22: Collaborative Supply Chain: Green Targets Planning	No	0.581
P23: Strategic SC collaboration	No	0.340
P24: SC integration system	No	0.865
*H22. The number of actors downstream influences the importance given to collaborative practices P_{21}, P_{22}, P_{23} and P_{24}*****.*		
P21: Collaborative Supply Chain: Information Planning	No	0.131
P22: Collaborative Supply Chain: Green Targets Planning	No	0.583
P23: Strategic SC collaboration	No	0.542
P24: SC integration system	No	0.876
*****The same results are obtained by considering the distinction between one or more than one actor up- or down-stream.		
H23. Cooperatives show a different degree of implementation to collaborative practices P_{21}, P_{22}, P_{23} and $P_{24}$with respect to firms.		
P21: Collaborative Supply Chain: Information Planning	No	0.292
P22: Collaborative Supply Chain: Green Targets Planning	**Yes**	**0.025**
P23: Strategic SC collaboration	No	0.190
P24: SC integration system	No	0.078
H24. A firm is not sensitive as a cooperative to its social impact (P_{18} and P_{19}).		
P18: Corporate Social Responsibility Programs.	No	0.088
P19: Green Human Resource Management.	No	0.878
H25. The degree of implementation of P_{25} depends on the number of actors upstream.	**Yes**	0.078 (**0.028**°)
H26. The degree of implementation of P_{25} depends on the number of actors downstream.	No	0.144
H27. The degree of implementation of P_{25} is conditioned upon the product portfolio of a company.	No	0.529
**The analysis is performed relying on descriptive statistics methodology. The results are discussed in the corpus of the document.		

Hypotheses	*Statistical Significance**	*p-value*

*As the p-value is less than the significance level 0.05, we can conclude that there are significant differences according to the text of the hypothesis.

° p-value adjusted for ties

APPENDIX G – OPEN QUESTIONS OUTCOMES

In the following, full text of the collected answers is provided as an answer to the questions:

1) *Is the attention towards sustainable development increasing in your company (with reference to the last 5 years)?*
2) *What are the main drivers that lead your company to implement sustainable practices?*
3) *Up to you, what are the main barriers to implement sustainable practices?*

1. Sustainability: example of project implemented

[SC1] Yes, I think so, ***because the market now demands this. The attention is paid not only on the quality of the product itself but also on how it is produced and to the company that produce it****. To date, for example, the consortium (Consortium of Parmigiano Reggiano) has implemented a system of contributions centered on the welfare of the animal, as there is an increasing attention on how the animal is raised and how a product is produced, which are given based on rankings made by specialists who evaluate the operations carried out by the company.*

[SF1] Yes, this emphasis on sustainability is growing slightly in recent years. It has taken the form, for example, of installing solar panels that exceed the company's needs. So in fact our company sells energy on the market. Then, we make semi-finished products for bakery, so we do not have a particularly energy-intensive company. Let's say that having a large surface area in terms of roofs (because we have several warehouses) it was decided to use them for this purpose.

[SF2] Let's say that the approach that was given to the company has already been in place for a few years, even if we are now planning to make a further investment linked to the treatment of zootechnical slurry. We are a dairy associated with three farms, so we are part of a small group made up of three farms. In the last few months, we have planned the purchase and the implementation of a new system for the treatment of zootechnical slurry, since there is a regulation concerning the treatment of these as it is necessary to maintain values that do not pollute lands. But apart from this investment, which will be made, in the last five years there has been nothing new compared to what was done before.

[SF3] Our company is an agro-industrial company and from the point of view of eco-compatibility with the external environment we have invested a lot (about 10% of our turnover, 10 million of investments) to make the company more environmentally friendly. The choice of

*investing in sustainable solutions**, it was a choice made to preserve our core business**. Our core products are oils and the related vegetable fuel obtained as residuals from oils. The latter are perhaps the products that is more convenient today than the raw material and the main product for which the company was designed. The attention towards sustainability has not increased in these last years because we had already adapted to the laws at European level. What we have not invested in, for example, are the alternative energies, since according to our size (we are talking about 1Gb of daily needs) there was no need to invest in alternative sources of energy production.*

[MC1] The attention towards sustainability is definitely an increasing concern for two major reasons: the first, and the most obvious, is to convey an image of sustainability to the final consumer that is supported by actions undertaken by the company. In our case for example, it has been translated by focusing the attention on a traceability project.

In our case, for example, it has been translated on a traceability project: the final consumer can know the farmer from which the milk comes. We are also beginning to work on environmental sustainability, trying to reduce electricity consumption, and then water consumption, although this has not yet been implemented. We have experimented a monitoring project on six farms and we are trying to understand how our farmers can better organize certain processes within the farm to reduce energy consumption. As a company at the top of the cooperative, we are working on environmental sustainability as well. We have the environmental certification 24100 and then we have acquired since a year also the energy certification 50001. So we are also trying as a company to adopt "cost saving" methods with regard to electrical consumption in general and energy consumption.

[MF1] This company began to deal in a systematic and organized way with environmental aspects in 2004 when we obtained the ISO 14000 certification. From that moment on, we started a structured and, in some way, progressive path that has allowed us to lower the consumption of natural resources such as for example water and energy. Therefore, since 2004, until today there is a progress that is made year after year, either with targeted projects, or with a careful management of resources. The targeted projects started a few years ago with the installation of photovoltaic panels, also thank to the incentives provided by the State. And we recently started a project to replace the fuel with which we run the steam generators. Which will certainly have an impact on the reduction of energy costs but also on emissions. And this also benefits us.

[MF2] Yes, yes, fundamentally yes. Things have been changing very quickly over the last five years, even if, on a personal level, it's something I discovered with the Danone group with its

dual economic and environmental project. And today this dual project has been transferred to my small company as a triple economic, environmental and societal project. With regard to my employees, for example, I have tried to get them more and more involved in the economic development of the company.

[MF3] No, the focus on sustainable development in our company is the same. We are not a very "eco-friendly" company, and the increased efficiency of our machines or plants is more due to the evolution of engineering than to the propensity to have something more environmentally friendly. In recent years we have invested in a cogeneration plant to produce electricity, we try to reduce water consumption as much as possible, for example we have installed a compression cooling system that uses air instead of water, and then we focus a lot on separate collection of both materials and packaging waste.

[LF1] I would say that there is a strong increase [on considering sustainability concerns] because we are in the process to obtain the certification B-corp. Thus since the beginning of the year there has been a lot of attention on these issues. Especially in recent months, the issue of sustainability has received a further acceleration because we are structuring ourselves to obtain the certification. Thus, sustainability has become one of the fundamental pillars of our strategy with greater importance than in the past.

[LF2] This is a subject we are dealing with a lot at the moment, both because we are in the process of drawing up a sustainability report and also because we want to explore this subject further. In this regard, we are working with Deloitte in order to try to correctly implement sustainability projects or at least establish priorities. Sustainability has unfortunately become such a broad topic that it is difficult to understand. The focus on sustainability is definitely growing.

[LF3] We are trying to actively participate in the issue of sustainable development, within our business and otherwise. So, we produce for supermarkets basically. We have a small brand, but our mission is to produce for supermarkets, so we follow the trends of large-scale distribution. We are dealing with social sustainability since the 2014, and about environmental sustainability since 2017. In a nutshell, it's in the last three years that we have organized our environmental and social sustainability strategy in a more organic way. Economic sustainability is less interesting for the supermarkets point of view and more to interesting for the company because clearly economic sustainability means diversifying risk, reducing sourcing from risky areas of fresh tomatoes rather than dried pulses (we process around 300,000 tones of fresh tomatoes and 60,000 tones of dried pulses), so clearly economic sustainability means buying from various countries in a competitive manner but without

speculating. So, let's say that in the last 6-7 years (2014 social 2017-18 environmental) there has been a strong pressure from the large-scale retail trade. However, we have always been committed to environmental and social sustainability. Clearly, in recent years, we have intensified these strategic choices and, we have learned how to present them to customers in a more organic way. Nowadays it is a must. For example, when we meet customers, they are less interested in visiting the factories and they are more interested in understanding from a strategic point of view what we are doing to protect the environment, reduce the use of chemicals rather than ensuring that business practices are carried out in a way that is fair on the workers, without abuse etc etc.

We have principles of environmental sustainability and ethics. Among the ***targets from the environmental*** *point of view there* ***are the reduction of the carbon footprint and of the consumption of natural resources, the reduction of food waste and the protection of biodiversity***, ***recycling of paper and plastic****. To date, we carry out many* ***packaging projects*** *(we have a person, the packaging manager, who oversees packaging innovation and sustainability). For example, we have removed a layer of chemical plastic and replaced it with a vegetable plastic in our packaging containers. We have reduced the weight of the labels to reduce the amount of what is called over packaging. in terms of the amount released into the environment. The use of plant-based plastics instead of fossil-based plastics is possible thanks to joint work with suppliers (multinationals). The same has been implement for paper and cardboard, we started with trays made of virgin paper, now we use trays containing up to 80% recycled paper. From the tomato point of view that is our core business, we have a direct management of the agricultural part. We manage about 400 farmers in five regions, but more than farmers they are partners because we have been working with them for several years, so* ***having this partnership relationship makes it easier for us to work on environmental sustainability projects****. So, we work to reduce chemicals and treatments are only done when strictly necessary. This means monitoring insects in a more accurate and detailed way. Then, about water waste, we have installed sensors that automatically alert farmers when humidity falls below a certain level that bring to a 15% reduction in water consumption. One of the latest projects implemented was the* ***bee project, in which we created fields with flowers near the tomato fields****. Flowers attract bees, which are used for pollination, but they also indirectly help to reduce the use of chemicals, because chemicals kill insects but also bees, so by reducing chemicals and thanks to flowers we increase the presence of bees (15% increase in bee activity). Obviously, these are projects that are extended to all farmers depending on the target goals that we set.*

*On the ethical side, there is a **code of conducts shared with all suppliers**, both agricultural and non-agricultural. Concerning the social sustainability, we have various certifications but also **training activities are provided** on the agricultural side **as well as audits**, trying to raise awareness of social aspects because then the risk of having untrained or non-contracted workers, apart from ending up in the newspapers, from an ethical point of view we do not want to do this. We produce for global customers, especially in the UK but also in the whole of northern Europe, and there is a great concern about these aspects. So, we make sure that the controls are detailed, and the training is adequate. Among the training activities what we offer are also Italian lessons for immigrants who are increasingly present in southern Italy and for whom not knowing the national language makes it much easier to be treated unfairly.*

2. Sustainability Drivers

*[SC1] The attention towards sustainability issues starts from **the guidelines of the group**. Then, other drivers are the benefits that follow from being recognized as a zero-impact company or as a sustainable breeding company, for example. This attention toward the sustainable development gives us much **more visibility on the market** and it makes us earn more. In the initial stages the return on investments does not cover all the expenditures, but in the future, it will be essential to keep going in this direction. The partners of the cooperative decided to follow this direction for two main reasons: their **personal responsibility** and the **visibility on the market**.*

*[SF1] Working in the food sector and having large companies (national and multinational) as customers, **we are forced to some extent by our customers to adopt sustainable practices**. In particular, in recent years there has been a significant number of acquisitions of Italian companies by French groups, and France has higher standard on these issues than Italy, so very often we receive requests from these clients that raise the level of demands. I can say that 80% of the sustainability actions adopted are **the result of requests from our customers**, while 20% depend **on our company management**, which is sensitive to these issues and to the efficiency of our plant.*

*[SF2] For those who have always experienced the reality of a farm, a livestock farm, and are in love with their land, **it is not really the regulations a driver for greater attention to sustainability**. It is clear, however, that sometimes farm owners have a different conception of what should be implemented than what the regulations require. Thus, the attention toward sustainability concerns comes from both **internal and external factors**.*

[SF3] What can drive an established company to implement sustainable practices is mainly because ***there are no alternative investments that a company can pursue to upgrade facilities****. In our region, the attention to the environment and to the climate change are very important and the* ***requirements imposed by the local government*** *must be followed very strictly. The region gives us general guidelines, then the provinces give their own guidelines based on the environmental needs.*

[MC1] First of all, ***the market****. Since we have our own market positioning, our slogan for milk is "100% milk from our region". Then consistency with this message must be translated into a commercial policy that takes into account the characteristics of the environment in which we operate and is committed to adopting appropriate actions to preserve this environment. Therefore, the main motivation in adopting sustainable breeding and production practices* ***is consistency with the message we bring to the market and the final consumer****. Moreover, from the company's internal point of view, we try to save energy and water consumption or reuse production waste also for economic reasons.*

[MF1] Since we are a profit-driven business, certainly ***the main driver are savings that are possible by using recyclable materials, implementing devices that allow us to avoid heavy energy consumption*** *(e.g., more efficient motors). Furthermore, an important driver is* ***the company direction*** *that annually sets a budget for a set of sustainable goals that have to be achieved.*

[MF2] There are two main factors: there is ***the social function of the company*** *and there is* ***the attention to the environment****. So, in relation to our company, it is to try as much as possible to keep our ecosystem alive, our small local, regional ecosystem by trying to buy raw materials, semi-finished products, locally, in France. Beyond the fact of making French employees work and ensuring that they are associated with the company's success. This is the first point, and then there is the sustainable aspect, that is the environmental aspect according to which we try to buy products locally to avoid transport and pollution.*

[MF3] First and foremost, it is ***the owners of the company*** *who pay special attention to these environmental needs. In addition, as we work a lot on behalf of third parties,* ***our clients ask us to comply with certain certifications****, such as the FSCC certification for sustainable paper. As a result, they require our suppliers to be certified.*

[LF1] Certainly ***the company mission****, which is to ensure that everyone has real-time access to a plant-based diet for the well-being of people and the planet. And therefore, being intrinsic to the company's mission, the implementation of sustainability projects follows directly. Working on sustainability concerns represents a driver in all aspects of the company, in terms*

of the production of our products, the environmental impact of the company itself, the commitment of people, the ability to recruit people who are aligned the same philosophy. Moreover, this [i.e., working on sustainability concerns] *has several advantages that definitely make it attractive.* [What about external drivers?] *I would say that* ***there are no external drivers****. It is intrinsic at the corporate level, it is not a path that has been undertaken as a reaction perhaps to a competitor, or to the market, or as a desire to add a marketing strategy. It is the company itself that wants to deal with this type of changes especially to be consistent with the business strategy.*

[LF2] Let's say that the focus on sustainability is subject to three main factors: ***greater sensitivity by the market****, and therefore by clients and consumers,* ***local and national policies*** *that go in that direction, so a food group, a large food group, cannot fail to take this into account because today there are directives and standards and objectives at European and national level that drive us in that direction. Having said that,* ***company management*** *is obviously moving in that direction.*

[LF3] I think it is ***the attitude and support of senior management*** *in performing sustainability activities. A moral obligation to perform certain activities and to make sure they are performed correctly. Then clearly, producing for* ***large clients****, certain actions are implemented because they are required by the contract. So, if the contract states that we have to perform certain good practices from an environmental and social point of view, these are necessarily adopted. But the first thing is always to protect the environment and to protect the people who work inside and outside the company. Because if we do not protect the environment, our products will probably no longer exist in the future. It is essential to consider sustainability concerns in day-to-day operations.*

3. Sustainability Barriers

[SC1] ***From the internal point of view, i.e., the board of the cooperative or the employees, there are no barriers****. The management of the cooperative tries to involve the employees in any kind of decision concerning the operations that need to be improved and where it is necessary to intervene. The main challenges are always trying to find a compromise between something that is necessary and something that is feasible. In this regard, I would like to underline that a cooperative has to make a fairly precise budget, something that private individuals get around quite easily. So, the cooperative must have a well-defined budget with specific depreciation, thus it must be very careful about the kind of investments that have to be implemented. For example, the biogas plant or the implementation of photovoltaic panels are somewhat risky*

investments that need to be evaluated carefully. In my opinion, if a company is not capable of evaluating the necessary investments, especially because in the agriculture sector many companies have remained somewhat tied to a more traditional ways of operating. This can represent a real limitation. ***All the challenges/barriers come from an external point of view such as bureaucratic barriers****.*

[SF1] We produce semi-finished products, so we have industrial suppliers and customers. The ***barrier in recent years is the competition on prices and margins*** *because we see many medium / small customers who become part of large groups. Thus, the competition is moving from the national to the international level, where groups that do our job but are larger than us have* ***the possibility of having savings due to size.***

[SF2] ***The main barriers are clearly of an economic nature****. The investment that is needed to put in place environmental protection systems are generally costly solutions that have a major impact on a company's economy. It is a different case when working on processes rather than plants. Changing a process has a lower cost than investing in systems and machinery. It is a different type of cost that mostly involve changing the comfort zone of people.* ***Forcing people to change their way of working, costs effort, commitment and training.*** *And then certainly* ***one barrier is the economic cost of investment****.*

[SF3] The main barrier ***is definitely the return on investment****.*

[But aren't there external barriers as well?]

No, no. The external barrier is: if you comply with the sustainability requirement you stay in the market, otherwise you have shut down. Local authorities give you time to adapt to the proposed guidelines and then there is an instrument that is the so-called "Environmental Authorization" which lasts about 15 years and which you have to comply with and whose requirements can change in the meantime. Let me give you an example: fine dust. Fine dust can only be reduced with electro filters. An electro filter consumes 1Gb of electricity to break down dust. Perhaps it would be better not to use electro filters but to adopt alternative systems (such as wet cleaning). The problem is that ***certain regulations sometimes follow certain beliefs, which are not always applicable in the right way or for all situations or companies****. In addition, a company that produces oil or a foodstuff that tries to develop and use secondary raw materials to produce electricity is not rewarded compared to another that does the same and uses gas.*

[MF1] The main barriers are, on one hand, the need to anticipate ***economic resources*** *and to operate in a system in which each change is not enough in itself but requires changes to the infrastructures, layout changes and therefore has an important impact. For example, if the*

investment in the change of the type of fuel has a cost of x, this in turn requires a whole series of ancillary works that double the final cost of the investment. When this type of investment is made, the impact involves multiple areas of the plant which forces us to review many things, in addition to an initial financial exposure that is not indifferent. In addition, when ***working habits are changed****, such as switching to a more rationed water management system, which takes people out of their comfort zones, this is hindered by the acceptance of the beneficiaries of these changes (not only the environmental ones, but any change that is proposed).*

From an external point of view (i.e., relationships with customers / suppliers) I cannot say which are the main barriers because the things we have done mainly impact the company from an internal point of view. However, recently our packaging supplier proposed us to use new packaging produced from recycled or recyclable materials and this is very important because if it were used as a marketing lever it could give us a return (propose on the market a sustainable product for which we are able to providing information on Life Cycle Assessment, understanding how much CO2 is needed to bring the product to the table could be an important marketing lever. I tell you sincerely that my company, but perhaps the entire sector, except for some special cases, is not yet ready. ***Precisely for mental barriers****. Since to do this kind of work you need to have a structure that is able to communicate these results, a lot of work is required. What's more, there is no immediate return, beyond a mere communication on the label.*

[MF2] ***The price.*** *Today it costs more to buy non-GMO products, to have pasta made without additives and to make a final product with natural flavors for example. From the internal point of view there are no particular barriers since sustainability project are implemented first of all for the well-being of the employees and the whole community.*

[MF3] ***The biggest barriers are external****. For example, some suppliers are not certified, or, in the case of palm oil, they do not have the facilities to handle segregation of palm oil.*

[MC1] Basically, the problems are linked to ***the time that the cooperative member can dedicate to the monitoring of the proposed initiatives, rather than to the economic investment itself****. That is, the return in economic terms and even more considering the image of the company, takes a very long time and often the agricultural enterprise goes towards this innovation if it sees that the return of the investment is in the short time. Let's say that the biggest barrier is to convey sustainability message and the related projects to the cooperative members because they involve require long implementation times and the return on investment is in the long run. The cooperative could encourage this, i.e., by supporting people in our companies who begin to deal with innovation projects in a systematic manner and not perhaps linked to the contingency or extemporaneity of a research project that may be funded by the*

region or the ministry. This the cooperative's strength that it is able to provide expert to the cooperative members who systematically follow the implementation of projects and the transfer of these innovations to the companies.

[LF1] The focus on sustainability is a process of transformation, so the difficulties that arise mainly concern two areas. ***The first is related to people****. This is because when you have employees of a certain seniority, there is a resistance to change. Although it is true that everyone supports the company's mission, when you actually go to change working practices, the approach to work, thinking, changing suppliers, perhaps even incurring in additional costs, there can be a resistance to the change that makes the process more difficult than the initial reaction in which everyone is in favor of the change. The* ***second dimension is related to*** *the business. For example, you may have* ***customers and/or suppliers*** *who are equally sensitive to the sustainability issues and others who are less sensitive. So, you to have to adapt your message to try to make them aware of it, or to have to do something more to overcome discrepancies that arise with respect to the way competitors work. As it is a developing matter [considering sustainability requirements] it is not immediately accepted that we have to adopt different practices to cope with sustainable development requirements, especially when competitors do not have the same approach and the customer does not perceive the need and is not so sensitive.*

[LF2] The main barriers are determined by the fact that ***sustainability has a cost****,* ***which cannot be transferred to the market****. All our analyses of the end consumer tell us that "yes, sustainable packaging, recycled plastic, paper, everything is fine, you're protecting the planet, but I don't want to pay more for a product that respects these standards". So at this stage it is really a cost/investment that the company has to bear.*

What about from an internal perspective?

The main barriers ***are technological barriers and investment barriers****. I like the expression "road to sustainability", that means starting a transformation in that direction. If I want to transform all the plastic into paper tomorrow morning, I could not. I have to make an investment plan and introduce the changes gradually.*

[LF3] The main barrier has been and still is linked to the ***agricultural stage****, even if the more we move in this direction the more the difficulties diminish. I am referring specifically to getting farmers to adhere to the importance of having an environmental and social strategy. I don't want to use the word convince, but farmers are basically traders, they are not entrepreneurs, most of them are farmers who see the land and want to make a profit quickly. To overcome this kind of difficulty, projects are implemented gradually, explained precisely, and training and*

collaboration are always provided. Inside our plants there are no barriers. Apart from all the certifications that can create some difficulties, within the group it is easier to carry out sustainability projects. There is a difficulty with supermarkets, because they are very demanding from the point of view of guarantees, but in the end ***the cost of a product is always a problem***.

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