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**PhD DISSERTATION PROJECT
Analysing business operations in the fruits and vegetables supply chain: quality of
commercial relations and food loss management at producer-retailer interface**

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ABSTRACT

One dynamic field of research in agri-food economics focuses on the analysis of commercial interactions in the upstream stages of the food supply chain, where significant inefficiencies may occur due to the different bargaining power of actors. The aim of this thesis is to explore the quality of commercial relations between producers and buyers, as well as the possible effects of inefficient practices—including the occurrence of food loss— generated in the fruit and vegetable supply chain in Italy. To contribute to this stream of research, the thesis is elaborated on three research questions: (I): How do Producer Organizations engage with commercial channels in the fruit and vegetable value chain, and how do private quality standards affect food loss from their perspective? (II): What is the extent of fruit and vegetable loss during the postharvest phase, both in terms of mass and economic value, and how much of this loss can be attributed to private quality standards? (III): According to producers' perceptions, what factors influence the quality of their commercial relationships with buyers?

The thesis is based on three scientific papers, each addressing specific research questions. PAPER I and PAPER III explore questions I and III; while PAPER II responds to question II. More specifically, PAPER I studies the role of Producer Organisations as key actors in the fruit and vegetable supply chain, investigating the Italian and German contexts. The semi-structured interviews conducted to Producer Organisations are analysed with the MAXqDA program, giving a qualitative and quantitative analysis of the contents. In PAPER II, a direct assessment of the impact of private cosmetic quality standards is conducted in the postharvest phase of carrots supply chain, at one Producer Organisation warehouse. The assessment is conducted on mass and value of carrots sold to fresh market, downgraded, and sold for food industry. PAPER III studies the factors that shape the quality of the commercial relations between producers and buyers. A mixed methodology approach is used, combining a focus group with Producer Organizations and a survey administered to Producers, with the aims to analyse their perceived quality of commercial relations with the two most important buyers. Basing on the evidence provided by these three papers, the thesis is elaborated with a common introduction, following by methodologies and results. The dissertation ends with a discussion of the overall results gathered across the papers, and the implications at practitioner, market, and policy level. The three papers are cited wherever needed in the dissertation, while their full text is reported at the end of the document.

KEYWORDS

Food supply chain; Fresh fruits and vegetables; Producer Organisations; Commercial relations; Food loss; Private quality standards.

ACRONYMS

CAP Common Agricultural Policy

EFSA European Food Safety Authority

EU European Union

FFV Fruits and Vegetables

FL Food Loss

FLW Food Loss and Waste

FW Food Waste

GHG Greenhouse Gas Emissions

PO(s) Producer Organisation(s)

SDG(s) Sustainable Development Goal(s)

UNECE United Nations Economic Commission for Europe

UTP Unfair Trading Practices

LIST OF PAPER PUBLICATIONS

PAPER I

Pietrangeli, R., Herzberg, R., Cicatiello, C., and Schneider, F. (2023). Quality Standards and Contractual Terms Affecting Food Losses: The Perspective of Producer Organisations in Germany and Italy. Foods, 12(10), 1984. <https://doi.org/10.3390/foods12101984>

PAPER II

Pietrangeli, R., and Cicatiello, C. (2024). Lost vegetables, lost value: Assessment of carrot downgrading and losses at a large producer organisation. Journal of Cleaner Production, 478, 143873. <https://doi.org/10.1016/j.jclepro.2024.143873>

PAPER III

Pietrangeli, R., Cicatiello, C., Galli, F., Carbone, A., Cacchiarelli, L., Sorrentino, A., & Russo, C. (2025). Exploring the Quality of Commercial Relations Between Producers and Buyers in the Fruit and Vegetable Supply Chain. Sustainability, 17(6), 2641. <https://doi.org/10.3390/su17062641>

TABLE OF CONTENT

ABSTRACT.....	3
INTRODUCTION	6
RESEARCH QUESTIONS.....	10
BACKGROUND	12
The FFV supply chain in Italy.....	12
Commercial relations and negotiations	13
Commercial quality standards and suboptimal products.....	15
Food Loss and Waste	17
MATERIAL, METHODS AND METHODOLOGICAL ADVANCEMENT.....	19
Qualitative methods.....	20
Quantitative methods.....	22
RESULTS AND DISCUSSIONS	30
Structure of the FFV supply chain	30
Impact of private quality standards	32
Quality of commercial relations	35
IMPLICATIONS OF THE RESEARCH.....	39
Implications for practitioners	39
Market implications.....	40
Policy implications.....	42
CONCLUSIONS.....	46
REFERENCES.....	47
PAPER I.....	54
PAPER II.....	69
PAPER III	81

INTRODUCTION

Reaching the sustainability of global food systems is one of the main challenges that societies are pursuing. This is also reflected in the Sustainable Development Goals (SDGs), n. 2-12-14, calling for zero hunger, sustainable production and consumption processes, and conservation of life below water. However, achieving these goals is challenging due to the environmental impact of food systems. It has been estimated that food supply chains generate 26% of anthropogenic Greenhouse Gas Emissions (GHG) emissions (Poore and Nemecek, 2018), which are responsible to alter the balance and the composition of natural ecosystems; and reduce biodiversity and ecological resilience (Bouwman et al., 2002). Among the different stages of the supply chain, primary production and processing have the greatest impact, accounting for the 61% of food's GHG emissions. Specifically, 31% of them is generated by livestock and aquaculture activities, 27% from cultivation processes; 24% are related to land consumption; while the remaining 18% is generated during the food production processes and depend on the subsequent stages of the food supply chain (Poore and Nemecek, 2018).

Indeed, although food production is an essential process for human being, it requires a significant amount of natural resources and energy, that have a negative impact on environment. These effects include, for example, land use, biodiversity loss, freshwater resource depletion, global warming, and contamination of terrestrial and marine ecosystems (Springmann et al., 2018).

FAO (2019) estimates that the demand of food products, and in turn agricultural products, will increase by 35-50% by 2050 due to the growing population, thus bringing a higher pressure on the environment. Moreover, FAO (2019) estimates that 14% of the food produced never reaches the distribution phase, as it is lost in the production or processing phases, thus becoming a Food Loss (FL). Of the food that reaches the distribution phase (86% of the produced food), UNEP (2024) states that 19% of food available to consumers is wasted at the retail, food service and household levels. This significant amount of Food Loss and Waste (FLW) generated during the food value chain represents an environmental issue, where it has been estimated that 6% of GHG emissions are generated worldwide from food that will never be consumed (Poore and Nemecek, 2018). FAO (2014) estimated that the annual FLW contribute for more than 4.4 gigatons of carbon dioxide equivalent (CO₂e) and that 10% of the world's total energy consumption is used to produce food that is lost or wasted (FAO 2017).

FLW not only affect the environment but also has significant economic impact and social consequences. It represents an economic loss for all the actors of the food supply chain, including consumers, and this reflects a highly inefficient use of resources. At the same time, FLW constitutes

a paradox in a world where almost 10% of the population struggle for food insecurity, since they lack of physical, social, or economic access to food (FAO, 2022). This paradox between FLW and food security has drawn the attention of policymakers and public opinion to this issue. In fact, the UN's SDGs include a target focused on FLW reduction, specifically the 12.3: *“By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses”* (UN, 2015) and two indicators are set to measure the progress of this target: (I) FL Index and (II) Food Waste Index. The thesis focuses particularly on the first index (I), which measures the total losses of agricultural commodities in the upstream stages of the supply chain -farm and processing level up to (but not included) retail level. It reflects the percentage of food removed from the supply chain with respect to the total food produced. Even with some limitations due to lack of data in the primary production, the FL Index revealed that in 2016, approximately 14% of food produced is lost before reaching the retail stage (FAO 2019) and its monetary value is approximately 400 billion USD (Surucu-Balci et al., 2021).

Reaching more fairer, healthier, environmentally, and sustainable food system is also a goal included in the Farm to Fork Strategy, which is part of the European Green Deal (European Commission, 2020), and the goal is to achieve neutral or positive environmental impact. This should help mitigate climate change, reverse biodiversity loss, and ensure food security, nutrition, and public health. It also aims to guarantee access to sufficient, safe, nutritious, and sustainable food for all, preserve the affordability of food, generate fairer economic returns, enhance the competitiveness of the EU supply sector, and promote fair trade. The main pillars of the Farm to Fork Strategy are:

- Sustainable food production;
- Sustainable food processing and distribution;
- Sustainable food consumption;
- FL and waste prevention.

To better monitor the advancement of the fourth pillars of the strategy with regard the assessment of FLW, in 2020 the EU has established a common methodological framework at the member states level (2018/851/EC; Caldeira et al., 2019), which allows to track the progress towards SDG 12.3 targets over the years. The last available data on Food Waste (FW) states that 131 kg per capita of food is wasted in the EU, and in Italy the data reaches 146 kg per capita (Eurostat, 2023). Among the various phases of the supply chain, consumers and household stages account for a total of 53% of FW, and the data does not include the waste generated in the food service sector; while the percentage accounted in agricultural production consists of 20% of the total FW.

Focusing more closely on the fruit and vegetable (FFV) supply chain, the quantity and dynamics of FW are well-studied at the retail and consumption stages (Cicatiello et al. 2017, Giordano et al., 2019;

Eriksson et al., 2017). However, a gap remains in the upstream stages of the supply chain in the analysis and the quantification of FL, in identifying its causes and address the inefficiencies that generates. In particular, perishable products such as FFV display higher losses in the supply chain than for other products, with a median of 6.4 % compared to 2.7–3.8 % of cereals, especially in low-middle income regions (Fabi et al., 2021).

FFV sector is one of the most important in Europe. In 2022, 2.0 million of hectares of land across Europe are cultivated in fresh vegetable, yielding and harvesting 59.8 million tonnes of crops (Eurostat, 2022). In terms of quantity, the three most grown vegetable products are tomatoes (15.4 million tonnes of harvested production), onions (6.2 million tonnes) and carrots (4.4 million tonnes) and the top-producer of tomatoes in Europe is Italy (Eurostat, 2022).

Agricultural FFV producers play a key role in the supply chain, however their relations with other stakeholders remain challenging: they deal with large buyers, such as retailers or food industry. Although the aim of EU is to have fairer and equitable food chains and ensure securer future for farmers (EU, 2025), negotiations and market powers are often unbalanced among the actors of the supply chain. This unbalanced power, which is in favour of buyers - and more specifically retailers - may generate inefficiencies in the interaction between the actors, especially with respect to the weakest part, the producers (Russo et al., 2023). Therefore, to improve their market power in the FFV supply chain, the EU has legally recognised and supported Producers Organisations (POs). The POs, which are formed by union of farmers, aggregate production and look after negotiation and commercialisation, increasing the bargaining power of farmers. However, the retailers and food industries superior position lead them to set and establish contractual terms, standards, and business practices for the weak links in the supply chain (Herberg et al., 2022). Among these requirements, private cosmetic quality standards pose one of the main challenges (PAPER I), resulting in a significant volume of products that fail to meet these standards and, thus, cannot be sold on the fresh market. These products, known as suboptimal, are downgraded directly at the producers' warehouse and reallocated to the most appropriate available commercial channel. However, if these operations are not performed promptly, suboptimal products may turn into waste. In this context, private cosmetic quality standards can significantly contribute to generate FL, while also causing financial losses and additional logistical costs throughout the supply chain (PAPER I; Herzberg et al., 2022). Moreover, during negotiations retailers impose conditions that may results unfair or perceived as such by producers. There is an ongoing debate in the scientific literature and policy discourse regarding the potential negative effects of unequal commercial relations on producers and the overall functioning of the food system. Evidence reports that the overall performance of the FFV supply is influenced by the quality of commercial relations between actors – especially if actors are engaged in

active, long-term relations characterized by trust, long-term commitment, social satisfaction, and cooperation (Schulze et al., 2006; Kühne et al., 2013; Molnàr et al., 2013). When the quality is higher, it represents a source of competitive advantage for producers and buyers (Grant., 2005).

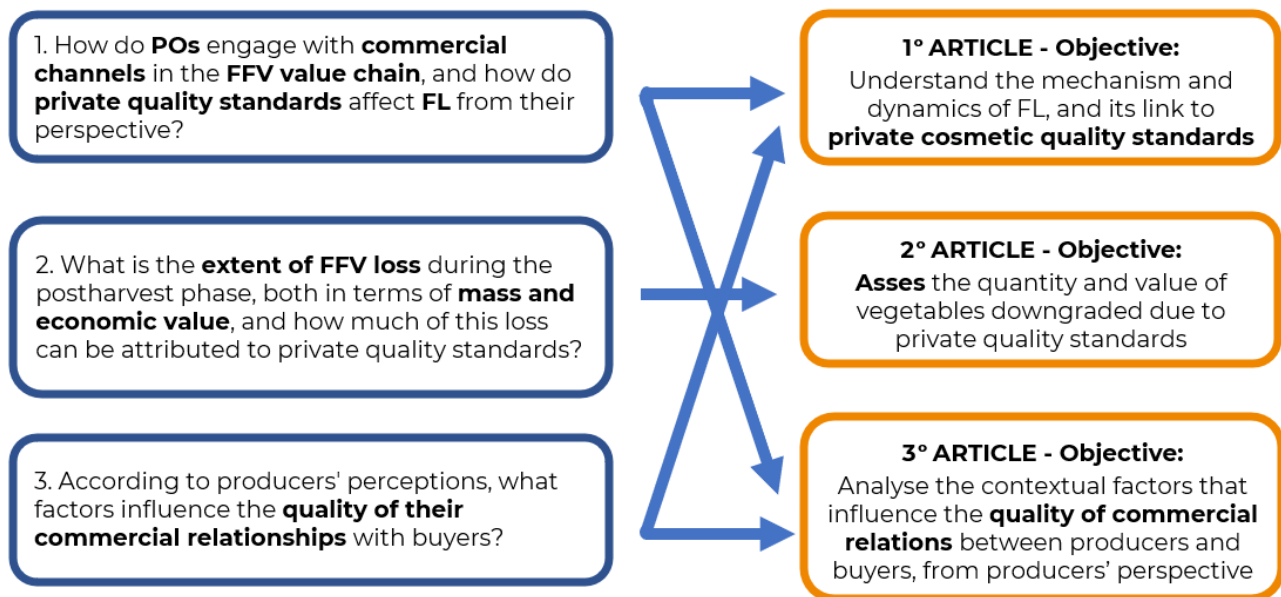
RESEARCH QUESTIONS

In this context, the thesis aims to contribute to analyse the inefficiencies that occur in the relation between producers and retailers, during the harvest and postharvest up to, but not including, the retail stage. The three research questions investigated are:

1. How do POs engage with commercial channels in the FFV value chain, and how do private quality standards affect FL from their perspective?
2. What is the extent of FFV loss during the postharvest phase, both in terms of mass and economic value, and how much of this loss can be attributed to private quality standards?
3. According to producers' perceptions, what factors influence the quality of their commercial relationships with buyers?

The answers to these questions are provided by three scientific papers, on which the thesis is based (Figure 1). Question I and III are answered by PAPER I and III, while PAPER II tackles question II. The full text of the three papers is appended at the end of the thesis.

Figure 1: Relation between research questions and scientific articles of the thesis.



Source: own elaborations

The scientific papers are developed with different methodologies, both qualitative and quantitative. PAPER I presents a qualitative methodology to analyse semi-structured interviews. PAPER II presents a quantitative methodology that involve a direct assessment. PAPER III uses a mixed methodology, where the first part is composed by qualitative methodology (focus groups) and the

second part uses a quantitative methodology (survey followed by statistical elaborations, section “*Material, Methods And Methodological Advancement*” at page 20).

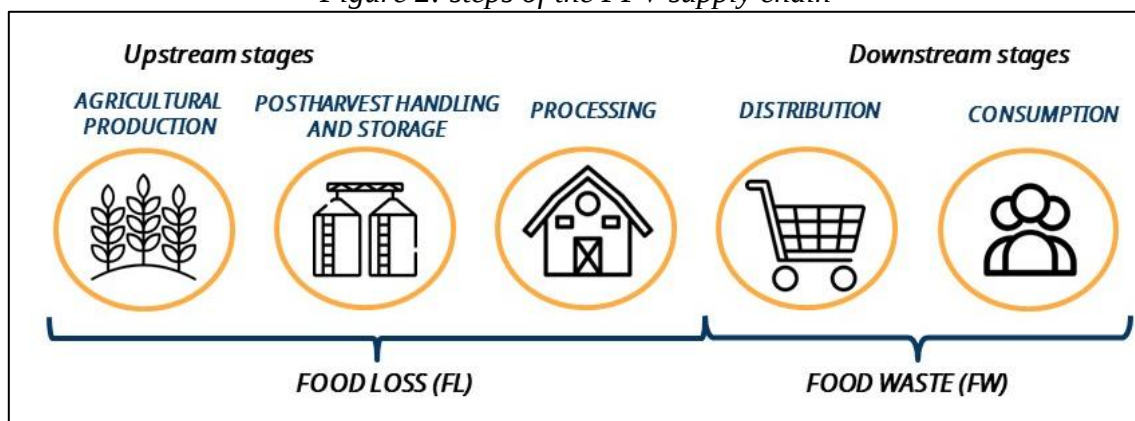
BACKGROUND

The FFV supply chain in Italy

The FFV supply chain includes all the actions and processes involved in getting products from the farm to the consumers, passing by different stages. Multiple actors take part in each stage, and each one is essential to guaranteeing that the finished products reach consumers. In Italy, the FFV sector is considered one of the main strategic for the economy, contributing with a percentage of 24% of the economic value (ISTAT, 2022). Italy is considered one of the main producers in Europe, together with Spain and France (Eurostat, 2022). Even though the Utilized Agricultural Area dedicated to vegetables account for 2%, and to fruit for 3%, the total annual turnover is about 8.5 milliard of 6.531 milliard of euro in 2022 (ISMEA, 2023). The main Italian FFV products are tomatoes, eggplant, artichokes, kiwifruit, hazelnuts, and wine grapes (Confagricoltura, 2020-2021).

The FFV supply chain can be represented as a sequence of five stages (Figure 2): agricultural production, processing, distribution, and consumption (Porat et al., 2018).

Figure 2: steps of the FFV supply chain



Source: own elaboration by Ishangulyyex et al 2019

In this thesis, the focus is on the upstream stages, especially in the harvest and postharvest phase of the supply chain, POs assume a crucial role. They are legally recognized as groups of farmers, financially supported by the EU (EU, 2013). The primary reason for their creation is to achieve greater bargaining power in the supply chain compared to individual farmers, strengthening their position with buyers (Sorrentino et al., 2018). They concentrate supply of agricultural commodities, negotiate contracts with buyers - especially retailers – and assume the economic risk associated with those transactions (Devin et al., 2018; Eriksson et al., 2017; Skorbiansky et al., 2019). Furthermore, they assist farmers in the harvest and postharvest operations, such as collecting, storing, processing, and selling the products. They also support farmers joint production planning, help with technical advice

and in machinery investments (Chlebicka et al., 2018; Hendrikse et al., 2002; Menard et al., 2007). POs may also aggregate in Association of POs (APOs) to reach more advantages and higher negotiation positions. POs and APOs facilitate collaboration in postharvest processing and commercialization of products, by concentrating in a single phase more than one stage of the supply chain (European Commission, 2018).

In Europe, 3400 POs are legally recognised, with 52% operating in the FFV sector, particularly in France, Germany, and Italy (European Commission, 2018). In Italy, 302 POs and 13 APOs operate in the FFV sector (MASAF, 2023), with a marketed FFV production higher than 12 million tons a year (MASAF, 2020).

POs normally collect FFV, handle them and sell to different buyers. Buyers are mostly composed by retailers, general markets, or food industries. The main distribution channel is represented by retailers, which cover the 80% of distribution for FFV in Italy (ISMEA, 2023). Most of the consumers' purchases take place here; therefore, they assume a stronger position in the supply chain. They set and establish contractual terms, conditions standards and business practices. They also dump the economic risk and relatives cost transactions on the upstream stage of the supply chain, at the expense of weaker players such as individual farmers to minimize economic risk emerging from transactions (PAPER I; Devin and Richards., 2018; Skorbiansky and Ellison., 2019).

During the negotiations, prices, quality, production standards, logistics, delivery, payment schedules, promotions, risk sharing, and many other details are typically agreed upon in supply contracts established between POs and buyers (EU, 2013). These contracts usually include conditions on the quantities and delivery times imposed by buyers, as well as cosmetic standards that the products must fulfil, stricter than the one imposed by Public Institutions (Fulponi et al., 2007). However, the relations between actors may generate many inefficiencies, such as economic risk, power imbalance of FLW (Galdeano-Gómez et al., 2015).

Commercial relations and negotiations

According to Grant (2005), the quality of relations is affected by a dichotomy between the transaction-based and relationship-based approach, and it is defined as the degree to which parties are engaged in an active, long-term working relations (Kühne et al., 2013; Razavi et al., 2016; Gajdić et al., 2021). Different degree levels correspond to different quality of the commercial relations.

The transactional approach is characterized by the discrete, short-term exchanges, where the most important elements are availability, timeliness, and price. The key features are minimal personal relationships and no expectation of future interactions beyond the immediate transaction; there is no relationship with the commodities offered.

The relational approach is based on long-term relations built on trust, commitment, and mutual benefit. Both parties cooperate, share information and work together to reach the common goal over the time. Here, this kind of relations generate long-term value and competitive advantages (Grant et al., 2005; Kühne et al., 2013; Razavi et al., 2016; Gajdić et al., 2021).

Commercial relations are based on two different theories: the Neoclassical Theory and the Transaction Cost Economics Theory. In the Neoclassical Theory, the approach is that farmers form cooperatives to balance market strength of process and obtain higher prices; the liquidation price given to farmer has an impact on satisfaction (Hernández-Espallardo et al., 2009). The Transaction Cost Economics theory can be used to explain the relations between buyer and supplier, and the effect on the performance (Marcos-Matás et al., 2013). The focus is on the costs associated with organising transactions and the management of relations: beyond the price, other factors determine the satisfaction and the intention to stay in a cooperative. Better access to information and the ability to evaluate performance positively influence satisfaction and continuity and adaptation. The ability to adapt the relations to changing circumstances in the external environment also impacts on satisfaction and on the intention to stay in the cooperative.

The quality of commercial relations is considered crucial for overall the FFV supply chain (Schulze et al., 2006) and exert an influence on the overall performance (Grant., 2005; Kühne et al., 2013; Molnàr et al., 2013). The three key elements where the quality of commercial relations is based are satisfaction, trust, and commitment (Kühne et al., 2013).

Trust and commitment are highlighted as fundamental elements in a business relation (Schulze et al., 2006). Trust refers to the belief in the integrity and reliability of the customer/partner. Commitment represents the desire to maintain this valued relation (Anderson and Weitz, 1992; Morgan, 1994). These factors are critical for long-term and high-quality relations between producer and suppliers (Ganesan, 1994; Morgan, 1994). Satisfaction is defined as the intention to remain in a cooperative beyond price, such as better access to information. The ability to evaluate performance positively influences satisfaction and continuity of adaptation, as well as the ability to adjust relations to changing circumstances in the external environment. This enables the intention to continue within the cooperative to be considered. The higher the quality of relations, the more they tend to a relational approach.

Although these factors are critical for long-term with high quality of relations (Ganesan, 1994; Morgan, 1994; Geyskens and Steenkamp, 2000), they have seldom been investigated in the agri-food supply chain (Gajdić et al., 2021; Bandara et al., 2017). Having relational relations is a difficult challenge due to the higher effort needed, which is not immediately rewarded with an economic benefit. Establishing close relations in FFV supply chain is particularly complex due to the large

number of small-scale producers, which makes forming close ties with large retailers more challenging (Schulze et al., 2006). Instead, in this context the transactional approach is most used, where factors as delivery speed and price holding greater value than relational factors.

During negotiations, retailers' superior position allows them to establish contractual terms, conditions standards, business practices to the weaker counterparts in the supply chain and this unbalanced power generates many inefficiencies, in particular the shift of the economic risk on the most weakened actors (Russo et al., 2023; Di Marcantonio et al., 2017). Therefore, many practices are set by the stronger players influence relations between producers and buyers that result to be unfair or perceived as such, and they are called Unfair Trading Practices (UTP). UTP are becoming increasingly significant and frequent, and to limit this, the EU supported POs with a legal framework, by adopting the Directive (EU) 2019/633 on UTP (EU, 2019). The aim is to achieve more efficient and fairer food supply chain, including the producer cooperation and measures to enhance market transparency. This directive has been adopted in Italy as D.L. 198/2021 and it set a list of 10 prohibited practices, called "*black-list*" in the FFV buyer-supplier relations and a "*grey list*", where practices are forbidden, unless agreed between the parties.

However, even though legislative stakeholders and policymakers enforced regulations, this framework does not seem to mitigate UTPs, and their impact is still unknown (Di Marcantonio et al. 2017). UTPs continue to persist and influence commercial relations.

Commercial quality standards and suboptimal products

Quality standards are mainly set to have products safe for human consumption and adhere to the regulations in force within EU member states. These standards may be either public or private.

The public standards are the ones set with legislative frameworks by Public and Quasi-Public institution, such as EU and United Nations Economic Commission for Europe (UNECE) to ensure food safety (PAPER I).

The minimum standards for FFV products are set according to the EU regulation 543/2011. Besides the safety aspect of the products for human consumption, the aesthetic features are also considered in this regulation, such as aspect, shape, dimension, and ripeness, with a tolerance of 10% (EU 543/2011). Additionally, a residual threshold for fungicide and pesticide is defined by CE 396/2005 and set European Food Safety Authority (EFSA) and this level is not dangerous for human consumption.

More specific recommendations are added by the UNECE, with the aim to facilitate trade between EU countries. They take over the minimum quality standards defined by the EU regulation and establish three aesthetic classes to FFV products. The three classes consist of (I) Extra products, a

superior category with only very slight surface defects; (II) Class I, good quality of products and variety, with slight defects in relation to shape, colour, and peel; and (III) Class II, that respect the minimum quality characteristics listed above; they may have defects in shape, colour, and skin as long as they retain the essential quality characteristics.

Besides public and quasi-public standards, each buyer -and especially retailers- arbitrarily set additional standards, defined as “*private*” because they are not regulated by law. They may differ between each buyer and are always stricter than the public ones. These private standards do not deal with assuring safety, rather they focus on cosmetic features, such as colour, shape, diameter, absence of cosmetic defects, or they set stricter standards on fungicides and pesticide residual levels. The aim in applying these standards is to satisfy consumers’ demand and standardize the appearance and features of the products (de Hooge et al., 2017; Harmann et al., 2021), under the assumption that retailers’ customers are not ready to buy products with aesthetic defects or they would have a lower willingness to pay the suboptimal products (Buzby et al., 2011; Stangherlin et al., 2019; de Hooge et al., 2017; Harmann et al., 2021).

According to POs, private cosmetic quality standards of FFV products are one of the hardest conditions set by retailers which is difficult to respect (PAPER I; de Hooge et al., 2017; Harmann et al., 2021) and they are often included in the contract with buyers (Fulponi et al., 2007).

The application of private quality standards generates the downgrading of a substantial amount of products, called “*suboptimal*”. They have the same intrinsic quality and safety of “*accepted*” ones, but are not conforming with cosmetic requirements, such as weight, shape, size (de Hooge et al., 2017). Suboptimal products must be quickly reallocated, otherwise they may become FL (de Hooge et al., 2017). Additionally, because most of FFV products are perishable, once rejected by buyers, their reallocation to an alternative commercial channel is hardly feasible, as they would spoil in the meantime. Many studies currently explore how to manage and sell suboptimal products in the retail sector (Hartmann et al., 2021; Huang et al., 2020). There is evidence of a growing awareness of consumers and their willing to buy these products; however, their effects on the upstream stages of the supply chain remain less explored.

During handling process, POs previously downgrade the suboptimal products and allocate them to alternative commercial channels where fewer aesthetic requirements are required, such as food industries or wholesale markets. However, they are not much remunerative as retailers. Additionally, during the reallocation, the suboptimal products may be reprocessed, thus generating additional costs (PAPER II).

The extent of losses and downgraded products due to cosmetic quality standards have seldom been measured in the available literature, as well as their economic impact. According to Porter (2018),

vegetables with high losses in UK are mostly composed by potatoes, carrots, onion, and brassicas. He assessed that the range of losses for cosmetic reason vary between 4-58% in the European Economic Area and 7-65% for UK. In total, they show a total cosmetic loss of 23-44% on-far, grade-out losses.

Food Loss and Waste

FLW occurs during the five key stages: agricultural production, postharvest handling and storage, processing, distribution, and consumption (Porat, 2018).

FW refers to the downstream stages of the supply chain. FAO (2013) states that FW refers to *“food appropriate for human consumption being discarded, whether or not after it is kept beyond its expiry date or left to spoil. Often this is because food has spoiled but it can be for other reasons such as oversupply due to markets, or individual consumer shopping/eating habits”*. In 2019, FAO redefined FW as *“the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food services and consumers”* (FAO 2019). However, according to EU definition, FW is considered *“any substance or product (processed, partially processed or unprocessed), intended to be, or reasonably expected to be ingested by humans that becomes waste”* (European Parliament, 2018). According to the definition of the FUSIONS project, *“FW is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed”* (Östergren et al., 2014). The relevance of this second definition is in also including beverage and any ingredient used to produce foods, composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea. In the developed countries, many studies have been conducted and large portions occurs during retail, consumption, logistic management operations and consumer behaviours (Porat et al. 2018, Cicatiello et al., 2017; Giordano et al., 2019)

Instead, FL refers to the upstream stages of the supply chain, especially the harvest and post-harvest phases. FAO (2013) define FL as *“decrease in mass (dry matter) or nutritional value (quality) of food that was originally intended for human consumption. These losses are mainly caused by inefficiencies in the food supply chains, such as poor infrastructure and logistics, lack of technology, insufficient skills, knowledge and management capacity of supply chain actors, and lack of access to markets. In addition, natural disasters play a role”*. In 2019, FAO updated the definition as *“the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers, and consumers”* (FAO, 2019).

The quantification and impact of FL is still a challenge, since data collected through direct quantification is limited (Caldeira et al., 2019; Corrado et al., 2018; Schneider et al., 2019). Also,

many of the available studies report data obtained through literature reviews or indirect measurements and significantly constraining accuracy (Corrado et al., 2019). Even less is known about the mechanisms that generate them in the upstream stage of the supply chain (Herzberg et al., 2022).

Among the available studies on FL in the FFV sector, Schneider et al (2019) quantifies FL in the potato harvest stage in Austria and Germany may vary between 1.4 and 9.1% of the potential potato yield. In Switzerland, Willersinn et al (2015), quantifies the total losses during the potato supply chain to be approximately 53–55% of the initial fresh potato production and 41–46% of the initial processing potato production. From the total initial production of fresh potatoes, 15–24% gets lost during agricultural production, a further 12–24% at wholesalers, 1–3% at retailers, and 15% at private households. In comparison, 5–11% of the initial production gets lost at wholesalers, a further 14–15% during processing, 0% at retailers, and 2% at private households. Losses during agricultural production do not vary much (13–25%) between fresh and processing potatoes. Also, they underline that approximately, half of the losses occurs because potatoes do not meet quality standards. Fernandez-Zamudio (2020) quantifies the persimmon during harvest and postharvest production phase in Spain. The total mass and economic loss assessed is 38.5% of the kilos that are ultimately commercialized or 29.5% of the entire volume produced. In class 2, where purely aesthetic damages are considered - that do not meet quality standards-, the average losses are 4.57%. De Falco et al. (2022) focus on losses of artichoke in Italy, where the incidence of residues on the total fresh biomass during the postharvest phase is very high, with values between 58.5% and 69%. The quantity of leaves is equal to 2.8 tons ha⁻¹ in dry weight, while the residues of primary and secondary heads amounted to 1.4 tons ha⁻¹ in dry weight. In the tomato supply chain in Australia, postharvest FL are equal to between 40.3% and 55.9% of the total harvestable product. Additionally, between 68.6% and 86.7% of undamaged, edible, harvested tomatoes are rejected as out grades and consequently discarded due to product specifications. Between 71.2% and 84.1% of produced tomatoes are left in the field and not harvested (McKenzie et al, 2017). In Thailand logan supply chain, the quantitative loss is 14.07% and qualitative loss due to cosmetic requirements is 11.02% for domestic consumption, quantitative loss 13.50% and qualitative loss 14.82% for export-bound fresh longans on-season, and quantitative loss 9.85% and qualitative loss 6.52% for export-bound fresh longans off-season (Tansuchat et al., 2023). Johnson (2018) studies the losses during harvest phase across six crop vegetable and it has been estimated that around 65% of non-harvested product is still edible, even if it did not fit the cosmetic specification requested by retailers. In the EU Northern countries, the mean harvest loss carrots on the studied farms are 2.9 t/ha, varying from 0.7 to 4.7 t per ha. A relatively small share of the produced carrot yield was left in the field or sorted in the field: on average 6.2%, varying from 1.3% to 14.9% (Hartikainen et al., 2017).

MATERIAL, METHODS AND METHODOLOGICAL ADVANCEMENT

In this work, a combination of different methodologies is used, both quantitative and qualitative. As a first step, qualitative methodologies have been used to analyse the mechanisms that occur in the supply chain between producers and retailers, from the producers' perspective. The focus of the analysis is on POs, which have been involved as key stakeholders of the postharvest phase. Semi-structured interviews (PAPER I) and a focus group (PAPER III) have been conducted with producers. These qualitative methodologies revealed that two main aspects that shape the producer-retailer interface in the FFV supply chain are private cosmetic quality standards and the quality of the commercial relation between these actors. These aspects are further analysed using two distinct quantitative methodologies, used in PAPER II and III. To study the effects of the private cosmetic quality standards on producers, a direct assessment on carrots supply chain has been conducted in PAPER II, at the warehouse of one Italian PO between June and September 2023. Here, the stream of losses and suboptimal carrots is assessed in terms of mass and value, as well as the quantity re-processed and marketed. Instead in PAPER III, the focus is on the factors that influence the quality of the commercial relations between producers and buyers (especially retailers), by means of a survey. The combination of these four methodologies is explained in Figure 3.

Figure 3: structure of methodologies used in the thesis, according to the article used

Qualitative methodologies	Quantitative methodologies
PAPER I Semi-structured interviews involving 10 POs	PAPER II Direct assessment of losses and suboptimal carrots at one PO
PAPER III Focus group discussion with 24 POs	PAPER III Survey to 99 producers and statistical analysis

Source: own elaboration

Qualitative methods

Two different qualitative methodologies have been used to investigate the mechanisms in the interface between producers and retailers. In PAPER I, semi-structured interviews to POs are used to explore the inefficiencies related to the generation of FL and their connections to private marketing standards. In PAPER III, a focus group with Italian POs aimed to identify potential UTPs in the commercial relation between POs and buyers, from the perspective of POs. During this latter analysis, it emerges that in the perception of POs there are many other factors besides UTP, that influence their commercial relations with buyers. Such factors are further investigated in relation to the perceived quality of the relationship with a quantitative methodology (survey).

Semi-structured interviews – PAPER I

As a first analysis to explore the FFV sector and the relationship among the actors of the supply chain, semi-structured interviews are conducted to provide insight on the mechanism and process related to FL at PO level. The semi-structured interviews are held both in Italy and Germany, by selecting POs working on FFV products among all the countries to guarantee to cover different crop types and different regions in both countries to have a representative sample. The people interviewed are responsible for sales and marketing, quality control or management of the POs. A guideline for the interviews is developed addressing the same issues to contribute to the objectivity and trustworthiness of the study. All interviews cover the following topics:

1. Causes of FL in the supplier/retailer interface;
2. Design of contracts and arrangements that POs have in place with farmers and retailers;
3. Relation between the structure of contracts, orders' management, and quantity of FL;
4. Quality management process along the supply chain and criteria that influence the decisions;
5. Management of products that do not meet the required quality standards.

Interviews in Germany are recorded and literally transcribed. Interviews held in Italy are not recorded, but full comprehensive notes are taken on the same day of the interview. In Germany, interviews are conducted between October 2020 and January 2021; in Italy between September and December 2022; if possible, interviews are conducted face-to-face, or online/via telephone if COVID-19 restrictions were still in place. In total, three interviews with Italian POs and seven with German POs are conducted. Despite conducting fewer PO interviews in Italy, the chosen POs have a significant impact on the national market; collectively, they account for over 5% of the country's fennel and potato production, with a total turnover of about EUR 300 million. In table 1 the description of PO involved in the study is shown.

Table 1: description of the POs involved in the study of the PAPER I

PO	Country	Number of members	Total acreage (ha)	Products
PO 1	Germany	19	600	Onions
PO 2	Germany	1200	900	Pomaceous Fruit, Berries and Asparagus
PO 3	Germany	60	152	Vegetables
PO 4	Germany	330	2,500	Pomaceous Fruit
PO 5	Germany	350	5,500	Pomaceous Fruit
PO 6	Germany	50	270	Vegetables and Herbs
PO 7	Germany	50	10,000	Vegetables and Herbs
PO 8	Italy	183	1,200	Salad, Potatoes, Carrots and Fennel
PO 9	Italy	85	565	Potatoes, Cabbage, Chickpeas, beans and Lentils
PO 10	Italy	4957	32,091	Fruits, Potatoes and Onions

Source: PAPER I

The content of the interviews is analysed through MAXqDA program, to develop a structured content analysis approach for qualitative data (Kuckartz et al., 2019). The MAXqDA software is fed with transcriptions for Germany and notes for Italy from the interviews. In the applied methodology, a coding system is created and used to sort all the statements of the interviews. The coding system is based on a deductive and inductive coding. The deductive codes are elaborated according with the theories and scientific literature available. The inductive codes are developed during the analysis of the material of the interviews, and then referred to the scientific literature. In this way, Italian and German interviews have the same coding system, where each sentence has a code, and the code is grouped and analysed in thematic areas.

Focus group to discuss commercial practices in the FFV supply chain – PAPER III

The first part of the methodology is included in a wider study on the analysis of UTP (Directive EU 2019/633) in the FFV supply chain in Italy¹. A focus group was organized in February 2024, bringing together 24 representatives—primarily sales managers—from Italian POs operating in the FFV sector. The participants were divided into two parallel sessions: an online session with 22 POs and an in-person session with 2 POs. POs that participated to the focus group are in different areas of Italy and they are of different size in terms of turnover and number of employees.

The two focus groups are conducted following the same guidelines to contribute to the objectivity and trustworthiness of the study (Kallio et al., 2016). The structure of each focus group includes different topics of discussion, with a focus on negotiation, pricing, commercial practices perceived

¹ The general objective of the PRIN AGREF (project code 2022FARZPJ, funded by the Italian Ministry of University and Research) project is to investigate commercial practices perceived as unfair by suppliers in the fruit and vegetable supply chain in Italy and attempting an estimation of the impact of such practices on farmers and POs.

as unfair and the overall quality of commercial relations that POs establish with buyers. The duration of the focus group discussion is approximately 120 min. The discussion is facilitated by a researcher who invites participants to use sticky notes to point out specific issues. Both focus group sessions are recorded and transcribed. We apply a structured content analysis for qualitative data following Kuckartz (2019), using deductive and inductive coding in Excel. The deductive coding is performed by identifying four categories that represent the main issues in a commercial relationship, based on the theories and the literature: (I) Relation in the value chain, (II) Contracts and negotiations, (III) Flexibility and scheduling, and (IV) External factors. Then, during inductive coding, each sentence is allocated to one of the codes, considering the affinity of the sentence's topic with the codes. Each sentence is allocated to only one code. Among all the sentences transcribed from the focus group, this study only analyses those referring to factors that affect the quality of the commercial relations from the perception of the POs.

Quantitative methods

Two different quantitative methodologies are used in the thesis. In PAPER II, the impact of private cosmetic quality standards is empirically assessed through a direct quantification at the warehouse of a PO, alongside the development of various scenarios exploring the hypothesis of changes in retailers' acceptance rates for suboptimal products. The second quantitative method used is a survey, which is conducted on farmers and PO to analyse the perceived quality of commercial relations they have with buyers, and the factors that influence these relations.

Direct assessment of carrots downgraded due to private quality standards at PO – PAPER II

To assess the impact of private cosmetic quality standards at postharvest phase of carrot supply chain, a direct quantification is conducted at the warehouse of a PO in Central Italy (PAPER II). The PO is responsible for post-harvest operations and commercialization towards the market, through retailers or industry. The total production of FFV of this PO consists of 78 million of kg per year, from 183 farms, and the annual turnover is around 40 million euro. The main products of the PO are fennels, carrots, potatoes, and salads, with a total acreage of over 32,000 ha. The case study is located in the centre of Italy, in a PO located in Abruzzo region.

The assessment period includes 18 days between July and September 2023. To conduct the direct quantification, carrots are classified in three categories based on their aesthetic quality attributes (Johnson et al., 2018), which are evaluated during the handling phase at the PO warehouse to determine their market destination. This classification is also in line with the European definition of FW (Directive EU – 2018/851) (Figure 4):

- *Marketable as fresh*: carrots that are suitable for human consumption, with no visual or cosmetic defects, diameter between 20 and 40 mm (imposed by buyers as part of private quality standards). These carrots are sold to retailers to be marketed as fresh.
- *Downgraded – Edible but not marketable as fresh (DØtot)*: carrots that are safe and nutritious, not under- or over-ripen but not saleable for fresh market because they do not meet the private quality standards related to size, shape, and colour; these carrots are re-processed and sold for industry.
 - *DminØ*: carrots with a smaller diameter than the minimum required by buyers (<20 mm);
 - *DmaxØ*: carrots with a larger diameter than the maximum accepted by buyers (>40mm);
 - *DØ*: carrots with a diameter included in 20-40mm, discarded due to cosmetic issues.
- *Unfit*: carrots discarded after harvest because they are unfit for human consumption, further classified in two categories:
- *Primary loss*: carrots that are damaged, diseased, decayed, under- or over-ripen and are discarded upon arrival at the PO warehouse.
- *Secondary loss*: inedible parts of carrots that are cut and discarded during the rehandling of downgraded carrots destined to industry.

Figure 4: classification of carrots in the three different categories: marketable as fresh (I), downgraded – edible but not marketable (II) and unfit (III).



Source: PAPER II

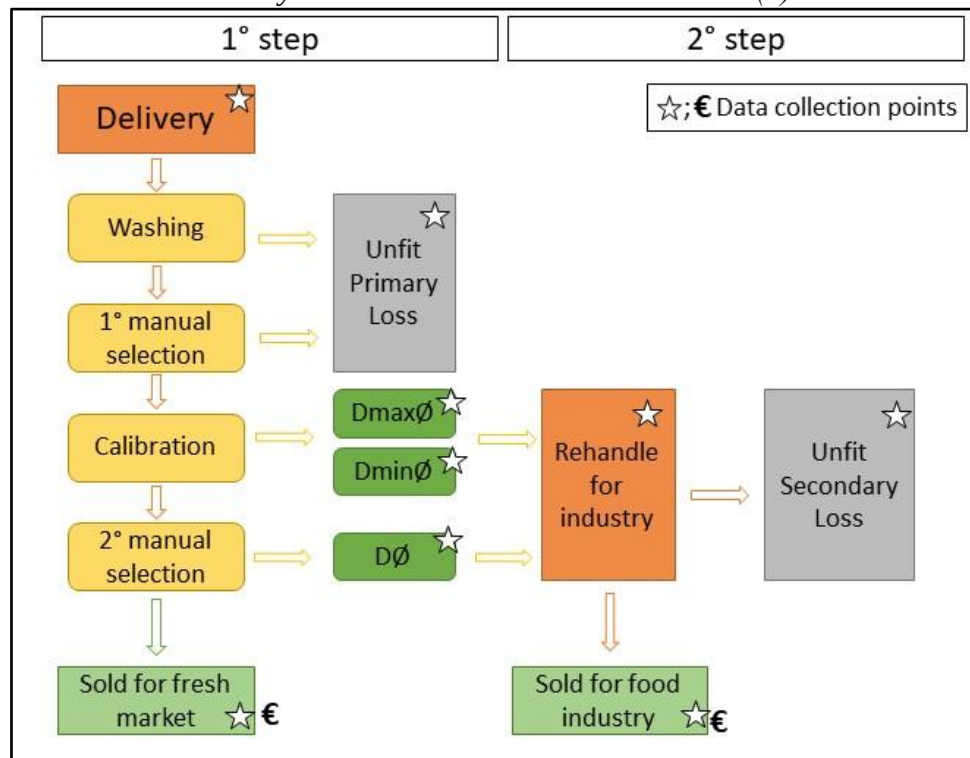
These parameters are specific to the PO in this case study, as they are the result of negotiation between buyers and suppliers. This study also attempts to evaluate the economic implications of carrot downgrading and loss. The definitions used for this purpose are:

- *Potential turnover*: turnover that could be gained if no private cosmetic quality standards were applied and all edible carrots were sold on the fresh market. Here, it is assumed that the additional carrots are sold at the same sales price.
- *Current turnover*: turnover currently gained with the application of private cosmetic quality standards.

The assessment is conducted at the warehouse of the PO, to measure the streams of carrots, in mass and economic value, all along the postharvest operations, starting from the moment when the harvested carrots are handled at the warehouse until they are sold to fresh market or industry.

The unit of measurement used for direct quantification is the kilogram (kg), while the unit of reference to assess the stream of carrots is the plastic bulk bin that is used to process carrots in the warehouse. Each bin is measured, and on average their capacity is 350–400 kg. Therefore, each bin processed corresponds to one observation in the final dataset. The method of data collection is based on several points of assessment, where streams of carrots are measured, as shown in figure 5. For each stream, the quantity of carrots in terms of mass (kg) and, if possible, value (sales price in €) is assessed.

Figure 5: carrots handling process that take place in the PO warehouse. Each arrow represents the stream of the process to the next step. Each star represents a data collection point, where the quantity (kg) is assessed for each bin handled. The quantity sold for fresh market and for food industry is also recorded in economic value (€).



Source: Paper II

During the harvesting, carrots are collected in bins (still with soil and stones). No selective harvesting is made on the field. Carrot bins are carried into the PO warehouse and left in the cold storage. Upon receipt of an order from a retailer, the carrot processing process starts. Each bin to be processed is weighed (still dirty) and unloaded onto a platform which transfers the carrots to the washing machine. Here, an initial stream leaves the process, consisting of unfit carrots (diseased or rotten), soil and

stones. Unfit carrots (primary loss) and soil and stones are weighed separately. After this, the carrots go through a process of manual selection, to detect any unfit ones.

The carrots then pass through the calibration machine, where they are sorted by size: carrots with a diameter between 20 and 40 mm continue in the process, while out of size carrots are downgraded because they are too small ($D_{min\emptyset}$ in Fig. 2) or too large ($D_{max\emptyset}$ in Fig. 2). The in-size carrots are manually re-sorted to remove any carrots with cosmetic imperfections that do not meet the private cosmetic standards imposed by buyers (mainly large retail companies); these carrots with cosmetic flaws are downgraded, meaning that they are not considered suitable to be sold as fresh products ($D\emptyset$ in Fig. 2). Carrots that are in-size and free from cosmetic imperfections are sold for the fresh market. They can be sold in bulk bags (average weight approximately 1100 kg), trays (1 kg, 500 g, 600 g or 750 g) or boxes (10 kg); they are packed and loaded onto trucks at the PO warehouse, to be delivered to retailers.

Downgraded carrots are re-processed, either on the same day or in the following days, to be sold to the food industry; this requires a process during which imperfections, black spots and splits are removed. Also in this case, the carrots are loaded onto trucks at the PO warehouse and delivered to the food industry. Meanwhile, unfit carrots are disposed as organic waste or used for animal feed. As a result of the data collection, for each bin assessed the quantities measured are weight on delivery, unfit carrots (primary loss), downgraded carrots divided into $D_{min\emptyset}$, $D_{max\emptyset}$, and $D\emptyset$, carrots sold for the fresh market, carrots re-processed for industry, carrots discarded during re-processing because unfit for human consumption (secondary loss), and carrots sold to the food industry. These secondary losses are also disposed as organic waste or used for animal feed.

To weight the bins, scales with a sensitivity of one kilogram are used; weight is measured with the help of forklifts. Instead, manual scales with a sensitivity of one gram are used for boxes; for trays, a scale built-in the packaging machine is used. All weights recorded during the study are net of tare. For each bin sampled at the beginning of the process, all the data at the data collection points are detected and noted in a database built in Excel. The accuracy of the data collection is verified on a day-by-day basis, by cleaning and monitoring the dataset, also using historical data of productive season years 2020, 2021 and 2022 as a reference benchmark.

Due to the different timing of post-harvest carrot operations at the PO warehouse, the data collection process is divided into two stages, reflected in Figure 1:

1. Collection of data on carrots processed, from their arrival at the PO warehouse to their sale on the fresh market or downgrading;
2. Collection of data on carrots re-processed for industry, from the reprocessing of downgraded carrots to their sale to industry.

The sales prices of the product are also recorded to support economic evaluation. Data on sales are acquired from PO records from 1st of January to 31st of August 2023. The names of the buyers are anonymized by means of a code, to prevent any sharing of market sensitive information. However, sales to different buyers are recorded separately because the PO negotiates the price of products individually with each, and significant differences in price are possible even within the same day for a given product. In the dataset, every individual sale that occurred within the period is recorded, along with the quantity and sales price. Sales are categorised by type of buyer, to distinguish between retailers (fresh market) and industry (re-processed carrots); they are also divided by the type of carrots sold (conventional or organic) and type of packaging.

In total, 182 bins of carrots are sampled during the study period, corresponding to a total mass of 279,757 kg of carrots, approximately 1% of the PO's overall yearly production. Two different datasets are elaborated, reflecting the two separate stages of the carrot process in the PO. Dataset 1 focuses on the first step of data collection, from harvest to the sale of carrots for the fresh market, including the side stream of downgraded carrots; Dataset 2 focuses on the second stage of the process, from downgrading to the re-processing of carrots, until they are sold to the food industry. A Dataset 3 is also elaborated, with the sales records acquired from the PO, including the product code, name, quantity, price, value, and the anonymized customer identification number. The datasets are composed of 136, 36 and 724 observations, respectively. As an initial part of the elaborations, a Sankey diagram is created to represent the streams of carrots during post-harvest operations at the PO warehouse, referring to step 1 of the data collection. Secondly, a descriptive analysis of Dataset 1, Dataset 2 and Dataset 3 is performed. In Dataset 3, price variation during the season is analysed. The third section concerns the analysis of the economic implications of downgrading. To this end, Dataset 1, Dataset 2 and Dataset 3 are analysed collectively.

Lastly, scenarios are modelled with various levels of acceptance of private cosmetic quality standards, with the aim of analysing the potential effect of greater acceptance of defects in carrots, in terms of the mass of carrots delivered to the fresh market or lost, and the consequent economic implications. Four different scenarios are modelled:

- Scenario 1 (S1): the mass of carrots downgraded due to excess size ($D_{max\emptyset}$) is decreased by 10%, reflecting a greater acceptance of carrots that are currently considered too large to be sold on the fresh Market
- Scenario 2 (S2): the mass of carrots downgraded due to small size ($D_{min\emptyset}$) is decreased by 10%, reflecting a greater acceptance of carrots currently considered too small to be sold on the fresh market

- Scenario 3 (S3): the mass of in-size carrots downgraded due to cosmetic defects (DØ) is decreased by 10%, reflecting a greater acceptance of cosmetic defects in carrots to be sold on the fresh market
- Scenario 4 (S4): the mass of carrots downgraded is decreased by -5% for each of the three defects considered (DmaxØ; DminØ; DØ), reflecting a higher acceptance of suboptimal carrots on the fresh market.

The economic value of the resulting mass of carrots accepted for fresh market is calculated by using the specific median price, considering the changes across the season, for conventional and organic carrots sold to fresh market, and for carrots reworked for food industry separately. The results are compared with the status quo situation.

Survey on the quality of commercial relations – PAPER III

The second part of the methodology of PAPER III includes a survey administered to producers, such as farmers and POs, with the aim to assess the perceived quality of the commercial relations they have with buyers and rating a set of factors that may influence such relations.

The survey is constructed following the framework developed by Schultze (2006), integrated with the results emerging from the focus groups. The survey is structured in three parts: (I) an introduction section with general questions about the respondent; (II) a second section where respondents are asked to rate set of factors related to commitment, price satisfaction, flexibility, trust, and cooperation; (III) a final section where respondents rate the overall satisfaction for the commercial relation. Respondents are asked to rate all the items with reference to the commercial relation they have with the first and the second most important buyers; therefore, every response generates two sets of answers.

After the introduction with general questions of Section I, Section II includes the 14 items (F1-F14) that belong to five dimensions. The dimensions are five, and described as follow:

- D1 “Long-term commitment” which refers to the willingness of actors to exert effort on behalf of the relationship, where they perceive to mutually benefit (Razavi et al., 2016; Morgan et al., 1994; Gundlach et al., 1995), and includes F1, F2, F3;
- D2 “Price satisfaction”, intended to assess the extent to which the economic outcome is important for the evaluation for the relationships (Schulze et al., 2006); this dimension includes an evaluation about prices (in comparison with other buyers) (Schulze et al., 2006) and margins, with F4 and F5;

- D3 “Adaptation on quality standards”, which assesses the flexibility of buyers and suppliers to mutually adapt to each other needs and capabilities regarding quality standards (Razavi et al., 2016; Håkansson et al., 1982), expressed by F6, F7, F8;
- D4 “Relational quality and trust” summarizing the degree of mutual trust, good personal relations, and transparency of communication between supplier and buyer (Gajdić et al., 2021), expressed by F10, F11, F12;
- D5 “Cooperation in case of issues” referring to situations where actors work conjointly to achieve mutual goals (Razavi et al., 2016; Anderson et al 1990), including F13 and F14.

Section III includes two summary variables to measure the overall perceived quality of the commercial relations:

- F15: “In the next 2-3 year, I would prefer to replace this buyer with another”;
- F16: “Overall, I am satisfied with the commercial relations with this buyer”.

A 1–7 Likert scale is used for all items to rate respondents’ level of agreement with the statements (1- not at all; 7 – at all). Items and dimensions are illustrated in Table 2.

Table 2: description of items and dimensions starting by the questions of the survey.

Cod	Dim.	Variable	Units	Mean	St. Dev.	Min	Max
F1	D1	This buyer gives me the certainty of being able to sell a large part of my production	Likert 1-7	4.48	1.81	1	7
F2	D1	This buyer gives me the certainty of having a medium-long term sales channel	Likert 1-7	4.57	1.53	1	7
F3	D1	With this buyer the contractual conditions are clear from the beginning of the season	Likert 1-7	4.1	1.84	1	7
F4	D2	This buyer offers me good prices for my products	Likert 1-7	4.16	1.45	1	7
F5	D2	This buyer gives me the possibility of making good margins on the products	Likert 1-7	4.1	1.55	1	7
F6	D3	The quality standards (aesthetic aspects, size, shape, colour etc.) required by this buyer are strict (compared to others)	Likert 1-7	4.81	1.67	1	7
F7	D3	The control of quality standards upon delivery is rather flexible	Likert 1-7	3.86	1.61	1	7
F8	D3	It often happens that the products we deliver to this buyer are rejected	Likert 1-7	3.48	1.68	1	7
F9	-	The buyer does not appropriately consider the uncertainty of the weather and seasonal conditions of the last period	Likert 1-7	4.39	1.91	1	7
F10	D4	There is no dialogue with this buyer	Likert 1-7	3.68	1.82	1	7
F11	D4	I have a good relation with the person with whom I contract the sale of the products	Likert 1-7	4.72	1.61	1	7
F12	D4	This buyer considers us reliable	Likert 1-7	5.35	1.43	1	7
F13	D5	If we make a mistake, this buyer is available to help us out.	Likert 1-7	4.39	1.55	1	7
F14	D5	If they (buyer) make a mistake, they are willing to fix it	Likert 1-7	4.28	1.68	1	7
F15	-	I would prefer to replace this buyer with another	Likert 1-7	3.19	1.66	1	7
F16	-	Overall, I am satisfied with the commercial relations with this buyer	Likert 1-7	4.76	1.61	1	7

Source: PAPER II

The survey is developed in Qualtrics, and the time needed to complete it is approximately 10 min. All respondents are asked to approve an informed consent form before starting the survey; no personal data or data that could lead to identifying the farms and POs answering the survey is collected. The survey was administered between April and October 2024 to POs and individual farmers contacted through agricultural networks, agricultural associations, extension services and professionals operating in the FFV sector. The total number of responses is 99. After data cleaning, 42 responses are considered invalid as the respondent did not complete the questionnaire for even one of the two buyers requested. 57 responses are retained, among which 16 provided the assessment of only one buyer, and 41 referred to two different buyers. The database is therefore composed of 98 observations, each one referring to the assessment of one buyer by one respondent. The data is analysed with the XLStat 2024.3 statistical software, which operates in Microsoft Excel environment.

Descriptive statistics are performed for these variables to summarize the intention to change buyer and the level of satisfaction. Additionally, the correlation matrix is used to evaluate the quality of commercial relations between items F15 and F16 and the variables related to type of buyer, % of turnover, and long-terms relations (expressed in years).

The individual variables for which higher rates in the Likert scale correspond to a lower quality of the commercial relation have been rotated, then a total rating is obtained for each dimension, by summing up the ratings of the individual items. The resulting 5 variables (D1, D2, D3, D4, D5) express the rating of each dimension; they are standardized and used to feed a k-means cluster analysis to classify different types of commercial relations. Four clusters are obtained.

A Kruskal–Wallis nonparametric test is used to examine whether the overall perceived quality of commercial relations differs across the clusters of commercial relations. The choice of this test is due to the non-normality of the dependent variables F15 and F16, tested with the Shapiro–Wilk test and resulting in $\alpha < 0.05$. In the Kruskal–Wallis test, F15 and F16 are used as dependent variables, with the aim of analysing any significant difference in the perceived quality of commercial relations among the clusters.

As a last step, a multiple correspondence analysis is developed to detect correspondence between high-low levels of perceived quality of the commercial relation and the belonging to a specific cluster, also considering the importance of commercial relations in terms of turnover.

RESULTS AND DISCUSSIONS

The results are organised along the three research questions they aim to answer. Each research question is addressed in one sub-chapter, building on the results of PAPER I, PAPER II, PAPER III. Sub-chapter “Structure of the FFV supply chain” refers to research question I; sub-chapter “Impact of private quality standards” refers to research question II; sub-chapter “Quality of commercial relations” refers to research question III.

Structure of the FFV supply chain

According to the result of PAPER I, POs assume a central role in FFV supply-chain, acting as intermediaries between farmers and retailers. They collect and store the products from farmers, negotiate contracts with buyers -especially retailers- and take charge of logistics and deliveries upon retailers’ orders. The interviews in PAPER I revealed that POs are present in more than a phase of the FFV supply chain, which have a structure vertically integrated. They plan their production together with the associated farmers; during the harvest and postharvest phase, farmers store most of the products at the PO warehouses; the PO is then responsible of the processing, commercialization, and delivery of products to buyers. The storage phase assumes a higher importance especially for the long shelf-life products. They remain in stock until the PO receives an order from a buyer.

As emerged by PAPER I, POs establish relations and negotiate contracts with various commercial channels, primarily including retailers, wholesalers, and food industries, as well as potential buyers. They also represent farmers in commercial relations and negotiations (EU, 2013). By working with different buyers allow POs to allocate products more effectively, ensuring the specific requirements of each buyer. This enables them to avoid FL and strategically distribute surplus or suboptimal products across various marketing channels (Aschemann-Witzel et al., 2019).

Among the standards imposed by buyers, private cosmetic quality standards are the most challenging to comply with (PAPER I). These standards are stricter than the legislative ones (whether public or quasi-public, as set by the EU and UNECE), with each buyer establishing their own specific requirements, such as visual standards, sizes, and pesticide limits.

According to POs’ perception analysed in PAPER I, each buyer has different requirements and food industries are considered as more reliable. Contracts are established at the beginning of the year with clear conditions and quantities, however the price paid for products is lower with respect to the other marketing channels. Additionally, the requirements and quality standards for products are not stringent and have already been specified in the contracts. Since quantities are fixed at the beginning of the year, this enables better production planning through the year and tray to ensure a fixed turnover

for POs, and therefore, farmers (PAPER I). Retailers are considered as the best option, as they potentially offer higher revenue; although, they impose strict contracts and challenging conditions (PAPER I; PAPER III). Sales price is not specified in the contracts; instead it is weekly or biweekly negotiated between the POs and retailers, since sales price is influenced by many factors such as the available quantity of product and/or European or foreign markets. Due to this difference between the revenue that can be gained by different marketing channel, PAPER I disclosed that one of the main challenges for POs is to find a balance between contracts with food industries, considered as safer, and the more remunerative ones with retailers (PAPER I). This is the reason why they tend to have different buyers and contract larger volumes of products with retailers rather than with food industries, as they offer higher remuneration (Camanzi et al., 2011).

Timing and quantity ordered during the year are not always specified in the contracts (PAPER I). This implies that both timing and quantity may vary significantly during the season, often leading to last-minutes changes in orders and cancellations, which typically occurs on a daily basis. In fact, POs declare in PAPER I that many orders are commonly placed with short notice (AxA, today for today; or AxB, today for tomorrow). However, last minutes changes in procurement decisions by retailers can always occur, driven by peaks or off-peaks in consumer demand for some products. This may result in sudden surplus stocks which, in turn, may drive prices down, generating FL as a consequence (Bustos et al., 2018).

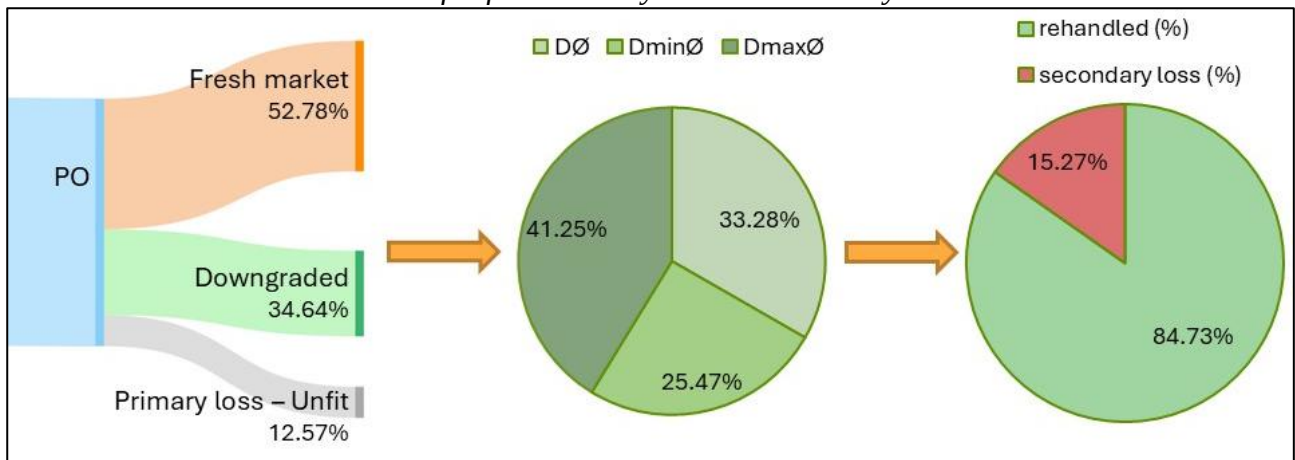
In PAPER I, the results of the interviews conducted with Italian POs are then compared with the answers of German POs, confirming the central role of these POs and several similarities across all thematic areas. Both Italian and German POs assume their similar role in the organisation of FFV supply chain during the harvest and postharvest phase: they collection, storage, allocate, and sell FFV products to different commercial channel. However, interviews disclose differences in crop planning during the harvest phase: in Italy, POs schedule most of their associated farmers' production, while in Germany farmers have more leeway in product and quantity planning. Regarding "contracts and agreements" area, both Italian and German POs acknowledge the strong bargaining power of retailers and their tendency to avoid the economic risk during negotiations, which is consequently transferred to POs and producers. Instead, all German and Italian interviewed POs recognise private quality standards – particularly the cosmetic ones - as one of the main factors contributing to generate FL, and this confirmed is also supported by evidences in literature (Brancoli et al., 2019; Kulikovskaja et al., 2017). However, the definition of these standards during the negotiations differs: in Italy they are mostly defined in a written form (e.g in contracts), whereas in Germany they are mostly defined through oral agreements.

Though a direct assessment on postharvest phase, the quantity of carrots that reach fresh market is 52.78% of the POs production (PAPER II). Although all the products sent by POs to retailers is already selected, retailers re-examine again them in the quality control. If products do not match the required quality standards, they are rejected and sent back to POs, thus potentially contributing to generating FL. Besides improve the selection of products directly at the warehouse, POs manage with different marketing channels to allocate suboptimal products (PAPER I): downgraded products are generally allocated to wholesales or food industries, where the requirements are less strict. Here, a great flexibility is required, since it is a logistic channel; poor management of the product could affect the generation of FL level (Hobbs et al., 2020) and consequently, the turnover.

Impact of private quality standards

In Italy, PAPER II represents the first study to quantify, in mass and value, the amount of suboptimal products and FL generated by private quality standards with a direct quantification in the carrot supply chain. The quantity sampled (279,757 kg of carrots) represents the 1% of the average annual production. After subtracting the tare (soils and stones), the mass of carrots starting the process in the PO warehouse is 263,755 kg. After the carrot process shown in Figure 6, 52.78 % of carrots are sold for the fresh market (139,223 kg), 34.64% (91,376 kg) are downgraded ($D_{\text{Øtot}}$), and 12.57% represent the primary loss (33,156 kg). Out of the total quantity of carrots downgraded, 66.72% is due to out-of-size carrots (60,963 kg of the total downgraded), of which 25.47% (corresponding to 8.82% of total carrots processed) are smaller than the minimum required diameter ($D_{\text{minØ}}$) and 41.25% (14.29% of total carrots processed) are larger than the required diameter ($D_{\text{maxØ}}$). 33.28% (30,413 kg) of downgraded carrots (corresponding to 11.53% of total carrots processed) are in-size, but they do not meet the cosmetic standards required for sale on the fresh market. In the second stage, carrots downgraded are reprocessed and it may occur on different days, so quantity reprocessed does not correspond to the quantity downgraded. In PAPER II, the downgraded carrots reprocessed are a total of 75,199 kg, and the percentage sold for food industry is the 84.73%, while the remaining 15.27% is discarded as a secondary loss.

Figure 6: Sankey diagram showing the first stage and second of the carrot processing in the PO, from harvesting to the selection of carrots in the warehouse for sale on the fresh market, downgraded and unfit as primary loss; and then a second step that show the quantity of carrots that are sold for food industry and the secondary loss.



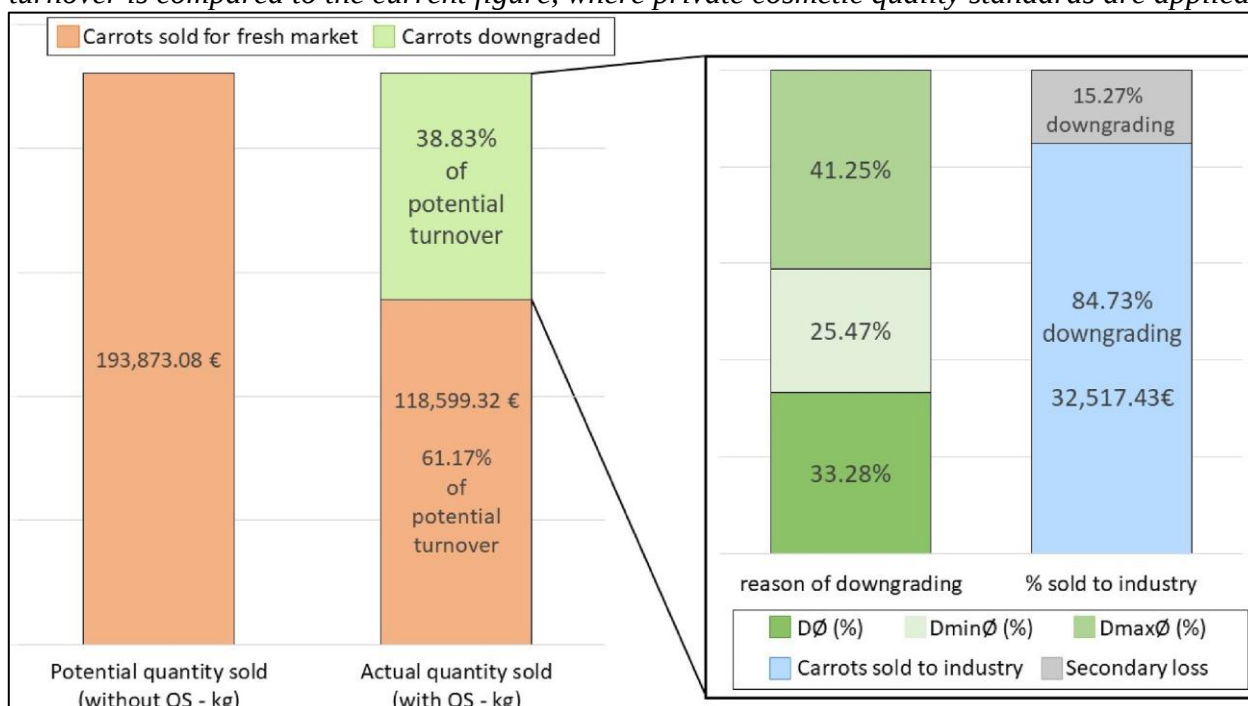
Source: adapted from PAPER II

The data obtained by the direct assessment of PAPER II seems to be in line with the ones available in literature. The downgrading ($DØ_{tot} = 34.64\%$ of processed carrots) is in line with FAO (2021), which estimates a range between 25% and 30% of carrots are lost before retailing due to physical or cosmetic defects, even if detected by indirect measurement (Stuart, 2009). Additionally, it is also in line with available data in the literature for carrots (FAO, 2021), potatoes, onions, and apples (Porter et al., 2018); while it seems lower compared with tomatoes (McKenzie et al., 2017).

Downgraded carrots are perfectly edible from a food safety perspective; they merely lack the “right appearance” to be accepted at retail. In PAPER II, downgraded carrots are not lost but reprocessed within the PO, prepared to be sold to food industry at a lower price, which is considered a more stable buyer, even if with a lower revenue (PAPER I). However, during reprocessing, not only carrots are downgraded, but also a secondary loss is generated to prepare carrots to be marketed for food industries. This secondary loss could be prevented; however, following the food hierarchy procedure (Papargyropoulou et al., 2014), it is mostly used for animal feed or disposed of as waste, or is biogas production, although this was not the case in our study because no facilities are available in the area. In PAPER II, the economic impact of the application of private cosmetic quality standards is analysed, thought a comparison between current and potential turnover ². The base quantity to calculate carrots turnover is the processed quantity of carrots (263,755 kg), of which primary loss as unfit for human consumption (12.57%) are subtracted and the daily median sales price recorded during the season is used. The comparison between current and potential turnover is shown in Figure 7.

² Current turnover: turnover currently gained with the application of cosmetic quality standards. Potential turnover: turnover potentially gained with no application of cosmetic quality standards, calculated by considering the mass of carrots that could potentially be sold on the fresh market if no private cosmetic quality standards were applied.

Figure 7: Economic implications of private cosmetic quality standards on turnover. Potential turnover is compared to the current figure, where private cosmetic quality standards are applied.



Source: Paper II

The economic loss linked to the application of private cosmetic quality standards amounts to 42,756.33 € for 263,755 kg carrots processed (less than 22.05% of potential turnover); and it is due to (I) the secondary loss that occurs during the reprocessing of carrots, and (II) the difference between the sales prices for the fresh market and industry (PAPER II). This economic loss does not consider the additional cost that the PO must bear to re-process downgraded carrots and prepare them for sale to industry.

Here, the consequence of downgrading is a double loss. In terms of mass, the impact of FL is not high, since suboptimal products are reprocessed and reallocated – following the hierarchy of FL (Papargyropoulou et al., 2014). However, most important impact of the loss is the economic one. Carrots are downgraded and sold to the food industry at a lower price, and the marketable quantity available for sale to the food industry is further reduced due to losses incurred during reprocessing. The actual economic loss may be even greater, since products are re-processing twice, leading to increase costs and effort (PAPER II). In this sense, food industries represent a reliable and stable commercial channel for POs: as well as in terms of products since it is possible to sell products that may not be accepted by other channel; that in terms of timing and quantity. Contracts signed with POs includes timing-scheduled product that are asked during the year and fixed price, even if with a lower sale price (PAPER I).

Private commercial quality standards vary between products and even among different buyers (PAPER I). Depending on buyer's preferences, a product might be rejected by one buyer that another buyer would accept. These criteria increase the difficulty for POs, as well as affecting logistics and production costs (PAPER I).

In PAPER II, different scenarios are also simulated, and the tolerance of downgrading product is modulated by 5 or 10% more, to analyse the impact of private cosmetic quality standards (Scenario 1-4), turnover and in terms of FL. Having more flexible requirements and accept products with high tolerance would increase the turnover due to fresh market by:

- +2.43 % in Scenario 1, where a greater flexibility in accepting carrots considered too large to be sold on the fresh market is simulated ($D\emptyset_{\max} > 10\%$);
- +1.43% in Scenario 2, where a greater flexibility in accepting carrots considered too small to be sold on the fresh market is simulated ($D\emptyset_{\min} > 10\%$);
- +2.48% in Scenario 3, where a greater flexibility in accepting carrots that are in-size, but show cosmetic defect, is simulated ($D\emptyset > 10\%$);
- +3.17% in Scenario 4, where a greater flexibility in accepting carrots with all types of defects is simulated ($D\emptyset_{\text{tot}} > 5\%$).

Quality of commercial relations

The conditions applied during negotiations are influenced by the quality of commercial relations occurring between producers – often represented by POs - and buyers. The quality of commercial relations is influenced by many factors, and, among them, the most important are trust, satisfaction, and commitment (Razavi et al., 2016; Gajdić et al., 2021; Schulze et al., 2006).

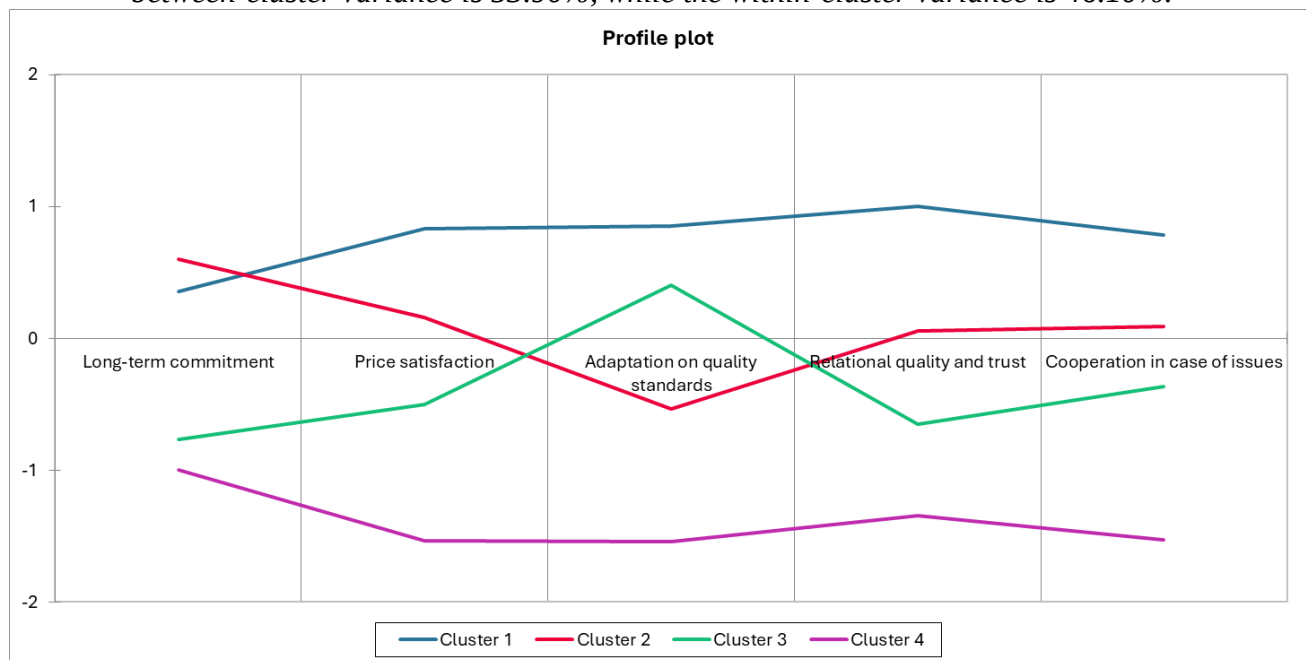
The focus group organized as part of PAPER III suggest that, upon producers' perception, these factors can be categorized in 4 groups: external factors, flexibility and scheduling, contracts and negotiations and relations in the value chain. Analysing the flexibility and scheduling, the main perception is that retailers do not take in consideration the seasonality and the reality of the season production typically of the agricultural production. Instead, they follow a plan of prices, promotions, quantity of orders, that sometime does not fit with the seasonal trend of FFV. In the contract and negotiations area, commissions, and intermediation costs; price, marginality, and remuneration; standard uniformity of buyers and quality standards are the main topic. Here, an important point that emerged is that “*retailers are more punctilious when the market goes down, they become overly attentive...*”; for example, at times of the season that are potentially positive for POs (in terms of availability of product, higher prices etc.). As emerged in PAPER III, according to POs, retailers tend to have a stricter control of quality standards, promotions, prices and timing of the deliveries and this

control increase the frequency of rejection of products, controversies, and in turn, additional costs for producers. Another issue emerged is the lack of communication with retailers' organisation and management (PAPER I and PAPER III).

To analyse the quality of commercial relations between FFV producers and buyers, a survey is administered to Producers (PAPER III). 98 commercial relations are analysed - 80.85% reported by individual farmers, among which 57.45% are members of a PO or cooperative, and 9.57% reported by POs. The main counterparts of these relations are retailers and wholesalers (24.47% and 27.66% of the observations). On a 1-7 Likert scale, the average satisfaction of producers for the commercial relations is 4.76, while the average willingness to replace the buyer with another one is 3.19.

The variables have been aggregated in five dimensions: long-term commitment, price satisfaction, adaptation on quality standards, relational quality and trust, cooperation in case of issues. Commercial relations are then clustered in four groups as shown in Figure 8 and the features of each cluster are analysed by looking at the centroids.

Figure 8: Centroids of the 4 clusters in relation to the 5 variables considered (standardized value; 0=average of the variable, positive values = above average, negative values = below average) The between-cluster variance is 53.90%, while the within-cluster variance is 46.10%.



Source: PAPER III

The four clusters in PAPER III reflect the orientation of the commercial relations, which refers to the dichotomy of transaction-relation approach.

Cluster 1, which includes the 29% of the observations, is oriented through a relational relation. It is characterized by higher reliability, where no stricter quality standards are applied. Price and margins are felt with high satisfaction by the producers and a good atmosphere and cooperation between

supplier and buyer is reported. This cluster is mainly composed by commercial relations with buyer called “other”, which include restaurants and local-based supply chains, which seem to perform very well in terms of establishing relations of high quality.

Cluster 2, with 33% of observations, is represented by buyers which are felt stable and reliable. The suppliers’ satisfaction for the economic aspects of the commercial relation is slightly above average, even if they show are very strict conditions in the application of quality standards on the products. This cluster is mainly composed of commercial relations with retailers

In Cluster 3, where 25% of observations are included, the commercial relations are characterized by high flexibility in the application of quality standards, while the other aspects are rated lower than in other clusters. Here, the cluster is mainly composed of commercial relations with wholesalers and wholesale market.

Lastly, in Cluster 4, 11% of observations, the commercial relations perceived as negative by the producers for all the aspects considered are included: long-term commitment, relational quality, trust, and cooperation are scored lower than in the other clusters. Here, commercial relations are oriented more in a transactional relation.

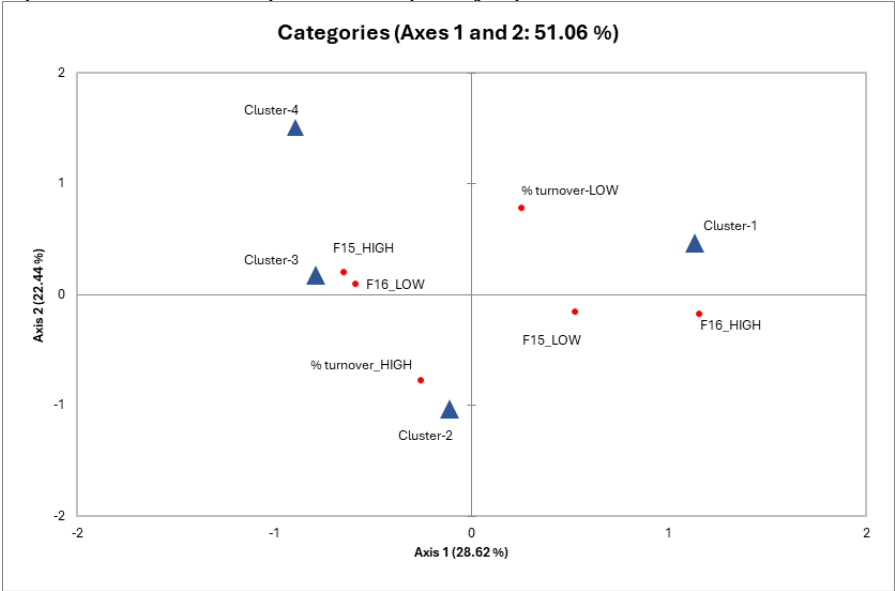
The cluster are also compared to the average values of satisfaction of commercial relations (F16); and it is significantly higher in Cluster 1 and 2 with respect to Cluster 4. However, it is not reflected in the willingness to change buyer (F15) where a significant difference is only observed in Cluster 1 and 4. As a result of PAPER III, this may significance that only when the relation is perceived as highly negative, there may be a driver for change: producers pursue an exit strategy after realizing that they have no voice to change things; otherwise, other factors tend to dominate the decision to remain in a commercial relation with the buyer.

Additionally, a multiple correspondence analysis is hold in PAPER III, where the clusters are used to analyse the relations between commercial relations, together with the percentage of turnover that the commercial relation generate, and the values of F15 and F16, both above and below the median for each item. The result of the analysis is visually displayed in Figure 9.

Cluster 1 is associated with commercial relations with high satisfaction (F16_HIGH), low willingness to change buyer (F15_LOW) and low turnover share. Cluster 2 is positioned near high turnover and low willingness to change buyers, and it represents commercial relations with retailers. Even if producers may not be satisfied for the relation with this buyer, retailers represent a highly remunerative channel, which is maybe the reason for the willingness to change being low (PAPER III). Cluster 3 reflects low satisfaction and a high intention to change buyers, it is associated with wholesalers and wholesale markets. Here, turnover is minimal, and POs choose this channel always

as an alternative one, since the preferred one is represented by retailers, as also confirmed by results of PAPER I.

Figure 9: correspondence between perceived quality of commercial relation, turnover and clusters



Source: PAPER III

IMPLICATIONS OF THE RESEARCH

Implications for practitioners

This study highlights the central role of POs in the FFV supply chain. According to PAPER I and III, this role becomes even more significant if considered in advocating for fairer and more equity contracts and more sustainable practices with the FFV stakeholders. Retailers hold a superior position and exert considerable bargaining power over producers by centralizing product demand, creating a critical dependence on the distribution sector (Herzberg et al., 2022).

Another key point that emerges in all papers (PAPER I-II-III) is that private quality standards represent a bottleneck in the FFV supply chain. They are intended to assure that only high-quality and perfectly shaped products reach the supermarkets shelves; but the risks and costs associated with selection and downgrading are completely born by producers. However, despite their best efforts, a certain quantity of production variability remains beyond human control, as FFV production takes place in the open field and is influenced by climatic conditions (Wheeler et al., 2000). This uncontrol quantity is represent by primary losses in PAPER II.

PAPER II reports that only 52.78% of the mass of harvested product is suitable to be marketed to retailers in the case of carrot value chain; while 34.64% of the products is downgraded and reprocessed to be allocated to food industry. This is in line with results available in literature, where more flexible standards may reduce the quantity of suboptimal products and FL (Fernandez-Zamudio et al., 2020; Opara et al., 2021; Commons, 2017; McKenzie et al., 2017; Tansuchat et al., 2023; Willersinn et al., 2015; Hartikainen et al., 2017), since the cost of the quality standard is born by producers when they must downgrade, reallocate, or reprocess products.

Applying more flexible approach to private quality standards may be a strategy to increase turnover, selling more fresh products to retailers and at the same time prevent the generation of FL. In PAPER II, different scenarios are built and, for example, having a tolerance of 10% on over size carrots ($D\emptyset_{max}$) or a flexibility to accept small cosmetic defects ($D\emptyset$), could improve producer turnover by up to 1.41% and at the same time reduce losses, especially the ones due to reprocessing.

Evidence from literature highlight that from retailers' point of view, some companies do not even perceive themselves as responsible for FL resulting from the application of quality standards, since it arises earlier in the supply chain (Herzberg et al., 2022). In addition, retailers are often hesitant to adopt flexible standards, as they fear the effects on the image of other products sold in the same store or with other competitors (Aschemann-Witzel et al., 2020). However, retailers are likely to become more flexible during seasons of short supply (Herzberg et al., 2022), while they are stricter when the product is abundant.

In this sense, the scenario hypnotized in PAPER II on flexibility of the private cosmetic quality standards appears reasonable, as there is evidence that consumers are willingness to purchase suboptimal products, particularly when offered at a more affordable price (de Hooge et al., 2017; Tait et al., 2024; Aschemann-Witzel et al., 2017). Additionally, the growing interest in topics such as sustainability or FLW is an important incentive to help to strengthen producers' positions, especially with respect to consumers e.g. to organic production, who are likely to be willing to accept less stringent cosmetic requirements. However, improving food literacy and educate all consumers can improve the acceptance of suboptimal products by aligning market preferences with environmentally responsible practices (Palumbo et al., 2019). Moreover, strategic communication and marketing may highlight the environmental and economic benefits of reducing waste (Hartmann, et al., 2021).

An alternative channel that is increasingly being used to sell suboptimal products is online platforms (de Hooge et al., 2018), where suboptimal products are sold using claims related to sustainability or FL reduction, as also some initiatives are presented in PAPER II, such as “*Bella dentro*” (<https://www.belladentro.org/>).

Flexibility in the implementation of quality standards could be possible if closer collaboration occurs between producers and buyers, giving benefits for both as emerged in PAPER I and PAPER II. In this sense, closer relations may lead to orient towards a relational approach (PAPER III). An example can be found in the German supply chain, where Government set up voluntary agreements with food industries, restaurants, and supermarkets, with the aim to incentivize companies to donate surplus food to charitable organizations rather than discarding it (BMEL, 2019). In Denmark, after surveying customers, a retail chain has started to sell second class FFV (Kuntscher et al., 2023).

In the light of these examples, policymaker and stakeholders should promote closer and equity cooperation among actors of the FFV supply chain by encouraging transparency and shared responsibility. This approach could reduce the transfer of the economic risk to the upstream stages of the supply chain, mitigate FL, and contribute to a more equitable and sustainable food system. Even embracing small changes on requirements of quality standards can bring significant benefits for all the actors involved.

Market implications

In the FFV supply chain, the dynamic of products between producers and buyers are influenced by several key factors, such as weekly or daily price negotiations, buyer-specific differences and requirements.

PAPER I and III highlight the factors that affect production - such as the natural growth process of products in the field and seasonal climate variations—are often overlooked by buyers when

requesting FFV products. These challenges are particularly pronounced in the organic sector, where according to the interview in PAPER I, the limited use of fertilizers and pesticides may lead to more frequent cosmetic defects, resulting in a higher rate of product downgrading.

Another factor in the negotiation between producers and retailers is the bargaining over price and quantity, which may take place daily or weekly, depending on the buyer and the conditions it imposes on suppliers, as outlined in PAPER I. During the scenarios elaborated in PAPER II, we assumed that the selling price for carrots does not change when an additional volume of lower-quality carrots is introduced into the market and which can be assumed true in this specific case, since PO sell this product during all the year. However, if we extend this scenario to other producers, it is likely that the price of carrots on the fresh market could decrease because of the increased supply of lower-quality carrots and it could bring to a lower turnover, especially if private cosmetic quality standards are more flexible. An important factor to consider in the market is demand elasticity. It is possible to hypothesize that if the selling price of carrots decreases, the demand for carrots increases. For example, Henneberry et al. (1999) estimates an own-price demand elasticity of -1.653 for carrots with respect to their price, suggesting that a 10% decrease in the price of carrots would lead to a 16.53% increase in demand. This relationship between price and demand underscores the potential for market expansion if the price of carrots is reduced due to the increased availability of lower-quality produce. Substitution effects between carrots and other vegetables may also occur (Henneberry et al., 1999), with potential impact on their markets. Additionally, carrots may be substituted for other vegetables, further affecting the demand and prices in their respective markets.

In PAPER II, we have assumed that consumers are ready to accept suboptimal carrots, assuming their willingness to pay for suboptimal carrots remain the same or could be closely lower to the perfect ones. However, it is closely linked to their perceived quality (Aschemann-Witzel et al., 2017). If private quality standards were relaxed for all producers, there could be a general decline in the quality of carrots available on the market, potentially reducing consumer willingness to pay higher prices for them. Studies have shown that this decline may not be linear. According to Qi et al. (2022), consumers' willingness to pay for carrots decreases significantly when just one carrot in a bunch is suboptimal. However, when up to 40% of carrots in a bunch are considered suboptimal, consumers' willingness to pay does not decline further. This suggests that there may be a threshold beyond which consumers are more accepting of lower-quality produce. Raising this “tolerance threshold” may be possible when food literacy and awareness of consumers increases (Lisciani et al., 2024).

Targeted marketing strategies, such as promotion of suboptimal products associated with claims of sustainability and FLW reduction, may serve to this purpose, as mentioned in PAPER I and PAPER II. Suboptimal products are often associated with the term “ugly”, which gives them a negative

attribute and shall probably be avoided to make it “normal” having different sizes and shapes of vegetables on the shelves. The authenticity and naturalness of the suboptimal products may attract environmentally conscious consumers, further supporting the demand for products of lower cosmetic quality but still as nutritious as perfect vegetables, especially if consumers are instructed before (Yuan et al., 2019). In this sense, also the EU aim to build a more attractive and sustainable agri-food sector, by propose a fairer, simpler, and targeted common agricultural policy, where among the main focuses it aims to reinforcing agri-food diplomacy and pursuing a stronger alignment of production standards and help farmers and farmers’ return (EU, 2025).

Policy implications

The analysis of producer-retailer interface in commercial relations reveals significant imbalances that disadvantage producers, particularly farmers and POs (PAPER I). To limit this imbalance, the application of the EU Directive 2019/633 aims to protect the weaker parties in the relations in the supply chain, including farmers. Although the aim of this directive is to balance the power among the actors of the supply chain, their effectiveness remains still limited and commercial relations remain unfair, as confirmed in PAPER I and PAPER III. During the investigations it emerges that buyers, and in particular retailers, often impose strict conditions that pass on the economic risk upon producers, such as last minutes changes in orders, returns of products, application of quality standards.

In this sense, the EU directive 2019/633, and consequently the Italian DL 198/2021, set the “*black practices*” of prohibited actions and the “*grey*” ones, allowed only if an agreement between the parties is in place and when explicitly agreed upon by both parties in advanced and written in the contract. Policymakers should prioritise the guarantees conformity of the current legislation and at the same time consider amendments that gives more protection and guaranties to producers.

An example could be rebalancing contractual power by establishing fixed baseline terms that prevent shifting the entire economic burden onto producers, rather than leaving it subject to the agreement of both parties. In fact, retailers can leverage their market power to compel suppliers to accept unfair contractual terms; while these conditions may not be considered unfair by law, since “*both parties agree*”, they are inherently unfair in practice.

As emerged in PAPER III, producers might be willing to continue a commercial relationship with buyers because of economic necessity or the lack of alternatives, even if they are not satisfied with the conditions. Since retailers ensure large share of producers’ total turnover, the economic outcome in commercial relations with producers and retailers remains positive, even when they impose stricter conditions and requirements (Camanzi et al., 2011) and it may outweigh concerns about fairness or

satisfaction. Therefore, from PAPER III, it emerges that is difficult to identify a clear distinction between transactional or relational approach in commercial relations, since economic and relational aspects are intertwined, and relations may be unsatisfactory for both parties, especially when they last over the year and ensure high turnover.

Additionally, the evidence in PAPER III may suggest that the willingness to change buyer is not an indicator of the quality of commercial relations, as it encompasses the necessity of the supplier to adapt to market opportunities. This mechanism may also be interpreted considering the Hirschman paradigm (Hirschman., 1970), suggesting that in some cases producers may be entrapped in commercial relations – especially with retailers -, despite their unsatisfaction since they feel to have no voice to express (Alpmann et al., 2015). The lack of alternative markets and the difficulty in diversifying sales channels clearly play a role in this situation.

Additionally, changing buyer may represent the risk of moving to different and possibly more stringent contractual conditions. Of course, the lack of alternative remunerative channel and the difficulty in diversifying sales channels play a crucial role in this situation.

Supporting positive commercial relations could involve a reinterpretation of Italian law, shifting from a focus on prohibitive actions to ones that promote transparency and collaboration strategies among actors, such as tax benefits or certifications. Alternatively, incentives for retailers could help reduce the imposition of overly strict conditions. Encouraging collaboration strategies between actors could lead to more positive and mutually beneficial commercial relations (Kühne et al., 2013).

Some of the evidence presented in this thesis may have implications in the frame of the European Green Deal, in the four pillars of the Farm to Fork strategy as well as in the Common Agricultural Policy (CAP).

Starting by the Farm to Fork strategy, actions related to the first pillar of the strategy “*Sustainable food production*” are intended to reduce the use of chemical pesticides, fertilizers and antimicrobials as well as increase agricultural land under organic farming. This may lead to an increase of the amount of suboptimal products, since the aesthetic character of the products cannot be controlled. In this sense, it is very important to build remunerative commercial channels for these products.

Looking at the pillar of the strategy focused on “*FW reduction*”, it must be underlined that the EU still lacks an official definition of FL. The current FL definition may be improved to include all the losses occurring at primary production, including those left in the field and several research projects (such as FOLOU - <https://www.folou.eu/>) founded by EU are now working to implement this definition.

Lastly, for what concerns the Farm to Fork pillar of “*Sustainable food processing and distribution*”, the goal is to reduce the overall environmental footprint of the food system and make the adoption of

healthy diets easier. In this frame, one initiative tackles a revision of EU marketing standards. In this regard, PAPER II provides scientific evidence of the impacts of different quality standards on FFV products.

The results emerging from this thesis can also be framed in the discourse in the context of the current debate on the digitalisation of the agri-food sector chains. According to literature, innovations focused on the digitalization of supply chain processes will increase the transparency of information across actors of the supply chain (Nasso et al., 2024). For example, tools that provide an account of agricultural practices implemented to improve quality may improve the awareness of buyers and consumers over the efforts of producers to deliver high-quality products. Collaborative tools may enhance producers' awareness of the challenges that retailers experience in their relations with consumers. In this respect, digitalization may help twin transaction to manage the FFV supply chain in a more sustainable way and improving at the same time the awareness of the actors of the supply chain, both producers and buyers. Having more transparency and collaboration in the FFV supply chain, may also lead to mitigate unbalanced power in the supply chain and build more sustainable relations in the FFV supply chain. The same tools may support an analysis of the production cost incurred by all actors of the supply chain, thus allowing efficiency-oriented actions as well as a greater recognition of the value creation along the supply chain. An example of digitalization is the Farm Sustainability Tool for nutrients (FaST), which is already available. It will combine data and manual input from farmers to provide customized recommendations on crop fertilization through a nutrient management plan. Building on this platform, much more information could become available to consumers and all actors across the value chain, such as details on downgraded products or the production costs of each actor. This approach would foster greater transparency between suppliers, buyers, and consumers, thereby encouraging stronger commercial relationships.

In the CAP, the due diligence is required to producers that aim to mitigate environment and social issues into their corporate strategy with the aim to enhance transparency of the operation in the supply chain. It may become a powerful tool to improve equity in the distribution of value and risk across actors of the supply chain. Increasing transparency for food industry and retail companies may become an encouraging to change behaviour and collaborate with Producers, rather than using their market power to dominate commercial relations. To promote the diffusion of these tools among farmers, POs are a key stakeholder and play a crucial role and this is also confirmed by PAPER I – II - III. In fact, EU provides the economic supports through the CAP, which is implemented by the operational plan that are mainly managed by POs. Indeed, supporting POs could be a strategy not only to assist producers, but also to raise awareness among supply chain actors, enhance transparency, and foster more positive and stable commercial relations. For this reason, a vision of EU (EU, 2025)

is help and mitigate the UTP rules and common market organisation regulation, to have more competitive markets and strengthening the power of the sector in Europe.

CONCLUSIONS

The focus of this thesis is the interface between producers and buyers in the FFV supply chain in Italy. PAPER I focus on the key role of POs in the supply chain, validating and comparing results in Italy and Germany. PAPER II analyses the impact of private cosmetic quality standards in terms of mass and value, by assessing suboptimal carrots at a PO warehouse. PAPER III analyses the factors who shape the quality of commercial relations, from the producers' point of view.

In the timeline of the PhD's path, the research started with an investigation of FL in the FFV supply chain, since it represents a priority target of food policies. During the research, it has been realised that looking at the issue of FL with a reuse-recycle approach focusing on alternative marketing channels and circular economy processes is not enough, especially if the cost for this is only born by producers. Prevention should always be regarded as a first propriety, and this means investigating the root causes of FL, that are often more complex than it appears at first sight.

The three papers of this dissertation provide evidence that one of the key issues to be solved is – still, despite the improvements pushed by the CAP in the past decades – the imbalances in the relations between suppliers and buyers in the supply chain. POs have an important role there to increase concentration and bargaining power of agricultural producers, which should be reinforced and further promoted. However, it is likely that a greater concentration of supply will push an even greater concentration in retail and industry because all actors act to increase their bargaining power; therefore, this action cannot stand alone.

New approaches to the relation between actors in the FFV supply chain based on long-term and trust-based relations, should be explored to enhance the overall efficiency of the supply chain and, in turns, its sustainability.

REFERENCES

- Alpmann, J., and Bitsch, V. (2015). Exit, voice, and loyalty in the case of farmer associations: decision-making of dairy farmers during the German milk conflict. *International Food and Agribusiness Management Review*, 18(4), 61-84. <http://dx.doi.org/10.22004/ag.econ.211654>
- Anderson, E., and Weitz, B. (1992). The use of pledges to build and sustain commitment in distribution channels. *Journal of marketing research*, 29(1), 18-34.; <https://doi.org/10.1177/002224379202900103>
- Aschemann-Witzel, J., Jensen, J.H., Jensen, M.H. and Kulikovskaja, V., (2017). Consumer behaviour towards price-reduced suboptimal foods in the supermarket and the relation to food waste in households. *Appetite* 116, 246–258. <https://doi.org/10.1016/j.appet.2017.05.013>
- Aschemann-Witzel, J., Gimenez, A., and Ares, G., 2020. Suboptimal food, careless store? Consumer's associations with stores selling foods with imperfections to counter food waste in the context of an emerging retail market. *J. Clean. Prod.* 262, 121252. <https://doi.org/10.1016/j.jclepro.2020.121252>
- Bandara, S., Leckie, C., Lobo, A., and Hewege, C. (2017). Power and relationship quality in supply chains: The case of the Australian organic fruit and vegetable industry. *Asia Pacific Journal of Marketing and Logistics*, 29(3), 501-518. <https://doi.org/10.1108/APJML-09-2016-0165>
- Brancoli, P., Lundin, M., Bolton, K., and Eriksson, M. (2019). Bread loss rates at the supplier-retailer interface—analysis of risk factors to support waste prevention measures. *Resources, Conservation and Recycling*, 147, 128-136. <https://doi.org/10.1016/j.resconrec.2019.04.027>
- Bundesministerium für Ernährung und Landwirtschaft (BMEL) (2019), National Strategy for Food Waste Reduction, https://www.bmel.de/SharedDocs/Downloads/EN/Food-and-Nutrition/Strategy_FoodWasteReduction.pdf?__blob=publicationFile&v=3. Accessed on 14/04/2025.
- Bustos, C. A., and Moors, E. H. (2018). Reducing post-harvest food losses through innovative collaboration: Insights from the Colombian and Mexican avocado supply chains. *Journal of Cleaner Production*, 199, 1020-1034. <https://doi.org/10.1016/j.jclepro.2018.06.187>
- Bouwman, A. F., Van Vuuren, D. P., Derwent, R. G., and Posch, M. (2002). A global analysis of acidification and eutrophication of terrestrial ecosystems. *Water, Air, and Soil Pollution*, 141, 349-382. <https://doi.org/10.1023/A:1021398008726>
- Buzby, J. C., Hyman, J., Stewart, H., and Wells, H. F. (2011). The value of retail-and consumer-level fruit and vegetable losses in the United States. *Journal of Consumer Affairs*, 45(3), 492-515. <https://doi.org/10.1111/j.1745-6606.2011.01214.x>
- Caldeira, C., De Laurentiis, V., Corrado, S., van Holsteijn, F., and Sala, S. (2019). Quantification of food waste per product group along the food supply chain in the European Union: a mass flow analysis. *Resources, Conservation and Recycling*, 149, 479-488. <https://doi.org/10.1016/j.resconrec.2019.06.011>
- Camanzi, L., Malorgio, G., and Azcárate, T. G. (2011). The role of producer organizations in supply concentration and marketing: a comparison between European countries in the fruit and vegetable sector. *Journal of Food Products Marketing*, 17(2-3), 327-354. <https://doi.org/10.1080/10454446.2011.548706>
- CE regulation o 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC Text with EEA relevance.
- Chlebicka, A., and Pietrzak, M. (2018). Size of membership and survival patterns of producers' organizations in agriculture—Social aspects based on evidence from Poland. *Sustainability*, 10(7), 2293. <https://doi.org/10.3390/su10072293>

- Cicatiello, C., Franco, S., Pancino, B., Blasi, E., and Falasconi, L. (2017). The dark side of retail food waste: Evidences from in-store data. *Resources, Conservation and Recycling*, 125, 273-281. <https://doi.org/10.1016/j.resconrec.2017.06.010>
- Commons, H.O., (2017). Food waste in England. technical report, house of commons: Environment, food and rural affairs committee. Eighth Report of Session 2016– 17. HC 429. Published on 30 April 2017 by authority of the House of Commons. <https://publications.parliament.uk/pa/cm201617/cmselect/cmenvfru/429/429.pdf>. Accessed on 10/08/2024.
- Confagricoltura - Fondazione Edison, (2020-2021), Italy's strenghts in agriculture: a leading producer of vegetable products in Europe and the world, <https://www.fondazioneedison.it/it/news/italys-strengths-in-agriculture>. Accessed on 16/11/2023.
- Corrado, S. and Sala, S., (2018). Food waste accounting along global and European food supply chains: state of the art and outlook. *Waste Management*. 79, 120–131. <https://doi.org/10.1016/j.wasman.2018.07.032>
- De Falco, E., Senatore, A., Roscigno, G. and Pergola, M., (2022). The Artichoke “Bianco di Pertosa”: The Enhancement of Crop Residues through Environmentally Friendly Uses. *Horticulturae* 8 (10), 900. <https://doi.org/10.3390/horticulturae8100900>
- De Hooge, I. E., Oostindjer, M., Aschemann-Witzel, J., Normann, A., Loose, S. M., and Almlí, V. L. (2017). This apple is too ugly for me!: Consumer preferences for suboptimal food products in the supermarket and at home. *Food Quality and Preference*, 56, 80-92. <https://doi.org/10.1016/j.foodqual.2016.09.012>
- de Hooge, I. E., van Dulm, E., and van Trijp, H. C. (2018). Cosmetic specifications in the food waste issue: Supply chain considerations and practices concerning suboptimal food products. *Journal of Cleaner Production*, 183, 698-709. <https://doi.org/10.1016/j.jclepro.2018.02.132>
- Devin, B., and Richards, C. (2018). Food waste, power, and corporate social responsibility in the Australian food supply chain. *Journal of Business Ethics*, 150, 199-210. <https://doi.org/10.1007/s10551-016-3181-z>
- Eriksson, M., Ghosh, R., Mattsson, L., and Ismatov, A. (2017). Take-back agreements in the perspective of food waste generation at the supplier-retailer interface. *Resources, Conservation and Recycling*, 122, 83-93. <https://doi.org/10.1016/j.resconrec.2017.02.006>
- European Commission. Agriculture and Rural Development. (2018). Available online: https://agriculture.ec.europa.eu/commonagricultural-policy/agri-food-supply-chain/producer-and-interbranch-organisations_en. Accessed on 7/12/2024.
- European Parliament (2018) Directive (EU) of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste. 2008/98/EC. Off J Eur Union L 150/109
- European Parliament (2019) Directive (EU) 2019/633 of the European Parliament and of the Council—of 17 April 2019—on Unfair Trading Practices in business-to-business relationships in the agricultural and food supply chain. (EU) 2019/633 L 111/59
- European commission (2020), https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en#:~:text=The%20Farm%20to%20Fork%20Strategy%20aims%20to%20accelerate%20our%20transition,reverse%20the%20loss%20of%20biodiversity. Accessed on 15/10/2024.
- European Union – Regulation No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products and repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007
- European Union (EU) (2025); A Vision for Agriculture and Food, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0075>. Accessed on 07/04/2025.

- EU 543/2011 - Commission Implementing Regulation (EU) No 543/2011 of 7 June 2011 laying down detailed rules for the application of Council Regulation (EC) No 1234/2007 in respect of the fruit and vegetables and processed fruit and vegetables sectors
- Eurostat (2022), The fruit and vegetable sector in the EU - a statistical overview, [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=The fruit and vegetable sector in the EU - a statistical overview](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=The_fruit_and_vegetable_sector_in_the_EU_-_a_statistical_overview). Accessed on 03/10/2024.
- Eurostat (2023), <https://ec.europa.eu/eurostat/en/web/products-eurostat-news/-/ddn-20220925-2>. Accessed on 4/10/2024.
- Fabi, C., Cachia, F., Conforti, P., English, A., and Moncayo, J. R. (2021). Improving data on food losses and waste: From theory to practice. Food Policy, 98, 101934. <https://doi.org/10.1016/j.foodpol.2020.101934>
- Di Marcantonio, F. and Ciaian, P., editor(s), Falkowski, J., Ménard, C., Sexton, R., Swinnen, J. and Vandevelde, S., (2017). Unfair trading practices in the food supply chain: A literature review on methodologies, impacts and regulatory aspects, EUR 28791 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-79-73831-9, doi:10.2760/800, JRC108394
- FAO (2014), The Water-Energy-Food Nexus: A New Approach in Support of Food Security and Sustainable Agriculture, Rome, FAO.
- FAO (2017); <https://www.fao.org/agroecology/knowledge/10-elements/circular-economy/en/>. Accessed on 18/09/2024.
- FAO. (2019). The State of Food and Agriculture 2019. Moving forward on food loss and waste reduction. Rome. Licence: CC BY-NC-SA 3.0 IGO.
- FAO, (2021). Beauty (And Taste!) Are on the inside. Food and Agriculture Organization. <http://www.fao.org/fao-stories/article/en/c/1100391/> . Accessed 14/11/ 2024.
- FAO, IFAD, UNICEF, WFP and WHO. (2022). The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable. Rome, FAO. <https://doi.org/10.4060/cc0639en>
- Fernandez-Zamudio, M. A., Barco, H., and Schneider, F. (2020). Direct measurement of mass and economic harvest and post-harvest losses in Spanish persimmon primary production. Agriculture, 10(12), 581. <https://www.mdpi.com/2077-0472/10/12/581#>
- Fulponi, L. (2007). The globalization of private standards and the agri-food system. In Global supply chains, standards and the poor: How the Globalization of Food Systems and Standards Affects Rural Development and Poverty (pp. 5-18). Wallingford UK: CABI. <https://doi.org/10.1079/9781845931858.0005>
- Ganesan, S. (1994). Determinants of long-term orientation in buyer-seller relationships. Journal of marketing, 58(2), 1-19. <https://doi.org/10.1177/002224299405800201>
- Gajdić, D., Mesić, Ž., and Petljak, K. (2021). Preliminary research about producers' perceptions of relationship quality with retailers in the supply chain of organic food products in Croatia. Sustainability, 13(24), 13673. <https://doi.org/10.3390/su132413673>
- Galdeano-Gómez, E., Pérez-Mesa, J. C., and Giagnocavo, C. L. (2015). Food exporters and co-opetition relationships: An analysis on the vegetable supply chain. British Food Journal, 117(5), 1596-1609. <https://doi.org/10.1108/BFJ-07-2014-0255>
- Geyskens, I., and Steenkamp, J. B. E. (2000). Economic and social satisfaction: measurement and relevance to marketing channel relationships. Journal of retailing, 76(1), 11-32. [https://doi.org/10.1016/S0022-4359\(99\)00021-4](https://doi.org/10.1016/S0022-4359(99)00021-4)

- Giordano, C., Alboni, F., and Falasconi, L. (2019). Quantities, determinants, and awareness of households' food waste in Italy: A comparison between diary and questionnaires quantities. *Sustainability*, 11(12), 3381. <https://doi.org/10.3390/su11123381>
- Grant, D. B. (2005). The Transaction – Relationship Dichotomy in Logistics and Supply Chain Management. *Supply Chain Forum: An International Journal*, 6(2), 38–48. <https://doi.org/10.1080/16258312.2005.11517146>
- Gundlach, G. T., Achrol, R. S., and Mentzer, J. T. (1995). The structure of commitment in exchange. *Journal of marketing*, 59(1), 78-92. <https://doi.org/10.1177/002224299505900107>
- Håkansson, H., and IMP Project Group. (1982). *International marketing and purchasing of industrial goods: An interaction approach*.
- Hartikainen, H., Svanes, E., Franke, U. and Mogensen, L., (2017). *Food Losses and Waste in Primary Production: Case Studies on Carrots, Onions, Peas, Cereals and Farmed Fish*. Nordic Council of Ministers
- Hartmann, T., Jahnke, B., and Hamm, U. (2021). Making ugly food beautiful: Consumer barriers to purchase and marketing options for Suboptimal Food at retail level—A systematic review. *Food Quality and Preference*, 90, 104179. <https://doi.org/10.1016/j.foodqual.2021.104179>
- Hendrikse, G., and Bijman, J. (2002). On the emergence of new growers' associations: self-selection versus countervailing power. *European Review of Agricultural Economics*, 29(2), 255-269. <https://doi.org/10.1093/eurrag/29.2.255>
- Henneberry, S.R., Piewthongngam, K. and Qiang, H., (1999). Consumer food safety concerns and fresh produce consumption. *Journal of Agricultural and Resource Economics*. 98–113
- Hernández-Espallardo, M., and Delgado-Ballester, E. (2009). Product innovation in small manufacturers, market orientation and the industry's five competitive forces: Empirical evidence from Spain. *European Journal of Innovation Management*, 12(4), 470-491.
- Herzberg, R., Schmidt, T., and Keck, M. (2022). Market power and food loss at the producer-retailer interface of fruit and vegetable supply chains in Germany. *Sustainability Science*, 17(6), 2253-2267. <https://doi.org/10.1007/s11625-021-01083-x>
- Hirschman, A. O. (1970). *Exit, voice, and loyalty: Responses to decline in firms, organizations, and states*. Harvard university press.
- Hobbs, J. E. (2020). Food supply chains during the COVID-19 pandemic. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, 68(2), 171-176. <https://doi.org/10.1111/cjag.12237>
- Huang, W. S., Kuo, H. Y., Tung, S. Y., and Chen, H. S. (2020). Assessing consumer preferences for suboptimal food: Application of a choice experiment in citrus fruit retail. *Foods*, 10(1), 15. <https://doi.org/10.3390/foods10010015>
- Ishangulyyev, R., Kim, S., Lee and S.H., (2019). Understanding food loss and waste—why are we losing and wasting food? *Foods* 8 (8), 297. <https://doi.org/10.3390/foods8080297>
- ISMEA (2023), rapporto ISMEA sull'agroalimentare italiano – 17 ottobre 2023, <https://www.ismea.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/12529>. Accessed on 17/11/2024.
- Istat. (2022). 7° Censimento Generale dell'Agricoltura.; <https://www.istat.it/statistiche-per-temi/censimenti/agricoltura/7-censimento-generale/>. Accessed on 08/05/2024.
- Johnson, L. K., Dunning, R. D., Bloom, J. D., Gunter, C. C., Boyette, M. D., and Creamer, N. G. (2018). Estimating on-farm food loss at the field level: A methodology and applied case study on a North Carolina farm. *Resources, Conservation and Recycling*, 137, 243-250. <https://doi.org/10.1016/j.resconrec.2018.05.017>

- Kallio, H.; Pietilä, A.-M.; Johnson, M. and Kangasniemi, M. (2016) Systematic methodological review: Developing a framework for a qualitative semi-structured interview guide. *J. Adv. Nurs.*, 72, 2954–2965. <https://doi.org/10.1111/jan.13031>
- Kuckartz, U. (2019). Qualitative content analysis: From Kracauer’s beginnings to today’s challenges. In *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research* (Vol. 20, No. 3, p. 20). DEU. <https://doi.org/10.17169/fqs-20.3.3370>
- Kühne, B., Gellynck, X., and Weaver, R. D. (2013). The influence of relationship quality on the innovation capacity in traditional food chains. *Supply Chain Management: An International Journal*, 18(1), 52-65. <https://doi.org/10.1108/13598541311293177>
- Kulikovskaja, V., and Aschemann-Witzel, J. (2017). Food waste avoidance actions in food retailing: The case of Denmark. *Journal of international food and agribusiness marketing*, 29(4), 328-345. <https://doi.org/10.1080/08974438.2017.1350244>
- Kuntscher, M. and Schmidt T., (2023) Pakt gegen Lebensmittelverschwendung im Groß-und Einzelhandel: Ergebnisbericht zum Monitoring.
- Lisciani, S., Camilli, E., & Marconi, S. (2024). Enhancing food and nutrition literacy: A key strategy for reducing food waste and improving diet quality. *Sustainability*, 16(5), 1726. <https://doi.org/10.3390/su16051726>
- MASAF (2020), Analisi e possibili sviluppi delle OP che commercializzano prodotti biologici, <https://www.reterurale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/22179>. Accessed on 08/08/2024.
- MASAF (2023), Elenco nazionale delle organizzazioni di produttori ortofrutticoli riconosciute, https://www.ruminantia.it/wp-content/uploads/2024/05/Elenco_OP_excel_per_sito_masaf_al_1_gennaio_2023.pdf. Accessed on 25/11/2024.
- Marcos-Matás, G., Hernández-Espallardo, M., and Arcas-Lario, N. (2013). Transaction costs in agricultural marketing cooperatives: effects on market performance. *Outlook on AGRICULTURE*, 42(2), 117-124. <https://doi.org/10.5367/oa.2013.0123>
- McKenzie, T. J., Singh-Peterson, L., and Underhill, S. J. (2017). Quantifying postharvest loss and the implication of market-based decisions: A case study of two commercial domestic tomato supply chains in Queensland, Australia. *Horticulturae*, 3(3), 44. <https://doi.org/10.3390/horticulturae3030044>
- Menard, C (2007). Cooperatives: Hierarchies or Hybrids? In *Vertical Markets and Cooperative Hierarchies. The Role of Cooperatives in the Agri-Food Industry*; Karantininis, K., Nillson, J., Eds.; Springer: Dordrecht, The Netherlands; pp. 1–17. ISBN 1-4020-4072-5.
- Molnár, A., Van Lembergen, K., Tarantini, F., Heene, A., and Gellynck, X. (2013). Price transparency as a prerequisite for fair competition: the case of the European food prices monitoring tool. The ethics and economics of agrifood competition, 243-261. https://doi.org/10.1007/978-94-007-6274-9_13
- Morgan, R. M. (1994). The commitment-trust theory of relationship marketing. *Journal of Marketing*. <https://doi.org/10.1177/002224299405800302>
- Nasso, M., Blasi, E., Pezzoli, F., and Cicatiello, C. (2024). Investigating Co-Innovation strategies to prevent food loss in the fruits and vegetables sector. *Journal of Cleaner Production*, 467, 142984. <https://doi.org/10.1016/j.jclepro.2024.142984>
- Opara, I. K., Fawole, O. A., and Opara, U. L. (2021). Postharvest losses of pomegranate fruit at the packhouse and implications for sustainability indicators. *Sustainability*, 13(9), 5187. <https://doi.org/10.3390/su13095187>
- Östergren, K., Gustavsson, J., Brouwers, H. B., Timmermans, T., Hansen, O. J., Møller, H., ... and Redlingshöfer, B. (2014). FUSIONS definitional framework for food waste.

- Qi, D., Penn, J., Li, R., Roe, B.E., (2022). Winning ugly: profit maximizing marketing strategies for ugly foods. *J. Journal of Retailing and Consumer Services*. 64, 102834. <https://doi.org/10.1016/j.jretconser.2021.102834>
- Palumbo, R., Adinolfi, P., Annarumma, C., Catinello, G., Tonelli, M. and Troiano, E (2019). Unravelling the food literacy puzzle: evidence from Italy. *Food Policy*. 83, 104–115. <https://doi.org/10.1016/j.foodpol.2018.12.004>
- Papargyropoulou, E., Lozano, R., Steinberger, J.K., Wright, N. and bin Ujang, Z., (2014). The food waste hierarchy as a framework for the management of food surplus and food waste. *J. Clean. Prod.* 76, 106–115. <https://doi.org/10.1016/j.jclepro.2014.04.020>
- Poore, J., and Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, 360(6392), 987-992. <https://doi.org/10.1126/science.aag0216>
- Porat, R., Lichter, A., Terry, L.A., Harker, R., Buzby, J., (2018). Postharvest losses of fruit and vegetables during retail and in consumers' homes: quantifications, causes, and means of prevention. *Postharvest Biol. Technol.* 139, 135–149. <https://doi.org/10.1016/j.postharvbio.2017.11.019>
- Porter, S.D., Reay, D.S., Bomberg, E. and Higgins, P., (2018). Avoidable food losses and associated production-phase greenhouse gas emissions arising from application of cosmetic standards to fresh fruit and vegetables in Europe and the UK. *Journal of Cleaner Production*. 201, 869–878. <https://doi.org/10.1016/j.jclepro.2018.08.079>
- Razavi, S. M., Abdi, M., Amirnequiee, S., and Ghasemi, R. (2016). The impact of supply chain relationship quality and cooperative strategy on strategic purchasing. *Journal of Logistics Management*, 5(1), 6-15.; DOI: 10.5923/j.logistics.20160501.02
- Russo, C., Di Marcantonio, F., Cacchiarelli, L., Menapace, L., and Sorrentino, A. (2023). Unfair trading practices and countervailing power. *Food Policy*, 119, 102521. <https://doi.org/10.1016/j.foodpol.2023.102521>
- Schneider, F., Part, F., Göbel, C., Langen, N., Gerhards, C., Kraus, G. F., and Ritter, G. (2019). A methodological approach for the on-site quantification of food losses in primary production: Austrian and German case studies using the example of potato harvest. *Waste Management*, 86, 106-113. <https://doi.org/10.1016/j.wasman>
- Schulze, B., Wocken, C., and Spiller, A. (2006). Relationship quality in agri-food chains: Supplier management in the German pork and dairy sector. *Journal on Chain and Network Science*, 6(1), 55-68. <https://doi.org/10.3920/JCNS2006.x065>
- Sexton, R. J., and Xia, T. (2018). Increasing concentration in the agricultural supply chain: Implications for market power and sector performance. *Annual Review of Resource Economics*, 10(1), 229-251. <https://doi.org/10.1146/annurev-resource-100517-023312>
- Skorbiansky, S. R., and Ellison, B. (2019). Contracting and quality standards in fresh produce markets and how they impact food loss. In *The economics of food loss in the produce industry* (pp. 250-262). Routledge. ISBN9780429264139
- Sorrentino, A., Russo, C., and Cacchiarelli, L. (2018). Market power and bargaining power in the EU food supply chain: the role of Producer Organizations. *New Medit*, 17(4), 21-31. DOI: 10.30682/nm1804b
- Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B. L., Lassaletta, L., ... and Willett, W. (2018). Options for keeping the food system within environmental limits. *Nature*, 562(7728), 519-525. <https://doi.org/10.1038/s41586-018-0594-0>
- Stangherlin, I. D. C., Duarte Ribeiro, J. L., and Barcellos, M. (2019). Consumer behaviour towards suboptimal food products: a strategy for food waste reduction. *British Food Journal*, 121(10), 2396-2412. <https://doi.org/10.1108/BFJ-12-2018-0817>

- Stuart, T. (2009). *Waste – Uncovering the Global Food Scandal*. Penguin Books, London. ISBN: 978-0-141-03634-2.
- Surucu-Balci, E., and Tuna, O. (2021). Investigating logistics-related food loss drivers: A study on fresh fruit and vegetable supply chain. *Journal of Cleaner Production*, 318, 128561. <https://doi.org/10.1016/j.jclepro.2021.128561>
- Tait, P., Saunders, C., Dalziel, P., Rutherford, P., Driver, T., and Guenther, M. (2024). How much less? Estimating price discounts for suboptimal food with environmental and social credence attributes. *Applied Economics*, 56(13), 1581-1594. <https://doi.org/10.1080/00036846.2023.2176460>
- Tansuchat, R., Pankasemsuk, T., Panmanee, C., Rattanasamakarn, T. and Palason, K., (2023). Analyzing food loss in the fresh longan supply chain: evidence from field survey measurements. *Agriculture* 13 (10), 1951. <https://doi.org/10.3390/agriculture13101951>
- UNEP - United Nations Environment Programme (2024). *Food Waste Index Report 2024*. Nairobi
- Wheeler, T. R., Craufurd, P. Q., Ellis, R. H., Porter, J. R., and Prasad, P. V. (2000). Temperature variability and the yield of annual crops. *Agriculture, Ecosystems and Environment*, 82(1-3), 159-167.
- United Nations (2025). *Transforming Our World: The 2030 Agenda for Sustainable Development*. In Resolution Adopted by the General Assembly on 25 September 2015; United Nations: New York, NY, USA.
- Willersinn, C., Mack, G., Mouron, P., Keiser, A and Siegrist, M., (2015). Quantity and quality of food losses along the Swiss potato supply chain: stepwise investigation and the influence of quality standards on losses. *Waste Manag.* 46, 120–132. <https://doi.org/10.1016/j.wasman.2015.08.033>
- Yuan, J. J., Yi, S., Williams, H. A., and Park, O. H. (2019). US consumers’ perceptions of imperfect “ugly” produce. *British Food Journal*, 121(11), 2666-2682.

PAPER I

Article

Quality Standards and Contractual Terms Affecting Food Losses: The Perspective of Producer Organisations in Germany and Italy

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Abstract: With the aim of disclosing the antecedents and dynamics of food loss generation in the upstream stages of the fruit and vegetable sector, this paper presents the results of a series of semi-structured interviews with 10 Producers' Organisations (POs) in Germany and Italy. The content of the interviews is analysed by applying a qualitative content analysis approach, thus disclosing the most relevant issues affecting food loss generation at the interface between POs and buyers (industry and retailers). Several similarities emerge as we compare the answers provided by Italian and German POs, especially concerning the role of retailers' cosmetic specification on products in the generation of losses. Instead, the structure of contracts regulating commercial transactions between POs, industry, and retailers show noticeable differences, apparently resulting in a greater capacity to plan the demand of products from the beginning of the season in the Italian context. Despite these differences, this study confirms the key role of POs in increasing farmers' bargaining power against the buyers, both in Germany and Italy. Further research is needed to compare circumstances in other European countries and to analyse why the similarities and differences identified occur.

Keywords: food loss and waste; fruit and vegetables; supply chain structure; content analysis; postharvest; qualitative interviews; supplier/retailer interface; bargaining power



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1. Introduction

Food loss (FL) occurs due to several factors and inefficiencies in the supply chain during the early stages of the food supply chain, from harvest up to, but not including, the retail level [1–3]. It is estimated that in the harvest and postharvest process, FL sums up to 14% [2] of production, while 17% of food available for consumption is wasted in the downstream stages of the supply chain [4]. FL can refer to a reduction in the mass of food destined for human consumption (quantitative losses), or to qualitative losses, referring to a decrease in food attributes that reduces the nutritional value of products or its economic value due to noncompliance with quality standards [2]. The Sustainable Development Goal 12.3 [5] states that FL should be reduced by 2030, and the progress towards this objective is measured with the Food Loss Index [6]. However, in the early stages of the value chain data is still scarce [7], and the dynamics of FL generation in the interface between suppliers (producers and their organisations) and buyers (retailers and industry) are still being studied.

Focusing on FL in the fresh fruit and vegetable (FFV) supply chains, FAO reports that between 20 and 25% of produce is lost from postharvest to distribution worldwide [2]. In this sector, producers' organisations (POs) play a crucial role. These are associations of farmers, which take charge of the postharvest phase by collecting, storing, processing, and selling the products, thus strengthening the farmers' collaborative bargaining power [8]. In

the European Union, POs are legally recognized and financially supported [9]. Their aim is to bridge farmers with buyers by concentrating the supply of agricultural commodities, negotiating the contracts, jointly planning the production, and supporting farmers with technical advice and help in machinery investments [8,10–12]. By aggregating the production of farmers, POs try to contrast the higher power of buyers during the negotiation of contracts, taking charge of the economic risk related to these transactions [13–15].

Prices, quality and production standards, logistics, delivery, payment schedules, promotions, risk sharing, and many other details are typically agreed upon in supply contracts established between POs and buyers [16]. These contracts usually include conditions on the quantities and delivery times imposed by buyers, as well as cosmetic standards that the products must fulfil [17]. These standards for commercialization may either be imposed by regulations to assure food safety, or applied by buyers to standardize the appearance and features of the products [18,19]. The latter, which are referred to as ‘private marketing standards’, are particularly relevant in the FFV sector. Retailers set strict quality standards under the hypothesis that customers would reject or have a lower willingness to pay for suboptimal products [18,20]. Such standards create a bottleneck for products entering the market, thus generating significant quantities of suboptimal products which have the same intrinsic quality and safety of ‘accepted’ products, but are not conforming with cosmetic standards (for example mass, shape, size, etc.), or are approaching the use-by date labelled on the packaging [18]. In the absence of alternative channels for commercialization, these products are likely to become FL [21]. Moreover, due to the perishable character of (most) FFV, once these products are rejected for cosmetic reasons, the redirecting to alternative channels is hardly feasible because they would spoil in the meanwhile. While there is a growing body of literature on how suboptimal products might be managed in the retail sector [19,21,22], there is a lack of knowledge about how the implementation of private marketing standards affects the other key players of the upstream supply chain, i.e., POs and, in turn, the affiliated producers.

Porter et al. [23] report that the range of losses of FFV due to cosmetic standards varies between 4 and 58% in the European Economic Area, excluding preharvest grade-out losses. This data is supported by other studies that estimate a loss of up to 40% of harvested FFV due to cosmetic standards requested by the retailers [24–26]. One of the few studies reporting a direct measurement monitored persimmon losses in Spain, indicating that 16.11% of delivered persimmon quantity is downgraded at the cooperative warehouse due to quality standards, and is not paid to primary producers [27]. Willersinn et al. [28] estimated that at the agricultural stage, losses of fresh potatoes were reduced by 3–5% on a total of 53–55% in all the supply chain when lower cosmetic standards were applied; this reduction was even more significant in the processing stage, where a lower standard could lead to a reduction of FL up to 11%.

However, data on FL and the dynamics of its generation in the upstream stages of the supply chain is still scarce [7]. This paper aims to contribute filling this gap by studying how FL is generated at the interface between farmers, POs, and buyers, that is, the harvest and postharvest stages of the FFV supply chain. This paper focuses on the perspective of POs, which represent a main actor in this phase of the supply chain. We compare the processes in relation to private quality standards and contractual terms that lead to FL in the value chain, at the PO level, and across Italy and Germany. Although there is literature available for some countries, such as Germany, the unique contribution of this paper is to provide insights on a new country, Italy, where little information is available, comparing Italy to a better-assessed country. To do so, semi-structured interviews have been conducted with seven German POs and three Italian POs. A standard guideline has been applied, using the MAXQDA program, to conduct the content analysis of the interviews, to make the method comprehensible, and to allow comparison of the two studied countries. The results are analysed in the framework of a structured qualitative content analysis to assess similarities and differences in food loss occurrence between Germany and Italy in the FFV supply chain.

The specific objective of this paper is to address the following research questions: (i) what are the similarities and differences in the market dynamics between POs and buyers in the FFV supply chain in Germany and Italy?; (ii) what are the reasons why FL is generated at the interface between POs and buyers in Germany and Italy?; (iii) do private marketing standards, set by buyers, influence FL in Germany and Italy, and how are the products managed if they do not meet these requirements?

2. Materials and Methods

2.1. Data Acquisition

A qualitative research approach was chosen to investigate FL and how it is connected to private marketing standards from the perspective of the POs. 52% of POs in Europe operate in the FFV sector. France, Germany, and Italy are the countries where POs are more present: Germany has 692 POs, among which, 31 are in the FFV sector, while Italy has 583 and 315 FFV POs, respectively [29].

We chose the method of semi-structured interviews to shed light on the mechanisms and processes related to FL at the PO level. In Germany and Italy, the interviewees were selected based on a list of POs working in the FFV sector within the country, making sure to cover different crop types and regions. A similar methodological approach was applied in both countries, with the aim to jointly analyse and compare the results. The interviewees were persons responsible for sales and marketing, for quality control, or for the management of the POs.

A guideline was developed for the interviews in Germany and Italy, addressing the same issues to contribute to the objectivity and trustworthiness of the study [30]; all interviews covered the following topics:

1. Causes of FL in the supplier/retailer interface;
2. Design of contracts and arrangements that POs have in place with farmers and retailers;
3. Relation between the structure of contracts, orders' management, and quantity of FL;
4. Quality management process along the supply chain and criteria that influence the decisions;
5. Management of products that do not meet the required quality standards.

Interviews in Germany were conducted between October 2020 and January 2021, and were partially analysed by Herzberg et al. [31], targeting the issue of food loss creation through unequal bargaining power, trading practices, product specifications, orders, and contracts in Germany. Interviews in Italy were conducted between September and December 2022.

The interviews were conducted face-to-face, whenever COVID-19 restrictions allowed for, or online/via telephone. In total, seven interviews were conducted with German POs and three with Italian POs. Although the number of interviews with POs conducted in Italy is lower, the selected POs are very relevant in the national market; all together, they produce more than 5% of the national production of fennel and potatoes; all in all, they reach a turnover of almost EUR 300 million. Table 1 provides the description of the POs involved in the study.

Table 1. Description of the POs involved in the study.

PO	Country	Number of Members	Total Acreage (ha)	Products
PO 1	Germany	19	600	Onions
PO 2	Germany	1200	900	Pomaceous Fruit, Berries, and Asparagus
PO 3	Germany	60	152	Vegetables
PO 4	Germany	330	2500	Pomaceous Fruit
PO 5	Germany	350	5500	Pomaceous Fruit
PO 6	Germany	50	270	Vegetables and Herbs
PO 7	Germany	50	10,000	Vegetables and Herbs

Table 1. Cont.

PO	Country	Number of Members	Total Acreage (ha)	Products
PO 8	Italy	183	1200	Salad, Potatoes, Carrots, and Fennel
PO 9	Italy	85	565	Potatoes, Cabbage, Chickpeas, Beans, and Lentils
PO 10	Italy	4957	32,091	Fruits, Potatoes, and Onions

Interviews in Germany were recorded and literally transcribed. Interviews held in Italy were not recorded, but full comprehensive notes were taken on the same day of the interview.

2.2. Data Analysis

We applied a structured content analysis approach for qualitative data, inspired by Kuckartz et al. [32], to the interviews. The MAXQDA software was fed with transcriptions for Germany and notes for Italy from the interviews.

In the applied methodology, a coding system was created and used to sort all the statements of the interviews. It is based on a deductive and inductive coding. The deductive codes are rooted in the theories and literature described in the introduction section of the paper. The inductive codes were developed during the analysis of the material of the German interviews. The same coding system was then applied to the notes of the Italian interviews.

3. Results and Discussion

As a result of the content analysis on the interviews, two different tables were developed: a quantitative cross table, and a qualitative segment matrix coding the data of the interviews. The results of the quantitative cross table are summarized in Figure 1. In total, we have 177 codings, divided into 3 thematic areas: the answers dealing with supply chain organisation (with 63 codings), followed by the issues related to contracts and agreements (with 37 codings), and lastly the FL and quality standards (with 77 codings). These three areas are reflected in the next subsections of the paper, where the results are reported and discussed separately for each topic.

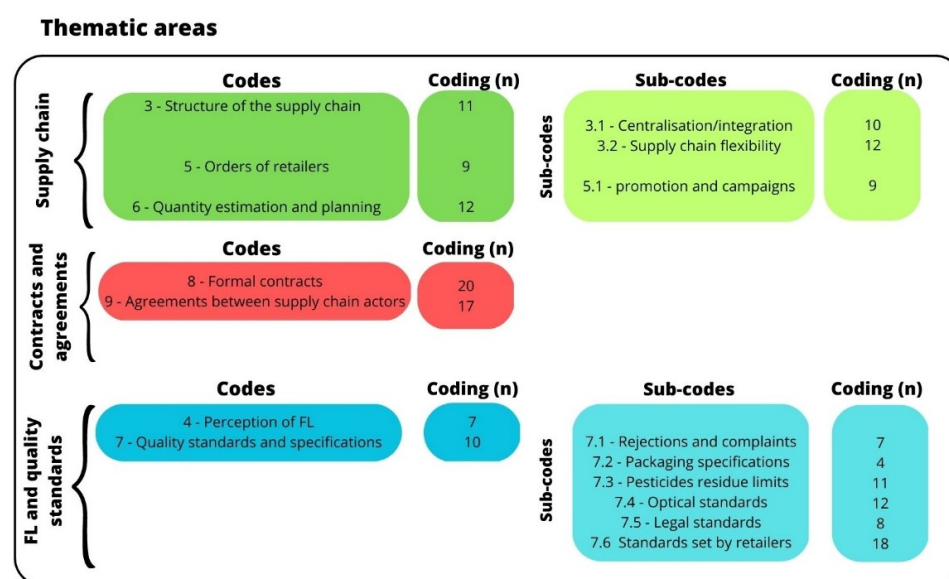


Figure 1. Structure of the coding systems developed and applied in the content analysis to sort the single statements (i.e., codings; $n = 177$). The codings are divided into three thematic areas: supply chain ($n = 63$), contracts and agreements ($n = 37$), and FL and quality standards ($n = 77$). Every thematic area has different codes, meaning different categories to sort the codings; some categories are also divided into subcategories (subcodes).

In the qualitative segment matrix, codes are listed in the rows, and the statements of each PO are reported in the columns. The segment matrix allows for the comparison of similarities and differences between the answers of the different POs on the same category in a qualitative manner. Therefore, it helps to compare POs and countries based on the selected codes and subcodes. Table 2 reports the main similarities and differences between German and Italian POs emerging from the interviews, which are organised along the three thematic areas represented in Figure 1.

Table 2. Summary of similarities and differences between German and Italian POs, divided by thematic areas.

Thematic Areas	Similarities	Differences
Supply chain organisation	Structure of the FFV supply chain is vertically integrated. Central role of the PO, and as intermediary between farmers and retailers. POs store and prepare the products to be sold. Orders are made with short notice. Flexibility of POs to supply orders.	Selection takes place at different stages of the products (field for Germany; POs' warehouse in Italy). POs mostly plan the quantity and products to be cultivated by farmers in the next season to better supply orders in Italy; some members have more leeway in product and quantity planning in Germany. Timing and quantities to be delivered are negotiated at the beginning of the season in Italy, informally agreed upon within annual consultations in Germany
Contracts and agreements	POs represent farmers in the commercial relations and negotiations. Buyers take advantage due to their bargaining position. POs usually have contracts with different buyers. Contracts with the food industry are generally considered more reliable (hardly changing quantity and timing that is demanded). Price paid by retailers is higher than the one of the food industries; therefore, retailers are the first choice. Timing and quantity of everyday orders can vary significantly during the season. Final quantities and prices are defined on a short-term basis by retailers and last-minute changes are frequent. Some of the contracts between POs and retailers are on the edge of unfair trading practices (EU legislation). Prices between POs and retailers are negotiated upon weekly or biweekly; influenced by the European and world market prices. Promotions are scheduled by retailers at the beginning of the year, while quantities are announced few weeks before; this is considered a potentially strategic tool to avoid FL.	Economic risks are with different actors of the supply chain. Ownership of the products belongs to POs in Italy, to different stakeholders (POs or farmers) in Germany. Timing, negotiation, and structure of contracts differs between POs and buyers. Differences in the mechanism of the price setting between POs and retailers, and between farmers and POs.

Table 2. *Cont.*

Thematic Areas	Similarities	Differences
FL and quality standards	Private quality standards are a crucial issue in generating FL. Each retailer asks for different specific quality standards that are generally stricter than the quasi-public and public standards imposed by the EU and UNECE. If private standards are not respected, products are not accepted during the retailer's quality control and are sent back to the PO, which potentially generates FL. Visual standards, calibres, and pesticide limits are the most difficult private quality standards to be reached. Many alternative marketing channels are available to reallocate suboptimal products. The combination of restrictions to pesticide use and cosmetic standards leads to a higher likelihood of FL generation in organic supply chains compared to conventional ones.	Quality standards are mostly specified in the contracts in Italy; retailers impose these standards in an informal manner (or written form but not contract) in Germany.

3.1. Supply Chain Organization

The content of the interviews confirms the central role of POs in the value chain, both in Germany and in Italy. Interviewees describe the POs as intermediary between farmers and retailers, collecting and storing the FFV products from farmers, negotiating contracts with retailers, and taking charge of logistics and deliveries upon retailers' orders. When products are harvested, farmers bring them to the PO, where they are stored or directly delivered to retailers.

The length and organisation of the process at the surveyed POs depend on the type of fruit and vegetables; super fresh products such as strawberries, salads, and other leafy vegetables are quickly delivered to retailers, which is in line with the findings from Surucu-Balci et al. [33]. In contrast, other products are typically stored in the warehouse of the PO until the order of the buyer. Some differences are detected in the structure of the postharvest operations across the two countries. In Italy, POs take charge of selection and packaging of products before delivering it to the buyers; these operations take place in the warehouse of the PO. Instead, in Germany, many items (for example cabbages and salads) are selected and packed directly in the field. Therefore, a selection and sorting out of unsuitable produce already happens in the field, while in Italy the selection mostly happens at the PO premises. This is particularly interesting in relation to FL generation, because the different organisational patterns influence where FL is generated. It therefore also defines the actor of the supply chain in charge of managing such losses [34], as well as the available options for recovery of the discarded items [35].

During the interviews, the structure of the FFV supply chain emerges as being vertically integrated. In general, POs plan their production together with farmers and they manage the quantity to be delivered by different farms, considering the changing environmental conditions. As also confirmed by the literature [36], these efforts are intended to reduce the volatility of prices in the FFV market. According to our study, Italian POs plan at the beginning of the season where to cultivate each item, based on the quantity they expect to deliver to the retailers during the upcoming season, and assuring a proper crop rotation in the fields. As argued by Aschemann-Witzel et al. [37], this approach assures a better management of the surplus products, giving the PO the possibility to reallocate surplus or suboptimal products to different marketing channels. In Germany, the process is basically the same, although the German sample comprises, on the one hand of POs that

work rather top-down and, on the other hand, of others that work less vertically integrated, where members have more leeway in product and quantity planning.

The interviewees disclosed that in both countries POs also store harvested products, especially those with a long shelf life. These items remain in stock until the PO receives an order from a retailer; orders are typically made with short notice (AxA, today for today; or AxB, today for tomorrow). The flexibility that is required in this situation, besides being a logistical challenge, can also affect FL levels, as also confirmed by Hobbs et al. [38].

The interviews also suggested that a main challenge for the POs is the estimation of the quantity of products they will need during the season to satisfy the orders. In Italy, the quantities to be delivered are agreed upon among POs and buyers at the beginning of the season. In Germany, quantities are informally agreed upon within annual consultations. Last minute changes in procurement decisions by retailers can always occur, considering peaks or off-peaks of consumer demand for that product. This could lead to sudden surplus stocks and bring prices down, causing FL as a consequence in our results, and suggested by Bustos et al. [39].

3.2. Contracts and Agreements

The role of POs as a bridge between farmers and the market is very clearly expressed in the interviews. POs represent the farmers in the commercial relations with the buyers of different marketing channels (retailers, food industry, and wholesale trading centres). The interviewees confirmed that buyers may take advantage of their bargaining position to minimize the economic risks emerging from the transaction [31,40]. To cope with this situation, POs usually have contracts with different buyers, and among them, with different retailers. This evidence is in line with Fałkowski et al. [41], who report that POs are recognized to improve farmers' position against the industry and retail sector. In addition, the larger the POs' size, the greater the benefits offered to their members, also in terms of profits, lower costs, and services [42]. German interviewees report that POs sometimes pass the economic risk onto the upstream farmers, e.g., by passing potential monetary discounts due to low product quality onto them. This does not happen in POs in the Italian sample.

The relations between the farmers and the POs are usually regulated through written contracts in the Italian POs surveyed. In this case, the product is owned by the PO from the beginning of the season. Instead, in Germany, there are different patterns: either the PO may buy the product from the farmer, as it happens in Italy, or the PO only acts as an intermediary between the farmer and the retailer, and the ownership of the product remains with the farmer until the retailer buys the product. What makes these German contracts different is the ownership of the goods, which is managed differently, and this also influences the responsibility of dealing with returned/rejected produce.

In most cases, POs negotiate contracts both with the industry and retailers, as well as with further potential buyers. The contracts with the food industry are generally considered more reliable by the Italian interviewees because, as one of them said, *"what they write in the contracts is what they ask for, products hardly remain in the field"*. In Italy and Germany, food industries hardly change the quantity demanded during the year, thus allowing for a better planning of crops. However, the price paid by retailers is higher than the price paid by the food industry. Therefore, POs must carefully find a balance between these kinds of contracts, considered as safer, and the more remunerative ones, signed with retailers. For this reason, as also suggested by Camanzi et al. [43], larger POs tend to have larger volumes of products contracted with retailers than with food industries, in order to have higher remuneration. Instead, POs with fewer members, and thus smaller in size, tend to have more contracts with food industries, to guarantee the sale of products. However, selling fresh FFV to the retailing sector remains the first choice due to the substantially higher economic margins. It should also be considered that the average acreage per farm and the number of farmers per PO is heterogenous, as shown in Table 1. This makes it difficult to generalize these concepts, as POs composed by smaller farms may produce a

broader variety of products that would be less likely to meet the private quality standards required by retailers.

The interviews reveal significant differences in the timing and structure of contracts between POs and buyers across Italy and Germany. In Italy, every contract is discussed and signed at the beginning of the year, which includes the specification of the quantities agreed upon by all the actors within the annual consultation. It also comprises the private quality product standards to be respected, delivery timing, and the schedule of promotions. Instead, in Germany, contracts cover several years, but they only state very general terms of cooperation among the parties, e.g., codes of conduct, working conditions of employees, etc. This means that no binding agreements are made on quantities, prices, crop types, etc. Yearly consultations to negotiate quantities and price corridors do take place in Germany at the beginning of each year, but no formal kind of contract emerges from these consultations, rather, agreements are written on a “*piece of paper*”, as mentioned by one of the German interviewees. Final quantities and prices are defined on a short-term basis. This situation may lead to last-minute changes in the orders of products in both countries. In Italy, the timing of orders and the quantity ordered every day can vary significantly during the season, especially for super fresh products that are harvested and delivered on the same day, although the annual quantity agreed upon within the contract stays the same. In Germany, short-term variations can concern both quantity and prices. German interviewees also reported that the lack of specifications within contracts between POs and retailers may bring the risk of having a surplus of products in the peak period of the season at the POs’ level. This is coherent with other evidence in the literature, suggesting that the behaviour of retailers can influence the amount of losses, not only at their stores, but also at the upstream stages of the supply chain [44,45].

Some of these contracts are on the edge of unfair trading practices, as defined by the recent EU legislation [46] which lists the practices which are banned, unless the parties agree otherwise. For example, the buyer is not allowed to unilaterally change the terms of agreements concerning the frequency, method, place, time or volume of supply or delivery of the products [46]. The directive also states that the short notice cancellation of orders for perishable products allows to assume that the supplier will not be able to find an alternative to market or use such products. Take-back agreements, that is the practice to return unsold products to suppliers, are also considered as unfair, though none of the POs in our sample report to have it in force.

German interviewees also mentioned that sometimes retailers may decide to buy items from another supplier (even from abroad) in the middle of the season. This approach can generate large amounts of losses for domestic suppliers.

The Italian interviews disclosed that contracts also define what happens if delivery time or/and quantity are not respected. In this case, retailers usually apply an additional cost to POs, representing a big fee for every delayed load. However, the same issue was not reported in the German interviews, nor was the problem confirmed in the available literature.

Another issue for contract specification is the price. If the price is not remunerative enough, farmers do not have any advantage to work with POs, and they would rather use the spot-market as individual businesses. The prices in agriculture are very volatile, and this is an issue for farmers [47]. The PO works as an intermediary, aiming to secure the farmer’s interest, but the interviews revealed several differences in how this role is interpreted. In Italy, the price that the PO pays to farmers is set in advance at the beginning of the season. In Germany, a price corridor is agreed upon during the annual meetings, and the contracts only include payment times, terms and conditions: “*That means in week A (..) the prices for week B are set, if necessary, the quantities are also discussed and then in week B there is actually only the dropping of this quantity. (..) That means there are no permanent contracts, the form is more of a planning and agreement*”, as well-described in a German interview. Instead, the price between buyer and PO is contracted during the season. Both in Italy and in Germany, prices between POs and retailers are agreed upon weekly or biweekly, and the price-setting for fresh products is influenced not only by the European market, but also

by the world market prices. The efficacy of this mechanism is crucial for the effective operation of the market because the connections between producers, processors, and POs assure market and price stability [48]. One of the main advantages that POs can provide to farmers is the stability of product prices, and therefore of their income in the long term [8], even if in some seasons the farmers may get a lower price through the PO than they would get from other market channels.

The European Union, in the Common Agricultural Policy, includes a range of measures to help mitigate price volatility in agricultural markets, including market interventions, risk management programs, and support for sustainable farming practices. One example is the use of public stocks and intervention purchases to stabilize prices during times of market disruption. On the one hand, these measures can help to prevent sharp price fluctuations that could negatively impact farmers and consumers. On the other hand, the withdrawal of products from the market can create a potential amount of FL [49].

Promotion campaigns are also mentioned by interviewees as a tool that is potentially strategic to avoid FL. In Italy, the promotions are already scheduled by retailers at the beginning of the year: POs know in advance in which week they will be active. In Germany, there is also a planning of promotional campaigns at the beginning of the season. However, retailers announce the estimated quantities of the promotion to POs just a few weeks before they start. On the one hand, an early scheduling of promotions enables POs and farmers to plan the production in advance, thus preventing the generation of FL. On the other hand, spontaneous campaigns can be used as leverage to react to unexpected excess quantities. Promotions imply, within a few days, an increasing demand for products that are sold and bought for a lower price; the estimation of the quantities that are actually requested remains difficult [31]. The Italian interviewees report that when retailers schedule promotions, they mainly consider the expected trend of consumer demand, as well as their own needs in terms of planning marketing actions; instead, they do not consider the seasonal variation of the timing of harvesting. The consequence is that the increasing demand for products by retailers, linked to the start of a promotion, may not match the actual peak of products ready for harvest in the field. With respect to this issue, Hobbs et al. [38] argue that POs should plan crop production and orders very carefully to be able to supply the amount required by retailers, but they should also be able to stay flexible.

Despite the planning efforts, excess production can always occur. The approach to handle these surplus products, which cannot easily be marketed, differs between the surveyed countries. From the Italian interviews, it emerges that during the peak of the season, some POs organize trucks to donate surplus products, which would otherwise be lost, to charities. Indeed, the donation of surplus products can help prevent food loss by redirecting excess, edible food to those who need it, and increase the efficiency of the food system [50]. This is facilitated by the existence of a specific legislative framework which regulates the donation of surplus products to charities in Italy [51]. Instead, planned regular donations from POs on a large scale do not seem to exist in Germany, maybe because charities would tend to be overwhelmed by such large amounts of produce, and the management effort would exceed the capacities of the POs. However, it can be expected that this destination for surplus produce will become more frequent in the future, following the launch of the “European Food Donation Act” to encourage food donations across the continent [52].

3.3. FL and Quality Standards

Private quality standards imposed by retailers emerge as a crucial issue related to FL generation in all interviews. Each retailer asks for different specific quality standards that are generally stricter than the quasi-public and public standards imposed by the EU and UNECE. Vandemoortele et al. [53] suggest that retailers systematically apply stricter standards because, in this way, they can obtain products of higher quality by inflicting to producers most of the costs related to the achievement of such quality. This mechanism also generates significant FL in the upstream supply chain [13,21,54].

In Italy, quality standards are mostly specified in the contracts. In Germany, POs explain that retailers rather impose these standards in an informal manner or in a written form, but not within the contracts. POs, however, have their own product profile for each variety that elaborates on characteristics that need to be met. Regardless, they must be complied with, otherwise the products are not accepted during the retailer's quality control upon delivery, and are sent back to the PO due to insufficient quality. One of the most frequently repeated argument by interviewees is that *"if it was for us (PO), we would have sold everything, but retailers do not want it"*. While there is evidence in the literature that retailers have an impact on consumer decision-making and purchasing behaviour [45], they prefer rejecting suboptimal products rather than taking the risk of remaining with unsold products.

When products are sent back from retailers to POs because they do not meet the quality standards requested, they cause FL in mass and economic terms [14]: POs need to repack and rework products that were rejected by retailers and find different marketing channels that are not as remunerative. As rework is also barely lucrative, POs try to avoid items being sent back from the outset. Depending on the general perishability of the rejected produce and the actual condition (e.g., ripeness), the aforementioned procedure will exceed the available time until the end of edibility is reached and, thus, produce has to be disposed of.

While discussing about different types of private quality standards, the interviewees reported that visual standards are one of the most difficult to be reached. Italian POs underline the importance of the visual aspect for Italian retailers: interviewees said that some retailers want the *"most perfect products, beautiful and clean"*. In addition, many German POs mentioned calibre as one of the main standards contributing to FL generation. The interviewees report that the main argument of retailers to justify these requirements is that the consumers would not buy substandard products. However, the evidence shows that there are existing retailer brands selling suboptimal products on a regular basis, at least in some countries (including Germany, Italy and Austria). Recent research shows that consumer acceptance depends on specific characteristics related to certain products. This means they accept a specific flaw (e.g., a dent) for one product, but not for another [18,55–57]. Moreover, there is no evidence that consumers are actually able to recognize small cosmetic differences among products, meaning that in some cases they might not even be able to identify non-compliance with cosmetic standards [58]. Interviewees argue that this would allow for a less strict implementation of cosmetic standards, for example, regarding the size of fruit and vegetables. Meyer et al. [59] suggest that a change from marketing more items per piece to a marketing per mass in Germany would reduce the pressure to produce same-size products. However, in Italy, most FFV products are already sold by mass, and still this issue was raised in the interviews.

Although some studies have detected a negative image effect on retailers due to selling of suboptimal products [60], POs argue that suboptimal products have the *"same organoleptic and quality characteristics and same taste, but they are just ugly"*. This claim is in line with other studies which underline the need for raising awareness among customers [18,58,61], especially adopting some marketing strategies [62].

Since suboptimal products are a big issue at the interface between POs and retailers, alternative marketing channels are available to reallocate products. There are marketing options (e.g., *"patata imperfetta"* in Italy or *"die krummen Dinger"* in Germany) to sell such produce at the fresh market by retail chains, but as mentioned above, marketing is challenging due to consumer preferences. Alternative fresh marketing channels could directly address open-minded consumers or public institutions, e.g., by offering suboptimal food boxes using online subscription systems in Germany (German examples are the start-ups Querfeld [63] and Etepetete [64]), Austria (Austrian example is the start-up Afreshed [65]), or the UK (UK example is the start-up Oddbox [66]) or to address food service businesses.

From the perspective of the POs interviewed, limits to pesticide residues also represent a critical issue, because German and Italian retailers ask for stricter thresholds than the ones imposed by EU regulations. Although in Italy they do not seem to affect FL to a great extent, German interviewees are of the opinion that the standards are quite hard to reach and are considered among the most important reasons affecting FL levels. Reasons are the inability to control pests and diseases by applying only small amounts or a restricted number of agents, but also the sorting out of produce exhibiting too high levels and/or too large numbers of pesticide residues.

The challenge seems to be even harder for organic FFV products, where higher restrictions are in force due to the requirement of the organic certification bodies. Interviewees argue that the combination of restrictions of pesticide use, and cosmetic standards leads to a higher likelihood of FL generation in organic supply chains, as compared to conventional ones.

3.4. Limitations

Three main limitations must be considered for this study. First, only three interviews were conducted in the Italian case, and they were not literally transcribed, as it was the case in Germany. However, the Italian POs involved in the study are quite large and relevant at the national level, and full notes were taken during the interviews. Second, interviews can only capture perceptions and knowledge on processes, and therefore enhance the understanding of FL mechanisms. However, the approach is not suitable for assessing quantities of FL. Therefore, we cannot relate the interviewees' views to the actual quantity of FL the POs generate. Third, and last, it should be remarked that the views reported in the study reflect the perspective of the POs, which may contrast with the perception of the other supply chain actors.

4. Conclusions

The aim of this paper is to examine differences and similarities between Italy and Germany considering FL generation in the upstream stages of the supply chain, focusing on the FFV sector. Through a series of qualitative interviews, we gained insights from POs about the organisation of the supply chain, the content of contracts and agreements with buyers, and the relation between FL and private quality standards imposed by buyers. The study confirms the key role of POs in the FFV supply chain. They increase farmers' bargaining power against retailers and food industry, both in Germany and in Italy. However, retailers still have the power to impose most of the conditions to POs and farmers concerning the terms of contracts and agreements. The content of these agreements shows differences among the two countries analysed, especially concerning the timing with which quantities and prices are defined. Retailers also require private quality standards to POs, which are typically stricter than those imposed by law. This mechanism can generate a significant amount of suboptimal products that are likely to become FL in the absence of alternative marketing channels.

This study suggests that some key antecedents of FL at the upstream stages of FFV supply chains, such as the concentration of the supply, the way private quality standards are enforced by retailers, and the opportunities to reallocate suboptimal products, are quite similar across POs located in Germany and Italy. Nevertheless, several conditions are different, such as levels of informality in Germany, especially in the contract agreements between POs and buyers. This, in turn, may lead to diverging responsibility for the produce, and thus result in varying points within the supply chain where actors can implement food loss prevention measures. An example is the packaging of produce earlier or later in the supply chain, which would require FL reduction measures either in the field or at the PO level, respectively. Overall, this means that POs represent a crucial role in the implementation of FL prevention strategies targeted at the upstream stages of the supply chain. In addition, from the policy perspective, involving the POs in the discussion and implementation of action against FL is crucial, also considering that the same dynamics

of FL generation might be found in the FFV sector of other EU countries. The evidence of this study confirms that the whole issue of food loss and waste must be addressed from a broader perspective. Additionally, in the first stages of the supply chain, the framework to address the issue should be set and implemented starting from the EU level and the Common Agricultural Policy instruments.

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References

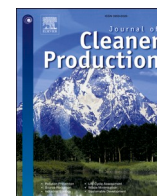
1. FAO. Women in agriculture, closing the gender gap for development. In *The State of Food and Agriculture*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2011.
2. FAO. Moving forward on food loss and waste reduction. In *The State of Food and Agriculture*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2019.
3. UNEP. *Annual Report*; UNEP: Nairobi, Kenya, 2013.
4. UNEP. *Food Waste Index, Report*; UNEP: Nairobi, Kenya, 2021.
5. United Nations (UN). Sustainable Development Goals. 17 Goals to Transform Our World. 2015. Available online: <https://sdgs.un.org/goals/goal12> (accessed on 1 December 2022).
6. FAO. Methodology for monitoring SDG target 12.3 as approved by the Inter-agency and Expert Group on SDG Indicators, 6 November 2018. The Global Food Loss Index-Design, Data Collection, Methods and Challenges. In *SDG 12.3.1: Global Food Loss Index*; FAO: Rome, Italy, 2018; 54p, Available online: <http://www.fao.org/3/CA2640EN/ca2640en.pdf> (accessed on 10 May 2023).
7. Caldeira, C.; De Laurentiis, V.; Corrado, S.; van Holsteijn, F.; Sala, S. Quantification of food waste per product group along the food supply chain in the European Union: A mass flow analysis. *Resour. Conserv. Recycl.* **2019**, *149*, 479–488. [CrossRef] [PubMed]
8. Sorrentino, A.; Russo, C.; Cacchiarelli, L. Market power and bargaining power in the EU food supply chain: The role of Producer Organizations. *New Medit* **2018**, *17*, 21–31. [CrossRef]
9. European Commission. *EU Regulation 2013/1308 and the Commission Delegated Regulation 2016/232*; European Commission: Brussels, Belgium, 2016.
10. Chlebicka, A.; Pietrzak, M. Size of membership and survival patterns of producers' organizations in agriculture—Social aspects based on evidence from Poland. *Sustainability* **2018**, *10*, 2293. [CrossRef]
11. Hendrikse, G.W.J.; Bijman, J. On the emergence of new growers' associations: Self-selection versus market power. *Eur. Rev. Agric. Econ.* **2002**, *29*, 255–269. [CrossRef]
12. Menard, C. Cooperatives: Hierarchies or Hybrids? In *Vertical Markets and Cooperative Hierarchies. The Role of Cooperatives in the Agri-Food Industry*; Karantininis, K., Nillson, J., Eds.; Springer: Dordrecht, The Netherlands, 2007; pp. 1–17. ISBN 1-4020-4072-5.
13. Devin, B.; Richards, C. Food Waste, Power, and Corporate Social Responsibility in the Australian Food Supply Chain. *J. Bus. Ethics* **2018**, *150*, 199–210. [CrossRef]
14. Eriksson, M.; Ghosh, R.; Mattsson, L.; Ismatov, A. Take-back agreements in the perspective of food waste generation at the supplier-retailer interface. *Resour. Conserv. Recycl.* **2017**, *122*, 83–93. [CrossRef]
15. Skorbiansky, S.R.; Ellison, B. Contracting and quality standards in fresh produce markets and how they impact food loss. In *The Economics of Food Loss in the Produce Industry*; Routledge: London, UK, 2019; pp. 250–262. [CrossRef]
16. European Union. *Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013*; European Union: Luxembourg, 2013.
17. Fulponi, L. The globalization of private standards and the agri-food system. In *Global Supply Chains, Standards and the Poor: How the Globalization of Food Systems and Standards Affects Rural Development and Poverty*; CABI: Wallingford, UK, 2007; pp. 5–18.
18. de Hooze, I.E.; Oostindjer, M.; Aschemann-Witzel, J.; Normann, A.; Loose, S.M.; Almlí, V.L. This apple is too ugly for me! Consumer preferences for suboptimal food products in the supermarket and at home. *Food Qual. Prefer.* **2017**, *56*, 80–92. [CrossRef]
19. Hartmann, T.; Jahnke, B.; Hamm, U. Making ugly food beautiful: Consumer barriers to purchase and marketing options for Suboptimal Food at retail level—A systematic review. *Food Qual. Prefer.* **2021**, *90*, 104179. [CrossRef]
20. Huang, W.-S.; Kuo, H.-Y.; Tung, S.-Y.; Chen, H.-S. Assessing Consumer Preferences for Suboptimal Food: Application of a Choice Experiment in Citrus Fruit Retail. *Foods* **2020**, *10*, 15. [CrossRef]

21. de Hooge, I.E.; van Dulm, E.; van Trijp, H.C. Cosmetic specifications in the food waste issue: Supply chain considerations and practices concerning suboptimal food products. *J. Clean. Prod.* **2018**, *183*, 698–709. [\[CrossRef\]](#)
22. Aschemann-Witzel, J.; Jensen, J.H.; Jensen, M.H.; Kulikovskaja, V. Consumer behaviour towards price-reduced suboptimal foods in the supermarket and the relation to food waste in households. *Appetite* **2017**, *116*, 246–258. [\[CrossRef\]](#) [\[PubMed\]](#)
23. Porter, S.D.; Reay, D.S.; Bomberg, E.; Higgins, P. Avoidable food losses and associated production-phase green-house gas emissions arising from application of cosmetic standards to fresh fruit and vegetables in Europe and the UK. *J. Clean. Prod.* **2018**, *201*, 869–878. [\[CrossRef\]](#)
24. Bloom, J. *American Wasteland: How America Throws Away Nearly Half of Its Food (And What We Can Do about It)*; Da Capo Press: Cambridge, MA, USA, 2011.
25. Davis, J.; Wallman, M.; Sund, V.; Emanuelsson, A.; Cederberg, C.; Sonesson, U. *Emissions of Greenhouse Gases from Production of Horticultural Products—Analysis of 17 Products Cultivated in Sweden*; SIK: Gothenberg, Sweden, 2011.
26. Stuart, T. *Waste: Uncovering the Global Food Scandal*; WW Norton & Company: New York, NY, USA, 2009.
27. Fernandez-Zamudio, M.-A.; Barco, H.; Schneider, F. Direct Measurement of Mass and Economic Harvest and Post-Harvest Losses in Spanish Persimmon Primary Production. *Agriculture* **2020**, *10*, 581. [\[CrossRef\]](#)
28. Willersinn, C.; Mack, G.; Mouron, P.; Keiser, A.; Siegrist, M. Quantity and quality of food losses along the Swiss potato supply chain: Stepwise investigation and the influence of quality standards on losses. *Waste Manag.* **2015**, *46*, 120–132. [\[CrossRef\]](#) [\[PubMed\]](#)
29. European Commission. Agriculture and Rural Development. 2018. Available online: https://agriculture.ec.europa.eu/common-agricultural-policy/agri-food-supply-chain/producer-and-interbranch-organisations_en (accessed on 7 December 2022).
30. Kallio, H.; Pietilä, A.-M.; Johnson, M.; Kangasniemi, M. Systematic methodological review: Developing a framework for a qualitative semi-structured interview guide. *J. Adv. Nurs.* **2016**, *72*, 2954–2965. [\[CrossRef\]](#)
31. Herzberg, R.; Schmidt, T.; Keck, M. Market power and food loss at the producer-retailer interface of fruit and vegetable supply chains in Germany. *Sustain. Sci.* **2022**, *17*, 2253–2267. [\[CrossRef\]](#)
32. Kuckartz, U. *Qualitative Inhaltsanalyse. Methoden, Praxis, Computerunterstützung. 4. Auflage*; Beltz Juventa (Grundlagentexte Methoden): Weinheim, Germany; Basel, Switzerland, 2018.
33. Surucu-Balci, E.; Tuna, O. Investigating logistics-related food loss drivers: A study on fresh fruit and vegetable supply chain. *J. Clean. Prod.* **2021**, *318*, 128561. [\[CrossRef\]](#)
34. Hamam, M.; Chinnici, G.; Di Vita, G.; Pappalardo, G.; Pecorino, B.; Maesano, G.; D’Amico, M. Circular Economy Models in Agro-Food Systems: A Review. *Sustainability* **2021**, *13*, 3453. [\[CrossRef\]](#)
35. de Oliveira, M.M.; Lago, A.; Dal’Magro, G.P. Food loss and waste in the context of the circular economy: A systematic review. *J. Clean. Prod.* **2021**, *294*, 126284. [\[CrossRef\]](#)
36. Gandorfer, M.; Porsch, A.; Bitsch, V. Producer price volatility in the German fruit and vegetable industry. *Eur. J. Hortic. Sci.* **2017**, *82*, 149–154. [\[CrossRef\]](#)
37. Aschemann-Witzel, J.; de Hooge, I.E.; Almli, V.L. Suboptimal food? Food waste at the consumer–retailer interface. In *Saving Food*; Academic Press: Cambridge, MA, USA, 2019; pp. 347–368. [\[CrossRef\]](#)
38. Hobbs, J.E. Food supply chains during the COVID-19 pandemic. *Can. J. Agric. Econ./Rev. Can. D’agroekon.* **2020**, *68*, 171–176. [\[CrossRef\]](#)
39. Bustos, C.A.; Moors, E.H. Reducing post-harvest food losses through innovative collaboration: Insights from the Colombian and Mexican avocado supply chains. *J. Clean. Prod.* **2018**, *199*, 1020–1034. [\[CrossRef\]](#)
40. Sexton, R.J. Market power, misconceptions, and modern agricultural markets. *Am. J. Agric. Econ.* **2013**, *95*, 209–219. [\[CrossRef\]](#)
41. Fałkowski, J.; Chlebicka, A. What product mix do they offer and what marketing channels do they use? Exploring agricultural producer organisations’ heterogeneity. *J. Rural. Stud.* **2021**, *85*, 1–12. [\[CrossRef\]](#)
42. Velázquez, B.; Buffaria, B.; European Commission. About farmers’ bargaining power within the new CAP. *Agric. Food Econ.* **2017**, *5*, 16. [\[CrossRef\]](#)
43. Camanzi, L.; Malorgio, G.; Azcárate, T.G. The role of producer organizations in supply concentration and marketing: A comparison between European countries in the fruit and vegetable sector. *J. Food Prod. Mark.* **2011**, *17*, 327–354. [\[CrossRef\]](#)
44. Brancoli, P.; Lundin, M.; Bolton, K.; Eriksson, M. Bread loss rates at the supplier-retailer interface—Analysis of risk factors to support waste prevention measures. *Resour. Conserv. Recycl.* **2019**, *147*, 128–136. [\[CrossRef\]](#)
45. Kulikovskaja, V.; Aschemann-Witzel, J. Food Waste Avoidance Actions in Food Retailing: The Case of Denmark. *J. Int. Food Agribus. Mark.* **2017**, *29*, 328–345. [\[CrossRef\]](#)
46. European Commission. *EU Directive 2019/633 of the European Parliament and the Council of 17 April 2019*; European Commission: Brussels, Belgium, 2019.
47. Reztis, A.N.; Pachis, D.N. Investigating the price volatility transmission mechanisms of selected fresh vegetable chains in Greece. *J. Agribus. Dev. Emerg. Econ.* **2020**, *10*, 587–611. [\[CrossRef\]](#)
48. Van Herck, K. *Assessing Efficiencies Generated by Agricultural Producer Organisations*; Publications Office of the European Union: Luxemburg, 2014; ISBN 978-92-79-39284-9.
49. Porter, S.D.; Reay, D.S.; Bomberg, E.; Higgins, P. Production-phase greenhouse gas emissions arising from de-liberate withdrawal and destruction of fresh fruit and vegetables under the EU’s Common Agricultural Policy. *Sci. Total Environ.* **2018**, *631*, 1544–1552. [\[CrossRef\]](#)

50. Bilska, B.; Wrzosek, M.; Kołożyn-Krajewska, D.; Krajewski, K. Risk of food losses and potential of food recovery for social purposes. *Waste Manag.* **2016**, *52*, 269–277. [CrossRef] [PubMed]
51. Giordano, C.; Falasconi, L.; Cicatiello, C.; Pancino, B. The role of food waste hierarchy in addressing policy and research: A comparative analysis. *J. Clean. Prod.* **2020**, *252*, 119617. [CrossRef]
52. European Commission. 2021. Available online: https://food.ec.europa.eu/safety/food-waste/eu-actions-against-food-waste/food-donation_en (accessed on 16 March 2023).
53. Vandemoortele, T.; Deconinck, K. When Are Private Standards More Stringent than Public Standards? *Am. J. Agric. Econ.* **2013**, *96*, 154–171. [CrossRef]
54. Athai, J.; Kuntscher, M.; Schmidt, T.G. *Lebensmittelabfälle und-Verluste in der Primärproduktion und in der Verarbeitung (Food Waste and Loss in Primary Production and Processing)*; Thünen Working Paper 209; Johann Heinrich von Thünen-Institut: Braunschweig, Germany, 2023; 125p. [CrossRef]
55. Lombart, C.; Millan, E.; Normand, J.-M.; Verhulst, A.; Labbé-Pinlon, B.; Moreau, G. Consumer perceptions and purchase behavior toward imperfect fruits and vegetables in an immersive virtual reality grocery store. *J. Retail. Consum. Serv.* **2019**, *48*, 28–40. [CrossRef]
56. Bolos, L.; Lagerkvist, C.; Kulesz, M. Complementarity of implicit and explicit attitudes in predicting the purchase likelihood of visually sub-optimal or optimal apples. *Food Qual. Prefer.* **2019**, *75*, 87–96. [CrossRef]
57. Beausang, C.; Hall, C.; Toma, L. Food waste and losses in primary production: Qualitative insights from horticulture. *Resour. Conserv. Recycl.* **2017**, *126*, 177–185. [CrossRef]
58. Loebnitz, N.; Schuitema, G.; Grunert, K.G. Who buys oddly shaped food and why? Impacts of food shape abnormality and organic labeling on purchase intentions. *Psychol. Mark.* **2015**, *32*, 408–421. [CrossRef]
59. Meyer, C.H.; Hamer, M.; Frieling, D.; Oertzen, G. Lebensmittelverluste von Obst, Gemüse, Kartoffeln zwischen Feld und Ladentheke—Ergebnisse einer Studie in Nordrhein-Westfalen. Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen (LANUV), Fachbericht 85. 2018. Available online: https://www.lanuv.nrw.de/fileadmin/lanuvpubl/3_fachberichte/fabe85_Lebensmittelverluste_gesichert.pdf (accessed on 23 March 2023).
60. Aschemann-Witzel, J.; Giménez, A.; Ares, G. Suboptimal food, careless store? Consumer’s associations with stores selling foods with imperfections to counter food waste in the context of an emerging retail market. *J. Clean. Prod.* **2020**, *262*, 121252. [CrossRef]
61. Aschemann-Witzel, J. Consumer perception and preference for suboptimal food under the emerging practice of expiration date based pricing in supermarkets. *Food Qual. Prefer.* **2018**, *63*, 119–128. [CrossRef]
62. Van Giesen, R.I.; de Hooge, I.E. Too ugly, but I love its shape: Reducing food waste of suboptimal products with authenticity (and sustainability) positioning. *Food Qual. Prefer.* **2019**, *75*, 249–259. [CrossRef]
63. Dein Abo zum Lebensmittel retten. Available online: <https://querfeld.bio> (accessed on 10 May 2023).
64. DEINE BIO-KISTE. Available online: <https://etepetete-bio.de> (accessed on 10 May 2023).
65. Gemüse & Obst in bester Bio-Qualität krumm, gerade, we don’t care Verformt statt genormt? Available online: <https://www.afreshed.at> (accessed on 10 May 2023).
66. Fight Food Waste with a Delivery of Deliciously Odd Fruit & Veg. Available online: <https://www.oddbbox.co.uk> (accessed on 10 May 2023).

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PAPER II



Lost vegetables, lost value: Assessment of carrot downgrading and losses at a large producer organisation

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ABSTRACT

Retailers usually impose strict private quality standards on fresh fruit and vegetable products, mainly focused on cosmetic features. At the supplier level, this generates a stream of suboptimal products that cannot be sold on the fresh market. This article studies the impact of these standards on suppliers by means of a direct quantification conducted in 2023 in the carrot supply chain of an Italian Producer Organisation. 34.64% of the carrots processed in terms of mass is downgraded because of non-compliance with the standards imposed by retailers, while 12.57% is lost at the primary stage due to food safety reasons. Downgrading occurs as a result of cosmetic imperfection (33.28% of mass) or because carrots are out-of-size (66.72%). The downgraded carrots are re-processed for industry, generating an additional loss of 15.27% of mass along the way. The economic loss linked to downgrading would account for 22.05% of potential turnover if no cosmetic quality standards were applied. By modelling a series of hypothetical scenarios, this article discusses the impact on the producer if the private quality standards imposed by retailers were more flexible.

1. Introduction

The incidence of food loss in the fruit and vegetable sector is estimated as 20–25% of production in terms of mass (Porat et al., 2018; FAO, 2019). When considering the early stages of the supply chain, from farms up to - but not including - retail, 13.8% of the economic value of food produced globally is lost (FAO, 2019). However, at these stages, the availability of data gathered through direct quantification is limited (Caldeira et al., 2019; Corrado et al., 2018; Schneider et al., 2019) and many studies rely on data obtained from literature reviews or indirect measurement, significantly limiting its accuracy (Corrado et al., 2019). The main factors contributing to food loss in the fruit and vegetables value chain are agronomic practices, disease, deterioration, incorrect storage, human error, and product defects (Ishangulyyev et al., 2019; Gustavsson et al., 2011). While many of these factors can hardly be managed or prevented through human action, several are due to the actions of operators in the value chain. This is the case of private quality standards, which are increasingly considered relevant to discussion about food loss in the fruit and vegetable sector (de Hooge et al., 2018; Pietrangeli et al., 2023; Porter et al., 2018; Porat et al., 2018).

Private quality standards are requirements that buyers (especially

retailers) impose on suppliers with the aim of standardising the appearance and features of fruits and vegetables (de Hooge et al., 2017, 2018; Hartmann et al., 2021). These standards are stricter than the requirements established by public and semi-public institutions (such as the EU or UNECE) to ensure food safety. The application of such standards prevents the sale of products with imperfections, for example black spots, non-straight shapes or other cosmetic issues, resulting in the rejection of a substantial volume of produce, referred to as suboptimal (Commons, 2017; Hezarkhani et al., 2023). These products have the same intrinsic quality and safety as products that meet the standards, but their visual appearance, shape or colour deviate from the norm; for this reason, they may be deemed undesirable by consumers and retailers may not accept them to be sold on the fresh market (Aschemann-Witzel et al., 2015).

For some products, the application of private quality standards starts in the field, with selective harvesting (Gunders, 2012; Suresh Kumar et al., 2023). More often, private quality standards are applied during post-harvest operations, when suboptimal products are selected and downgraded, thus leaving the stream of products destined for the fresh market. If they are not quickly reallocated to alternative, less remunerative, marketing channels (such as the food industry, Pietrangeli

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et al., 2023), they can become a food loss, due to their perishability (de Hooge et al., 2018).

FAO (2021) estimates that between 25% and 30% of carrots do not reach grocery stores due to physical or cosmetic defects. In the UK, on-farm and grade-out losses due to cosmetic issues are between 23% and 44%, and the products with the highest losses are potatoes, carrots, onions, and brassicas (Porter et al., 2018). In England, 3%–13% of potatoes, 9%–20% of onions, and 5%–25% of apples are discarded for aesthetic reasons (Commons, 2017). In a study conducted in Australia, tomato losses during post-harvest operations are 40.3% of the total harvestable product; of this, between 68.6% and 86.7% are rejected due to out-grades (McKenzie et al., 2017). In the fresh longan fruit supply chain in Thailand, from harvesting, sorting, grading and packaging to transportation, qualitative loss amounts to 11.02% of total production (Tansuchat et al., 2023). In Finland, 13%–31% of carrots produced are diverted to a side stream, the main reason being flaws in quality, size or appearance (Hartikainen et al., 2017).

In Switzerland, Willersinn et al. (2015) found that total potato losses are approximately 41%–46% of the initial processing mass, and half of these losses are due to quality standards. Fernandez-Zamudio et al. (2020) quantified losses of persimmon in Spain at the harvest and post-harvest stages as equal to 38.5% of the mass ultimately commercialised, or 29.5% of the entire volume produced; persimmons presenting purely aesthetic damage, and thus not meeting quality standards, are 4.57% of the harvested fruit on average. De Falco et al. (2022) studied the artichoke chain in Italy, where food loss was between 58.5% and 69% in the post-harvest phase.

The application of private quality standards has a huge impact on operators in the upstream stages of the supply chain: harvesting, processing, and distribution (Porter et al., 2018). In the fruit and vegetable supply chain, Producer Organisations (POs) play a crucial role in harvest and post-harvest operations. These are farmers' associations which oversee the harvesting and marketing of produce, achieving greater bargaining power than individual farmers (Herzberg et al., 2022). POs perceive private quality standards as a challenge, due to the strict requirements set by retailers (Pietrangeli et al., 2023).

This paper aims to contribute to this stream of research by providing a direct quantification of the carrots lost and downgraded due to private quality standards, in terms of mass and value, on the basis of field data retrieved at one large PO in Italy. The research questions behind this study can be defined as follows: (i) what proportion of carrots are downgraded due to private cosmetic quality standards, and how many are lost, out of the total mass processed at a PO? (ii) what are the economic implications of downgrading and loss of carrots, in terms of turnover for the PO and, in turn, for producers? (iii) what are the possible actions to reduce downgrading and sell more carrots on the fresh market?

2. Material and methods

2.1. Case study

This paper focuses on the postharvest phases of the carrot supply chain. Carrots fall within the EU common market organisation for fruit and vegetables, and producers are frequently associated in POs, which take care of post-harvest operations and market commercialisation, through retailers or industry. The field study was conducted at the warehouse of a PO located in central Italy. The total production of fruit and vegetables by this PO is 78 million kilos per year from 183 farms, and its annual gross turnover from all services provided by the PO is around 40 million euros. The main products of the PO are fennel, carrots, potatoes and salad vegetables, with a total cultivated area of over 32,000 ha. Italy is the 5th largest producer of carrots in the EU and the 15th in the world (Brandi et al., 2021), with a total production of 4,991,515 quintals per year (Istat, 2023). The case study PO is located in Abruzzo, the top Italian region in terms of quantity of carrots produced

(1,501,000 q per year).

2.2. Definitions

This study focuses on post-harvest operations in the carrot value chain. In this case study, carrots are sorted into three categories, based on their quality attributes (Johnson et al., 2018), and in line with the European definition of food waste (Directive EU – 2018/851) (Fig. 1).

- *Marketable as fresh*: carrots that are suitable for human consumption, with no visual or cosmetic defects, diameter between 20 and 40 mm (imposed by buyers as part of private quality standards). These carrots are sold to retailers to be marketed as fresh.
- *Downgraded – Edible but not marketable as fresh (DØtot)*: carrots that are safe and nutritious, not under- or over-ripe but not saleable on the fresh market because they do not meet the private quality standards relating to size, shape and colour; these carrots are re-processed and sold for industry.
 - *DminØ*: carrots with a smaller diameter than the minimum accepted by buyers (<20 mm);
 - *DmaxØ*: carrots with a larger diameter than the maximum accepted by buyers (>40 mm);
 - *DØ*: carrots with a diameter between 20 and 40 mm, discarded due to cosmetic issues.
- *Unfit*: carrots discarded after harvest because they are unfit for human consumption; these are further sorted into two categories:
 - *Primary loss*: carrots that are damaged, diseased, decayed, under- or over-ripe and are discarded upon arrival at the PO warehouse.
 - *Secondary loss*: inedible parts of carrots that are cut and discarded during the re-processing of downgraded carrots destined for industry.

These parameters are specific to the PO in this case study, as they are the result of negotiation between buyers and suppliers.

This study also attempts to evaluate the economic implications of carrot downgrading and loss. The definitions used for this purpose are.

- *Potential turnover (€/kg)*: turnover that could be gained if no private cosmetic quality standards were applied and all edible carrots were sold on the fresh market. Here, it is assumed that the additional carrots are sold at the same sales price.
- *Current turnover (€/kg)*: turnover currently gained with the application of private cosmetic quality standards.

2.3. Methodology of assessment

For the purposes of this study, a field assessment was conducted at the warehouse of the PO, to measure the streams of carrots, in terms of mass and economic value, at every stage of post-harvest operations, from the moment the harvested carrots enter the warehouse until they are sold to the fresh market or industry.

The unit of measurement used for direct quantification is the kilogram, while the unit of reference to assess the stream of carrots during processing in the PO warehouse is the plastic bulk bin that is used to process carrots. Each bin is measured, and on average their capacity is 350–400 kg. Therefore, each bin processed corresponds to one observation in the final dataset.

The method of data collection is based on several points of assessment, where streams of carrots are measured, as shown in Fig. 2. For each stream, the quantity of carrots in terms of mass (kg) and, if possible, value (sales price in €) is assessed.

During harvesting, the carrots are collected in bins (still with soil and stones). No selective harvesting occurs on the field. The carrot bins are taken into the PO warehouse and placed in cold storage. Upon receipt of an order from a retailer, the carrot processing process starts. Each bin to be processed is weighed (still dirty) and unloaded onto a platform which



Fig. 1. Classification of carrots in the three different categories: marketable as fresh (I), downgraded – edible but not marketable (II) and unfit (III).

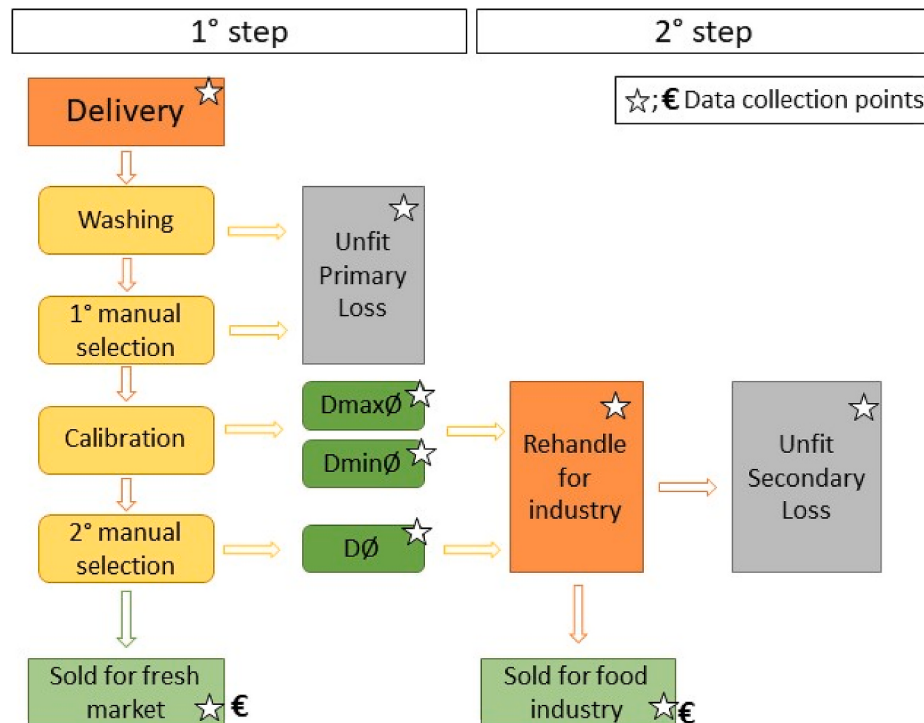


Fig. 2. Carrot processing operations in the PO warehouse. Each arrow represents the flow of the process to the next step. Each star represents a data collection point, at which the quantity (kg) is assessed for each bin processed. For quantities sold for the fresh market and the food industry, the economic value is also recorded (€).

transfers the carrots to the washing machine. Here, an initial stream leaves the process, consisting of unfit carrots (diseased or rotten), soil and stones. Unfit carrots (primary loss) and soil and stones are weighed separately. After this, the carrots go through a process of manual selection, to detect any unfit ones. The carrots then pass through the calibration machine, where they are sorted by size: carrots with a diameter between 20 and 40 mm continue in the process, while out-of-size carrots are downgraded because they are too small ($D_{min}\emptyset$ in Fig. 2) or too large ($D_{max}\emptyset$ in Fig. 2). The in-size carrots are manually re-sorted to remove any carrots with cosmetic imperfections that do not meet the private cosmetic standards imposed by buyers (mainly large retail companies); these carrots with cosmetic flaws are downgraded, meaning that they are not considered suitable to be sold as fresh products ($D\emptyset$ in Fig. 2). Carrots that are in-size and free from cosmetic imperfections are sold for the fresh market. They can be sold in bulk bags (average weight approximately 1100 kg), trays (1 kg, 500 g, 600 g or 750 g) or boxes (10 kg); they are packed and loaded onto trucks at the PO warehouse, to be delivered to retailers.

Downgraded carrots are re-processed, either on the same day or in the following days, to be sold to the food industry; this requires a process during which imperfections, black spots and splits are removed. Also in

this case, the carrots are loaded onto trucks at the PO warehouse and delivered to the food industry. Meanwhile, unfit carrots are disposed of as organic waste or used for animal feed.

As a result of the data collection, for each bin assessed the quantities measured are: weight on delivery, unfit carrots (primary loss), downgraded carrots divided into $D_{min}\emptyset$, $D_{max}\emptyset$, and $D\emptyset$, carrots sold for the fresh market, carrots re-processed for industry, carrots discarded during re-processing because unfit for human consumption (secondary loss), and carrots sold to the food industry. These secondary losses are also disposed of or used for animal feed.

The field data collection covers 18 days during the months of July, August and September 2023. The total mass of carrots sampled is 279,757 kg, which represents around 1% of the PO's total production in one season.

To weigh the bins, scales with a sensitivity of 1 kg are used; weight is measured with the help of forklifts. Meanwhile, manual scales with a sensitivity of 1 g are used for boxes; for trays, a built-in scale in the packaging machine is used. All weights recorded during the study are net of tare.

For each bin sampled at the beginning of the process, all the data at the data collection points are detected and recorded in a database built

on Excel. The accuracy of the data collection is checked on a daily basis by cleaning and monitoring the dataset, also using historical data from the production years 2020, 2021 and 2022 as a benchmark.

Due to the different timing of post-harvest carrot operations at the PO warehouse, the data collection process is divided into two stages, reflected in Fig. 1.

1. Collection of data on carrots processed, from their arrival at the PO warehouse to their sale on the fresh market or downgrading;
2. Collection of data on carrots re-processed for industry, from the re-processing of downgraded carrots to their sale to industry.

The sales prices of the product are also recorded in order to support economic evaluation. Data on sales are acquired from PO records from 1st of January to 31st of August 2023. The names of the buyers are anonymised by means of a code, to prevent any sharing of market-sensitive information. However, sales to different buyers are recorded separately because the PO negotiates the price of products individually with each, and significant differences in price are possible even within the same day for a given product. In the dataset, every individual sale that occurred within the period is recorded, along with the quantity and sales price. Sales are categorised by type of buyer, to distinguish between retailers (fresh market) and industry (re-processed carrots); they are also divided by the type of carrots sold (conventional or organic) and type of packaging.

2.4. Elaborations

In total, 182 bins of carrots were sampled during the study period, corresponding to a total mass of 279,757 kg of carrots, approximately 1% of the PO's overall yearly production. Two different datasets are elaborated, reflecting the two separate stages of the carrot process in the PO. Dataset 1 focuses on the first step of data collection, from harvest to the sale of carrots for the fresh market, including the side stream of

downgraded carrots; Dataset 2 focuses on the second stage of the process, from downgrading to the re-processing of carrots, until they are sold to the food industry. A Dataset 3 is also elaborated, with the sales records acquired from the PO, including the product code, name, quantity, price, value, and the anonymised customer identification number.

The datasets are composed of 136, 36 and 724 observations respectively. Table 1 describes the variables used for the elaborations.

As an initial part of the elaborations, a Sankey diagram is created to represent the streams of carrots during post-harvest operations at the PO warehouse, referring to step 1 of the data collection.

Secondly, a descriptive analysis of Dataset 1, Dataset 2 and Dataset 3 is performed. In Dataset 3, price variation during the season is analysed.

The third section concerns the analysis of the economic implications of downgrading. To this end, Dataset 1, Dataset 2 and Dataset 3 are analysed collectively.

Lastly, scenarios are modelled with various levels of acceptance of private cosmetic quality standards, with the aim of analysing the potential effect of greater acceptance of defects in carrots, in terms of the mass of carrots delivered to the fresh market or lost, and the consequent economic implications. Four different scenarios are modelled.

- Scenario 1 (S1): the mass of carrots downgraded due to excess size (DmaxØ) is decreased by 10%, reflecting a greater acceptance of carrots that are currently considered too large to be sold on the fresh market
- Scenario 2 (S2): the mass of carrots downgraded due to small size (DminØ) is decreased by 10%, reflecting a greater acceptance of carrots currently considered too small to be sold on the fresh market
- Scenario 3 (S3): the mass of in-size carrots downgraded due to cosmetic defects (DØ) is decreased by 10%, reflecting a greater acceptance of cosmetic defects in carrots to be sold on the fresh market

Table 1

Variables used in the elaborations of the article. FM = fresh market.

Numerical variables						
Variable	Description	Unit	Min	Max	Mean	Std. Dev.
Tot_kg_processed	Total quantity of carrots harvested	Kg	250.00	13470.00	1939.38	2839.96
Tot_kg_FM	Total quantity of carrots sold to FM	Kg	89.00	6475.00	1023.70	1166.94
DØtot	Total carrots downgraded	Kg	50.00	5594.00	671.88	1118.33
DØ	Carrots downgraded for cosmetic reasons	Kg	0.00	928.00	223.63	147.98
DminØ	Carrots downgraded due to small diameter	Kg	3.00	3651.00	171.13	490.33
DmaxØ	Carrots downgraded due to large diameter	Kg	0.00	3521.00	277.13	696.74
Unfit_primary loss	Carrots unfit for human consumption	Kg	10.00	3955.00	243.80	620.75
Loss	Primary loss carrots discarded	Kg	10.00	3014.00	230.50	568.75
Animal	Primary loss carrots used for animal feed	Kg	0.00	941.00	13.29	90.34
Industry_kg	Total carrots re-processed for industry	Kg	80.00	4087.00	1074.27	1073.69
Industry_worked_kg	Total carrots sold to industry after re-processing	Kg	52.00	3328.00	910.20	902.59
Industry_secondary_loss	Secondary loss from industry re-processing	Kg	10.00	863.00	164.07	191.37
Tot_kg_FM (%)	Total quantity of carrots sold to FM	%	22.53%	91.11%	59.87%	13.47%
DØtot (%)	Total carrots downgraded	%	7.85%	62.58%	32.31%	11.43%
DØ (%)	Carrots downgraded for cosmetic reasons	%	0.00%	48.14%	19.09%	11.35%
DminØ (%)	Carrots downgraded due to small diameter	%	0.43%	29.99%	4.54%	4.68%
DmaxØ (%)	Carrots downgraded due to large diameter	%	0.00%	29.49%	8.68%	6.09%
unfit_primary loss (%)	Carrots unfit for human consumption	%	1.05%	32.07%	7.82%	4.55%
Loss (%)	Primary loss carrots discarded	%	0.87%	24.44%	7.54%	4.32%
Animal (%)	Primary loss carrots used for animal feed	%	0.00%	7.63%	0.28%	0.95%
industry_worked_kg (%)	Total carrots sold to industry after re-processing	%	0.09%	0.97%	0.83%	0.09%
loss_industry (%)	Secondary loss from industry re-processing	%	0.52%	0.48%	0.17%	0.09%
€_conventional_carrots	Sale price of conventional carrots sold to FM	€/kg	0.25€/kg	1.20€/kg	0.72 €/kg	0.18€/kg
€_organic_carrots	Sale price of organic carrots sold to FM	€/kg	0.33€/kg	1.50€/kg	0.85 €/kg	0.20€/kg
€_industry	Sale price of carrots sold to industry	€/kg	0.27€/kg	0.85€/kg	0.49 €/kg	0.11€/kg
Category and dummy variables						
Variable	Description	Type	Category	Category description	Observations	%
Organic_c	Conventional carrots	Dummy	0	No	30	16.50%
	Organic carrots		1	Yes	152	83.50%

- Scenario 4 (S4): the mass of carrots downgraded is decreased by 5% for each of the three defects considered ($D_{\max\emptyset}$; $D_{\min\emptyset}$; $D\emptyset$), reflecting a greater acceptance of suboptimal carrots on the fresh market.

The economic value of the resulting mass of carrots accepted for the fresh market is calculated by using the specific median price, considering variations across the season, for conventional and organic carrots sold to the fresh market, and for carrots re-processed for the food industry separately. The results are compared with the status quo.

3. Results

3.1. Descriptive analyses of the quantity of carrots processed

A total of 279,757 kg of carrots is sampled. Subtracting tare (soil and stones), the mass of carrots starting the process in the PO warehouse is 263,755 kg. Of these, in the first stage, 52.78 % are sold for the fresh market (139,223 kg), 34.64% (91,376 kg) are downgraded ($D\emptyset_{\text{tot}}$), and 12.57% are primary loss (33,156 kg). Analysing the reasons for downgrading, out-of-size carrots account for 66.72% (60,963 kg of the total downgraded), of which 25.47% (corresponding to 8.82% of total carrots processed) are smaller than the minimum required diameter ($D_{\min\emptyset}$) and 41.25% (14.29% of total carrots processed) are larger than the required diameter ($D_{\max\emptyset}$). 33.28% (30,413 kg) of downgraded carrots (corresponding to 11.53% of total carrots processed) fail to meet the private cosmetic quality standards required for sale on the fresh market, even if they are the correct size, and are therefore downgraded (Fig. 3).

Fig. 4 analyses the distribution of downgrading across the observations of Dataset 1. The variables present a normal distribution. Average downgrading amounts to 32.31% and is composed of values that are generally higher than the average. Analysing the three variables that lead to downgrading ($D_{\max\emptyset}$, $D_{\min\emptyset}$ and $D\emptyset$): $D\emptyset$ has an average of 19.09%, higher than the out-of-size carrots, with a normal distribution; $D_{\max\emptyset}$, with an average of 8.68%, has many values lower than the average; $D_{\min\emptyset}$, with an average of 4.54%, presents the opposite situation. The proportion of unfit carrots (primary loss) has an average of 7.82%, and the distribution shows a shift towards lower values than the average.

The second stage focuses on the re-processing of downgraded carrots,

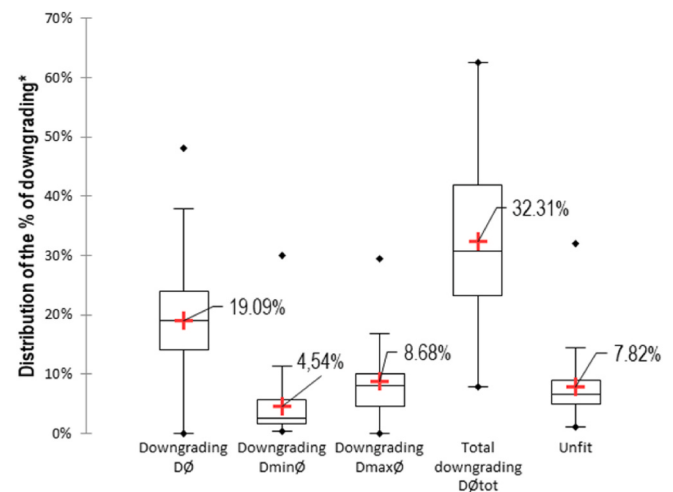


Fig. 4. Boxplot showing the distribution of downgraded and unfit carrots in the first stage of the PO process, calculated on the basis of the quantity processed in the same observation in the row. Values are expressed as percentages (%). On the Y axis, the distribution of the percentage of downgrading (calculated as mass of downgraded carrots as a proportion of the total mass of carrots processed) across observations ($N = 136$); on the X axis, the variable analysed: $D_{\max\emptyset}$, $D_{\min\emptyset}$, $D\emptyset$, $D\emptyset_{\text{tot}}$ and unfit carrots, representing primary loss.

which are sold to industry. For this elaboration, Dataset 2 is used. The quantity re-processed does not correspond to the quantity downgraded recorded in Dataset 1 because the re-processing may occur on different days. The sample to which Dataset 2 refers has a total mass of 75,199 kg of downgraded carrots. Of these, 84.73% (63,714 kg) is sold to industry, while the remainder, 15.27% (11,485 kg), is discarded as a secondary loss.

3.2. Descriptive analysis of the sales price of carrots

Carrot sales prices are analysed for carrots sold both to the fresh market and to the food industry (Fig. 5). The sales price of carrots sold to the fresh market varies with the week and the various buyers, depending on ongoing negotiations between the PO and retailers. Different

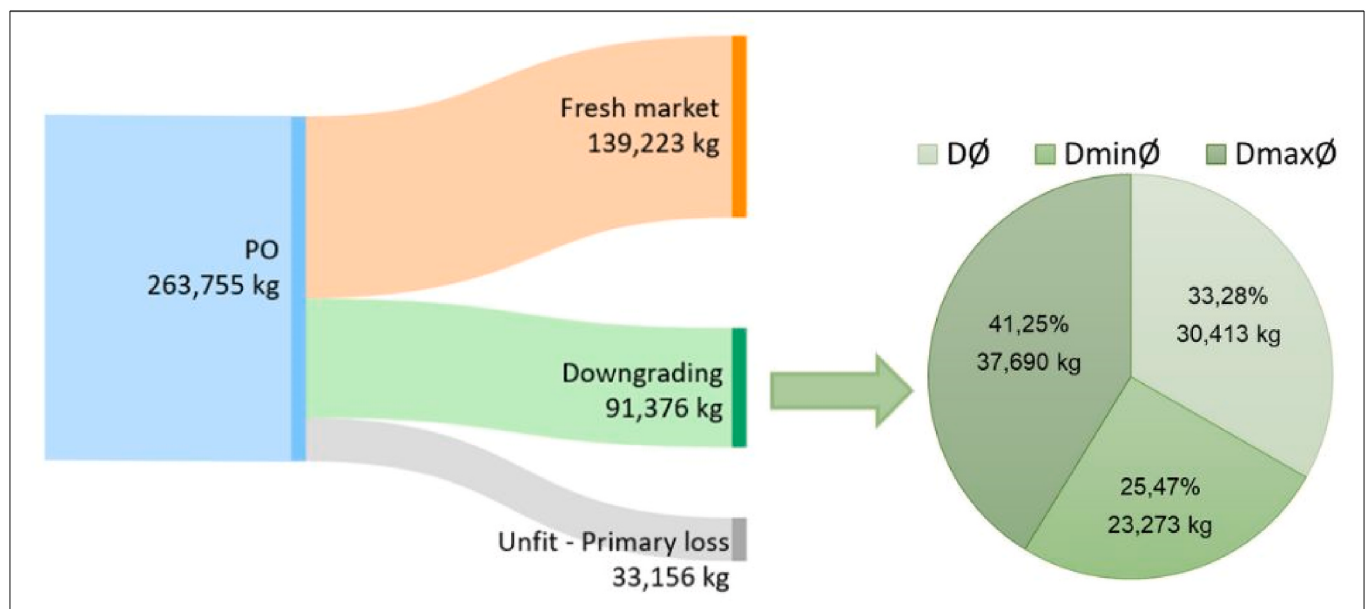


Fig. 3. Sankey diagram showing the first stage of the carrot processing in the PO, from harvesting to the selection of carrots in the warehouse for sale on the fresh market, downgraded and unfit as primary loss.

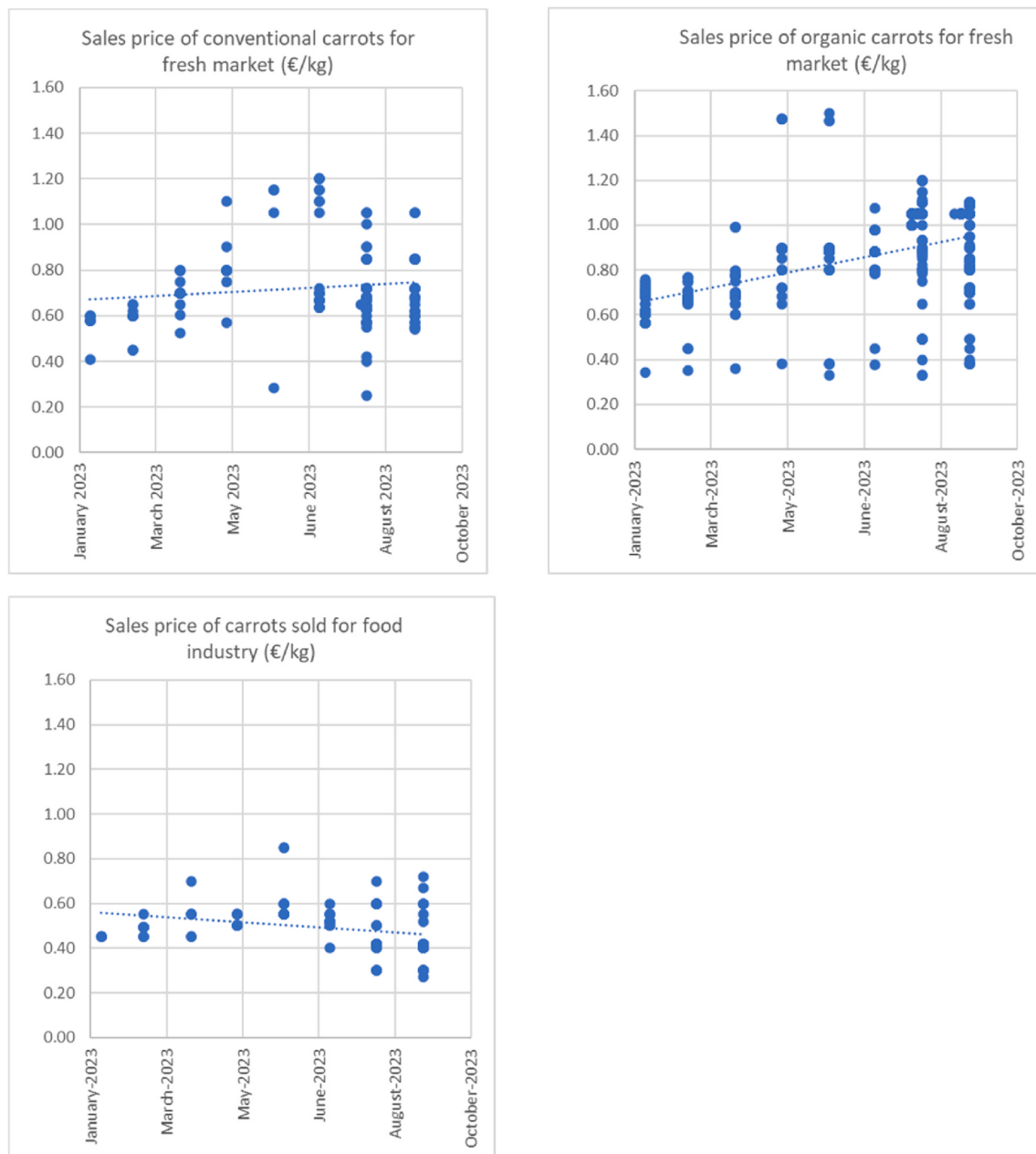


Fig. 5. Scatter plot of sales prices divided by market channel destinations (fresh market or industry). For the fresh market, the sales price is divided into conventional and organic carrots. The X axis shows the months of 2023; the Y axis shows sales prices (expressed in €/kg).

negotiations, and therefore different prices, are reported for conventional and organic carrots, with an average sales price from January 2023 to August 2023 of 0.72 €/kg and 0.85 €/kg respectively, and a median price of 0.68 €/kg and 0.86 €/kg.

Regarding the sales price for industry, this is systematically lower than the fresh market price; it also shows less fluctuation, remaining more stable throughout the season. Here, conventional and organic carrots are sold at the same price, but the sales price may vary between buyers (various food industry companies). The average sales price from January to August 2023 is 0.49 €/kg, while the median price is 0.50 €/kg.

Table 2 focuses on the variation in sales price during the months of the field data collection. In particular, between June and August 2023 the sales price for conventional carrots averages 0.72 €/kg, with a lower standard deviation (0.18 €/kg) and a median of 0.68 €/kg. The price of organic carrots is higher; the average sales price is 0.85 €/kg, with a

standard deviation of 0.20 €/kg and a median of 1.00 €/kg, showing a higher fluctuation at the higher end.

The industry sales price is more stable over the season, with small fluctuations compared to the price on the fresh market: the average is 0.49 €/kg, with a standard deviation of 0.11 €/kg and a median of 0.42 €/kg during the months of the data collection.

3.3. Economic implications

The economic implications of the application of private cosmetic quality standards by retailers are analysed on the basis of Dataset 1, as shown in Fig. 6, comparing the current turnover (turnover currently gained with the application of such quality standards) with the potential turnover. Potential turnover is calculated by considering the mass of carrots that could potentially be sold on the fresh market if no private cosmetic quality standards were applied, and represents the turnover

Table 2

Sales price of carrots during the months of the data collection, divided by destination (fresh market or industry) and type of carrots (conventional or organic). All prices are in €/kg. FM = fresh market.

	Mean	Median	Stan dev	Min	Max
	€/kg	€/kg	€/kg.	€/kg	€/kg
Sales price for conventional carrots sold to FM	0.72	0.68	0.18	0.25	1.20
June 2023	0.87	0.70	0.24	0.64	1.20
July 2023	0.68	0.67	0.15	0.25	1.05
August 2023	0.72	0.72	0.14	0.54	1.05
Sales price for organic carrots sold to FM	0.85	1.00	0.20	0.33	1.50
June 2023	0.86	0.88	0.13	0.38	1.08
July 2023	0.94	1.00	0.18	0.33	1.20
August 2023	0.91	1.00	0.18	0.38	1.10
Sales price for carrots sold to food industry	0.49	0.42	0.11	0.27	0.85
June 2023	0.52	0.52	0.04	0.40	0.60
July 2023	0.45	0.42	0.10	0.30	0.70
August 2023	0.44	0.42	0.12	0.27	0.72

that could be achieved if no such standards were applied. Starting with the total carrots processed (263,755 kg), the primary loss (12.57%) is discarded as unfit for human consumption. Potential turnover is calculated as the gross revenue from carrots sold to the fresh market, plus the gross revenue that could come from downgraded carrots, if they were also sold to the fresh market. The median sales price recorded during the season is used for this purpose. The potential turnover, corresponding to 87.43% of carrots processed (currently sold to the fresh market, plus downgrading), amounts to 193,873.08 €. However, due to private cosmetic quality standards, only 52.78% of total carrots processed is sold to the fresh market, corresponding to a turnover of 118,599.32 €, 61.17% of potential turnover. The remaining carrots are downgraded and re-processed for the food industry. In this process, a secondary loss

equivalent to 15.27% of the re-processed mass occurs, therefore 84.73% of the total mass of re-processed carrots is sold to the food industry. Considering the median price at which carrots are sold for industry, this process generates an additional turnover of 32,517.43 €. In the current situation, total turnover is 151.116,75 € for 263,755 kg of carrots processed.

The economic loss linked to the application of private cosmetic quality standards amounts to 42,756.33 € (22.05% of potential turnover), and is due to (i) the secondary loss that occurs during the re-processing of carrots, and (ii) the difference between the sales prices for the fresh market and industry. This economic loss is directly dependant on the private cosmetic quality standards imposed by buyers, and does not take into account the additional cost that the PO must bear to re-process downgraded carrots and prepare them for sale to industry.

In this calculation, we assume that the sales price remains the same for all carrots sold on the fresh market.

For a more in-depth study of the impact of private cosmetic quality standards, the mass of carrots sold to the fresh market and the associated economic loss are calculated for the four scenarios outlined in the methodology, and compared with the status quo scenario described above. All calculations are made on the basis of a total mass of carrots of 263,755 kg.

3.3.1. Scenario 1 (S1)

Scenario 1 (S1) reflects a greater acceptance of carrots that are currently considered too large to be sold on the fresh market, with a decrease of 10% of DmaxØ. In this situation, the turnover increases to 152,657,80 €, 1.02% higher than current turnover. At the same time, economic losses decrease by 3.60%. In terms of the mass of carrots, secondary losses (in kg) decrease by 4.12%.

3.3.2. Scenario 2 (S2)

Scenario 2 (S2) reflects a greater acceptance of carrots that are currently considered too small to be sold on the fresh market, with a

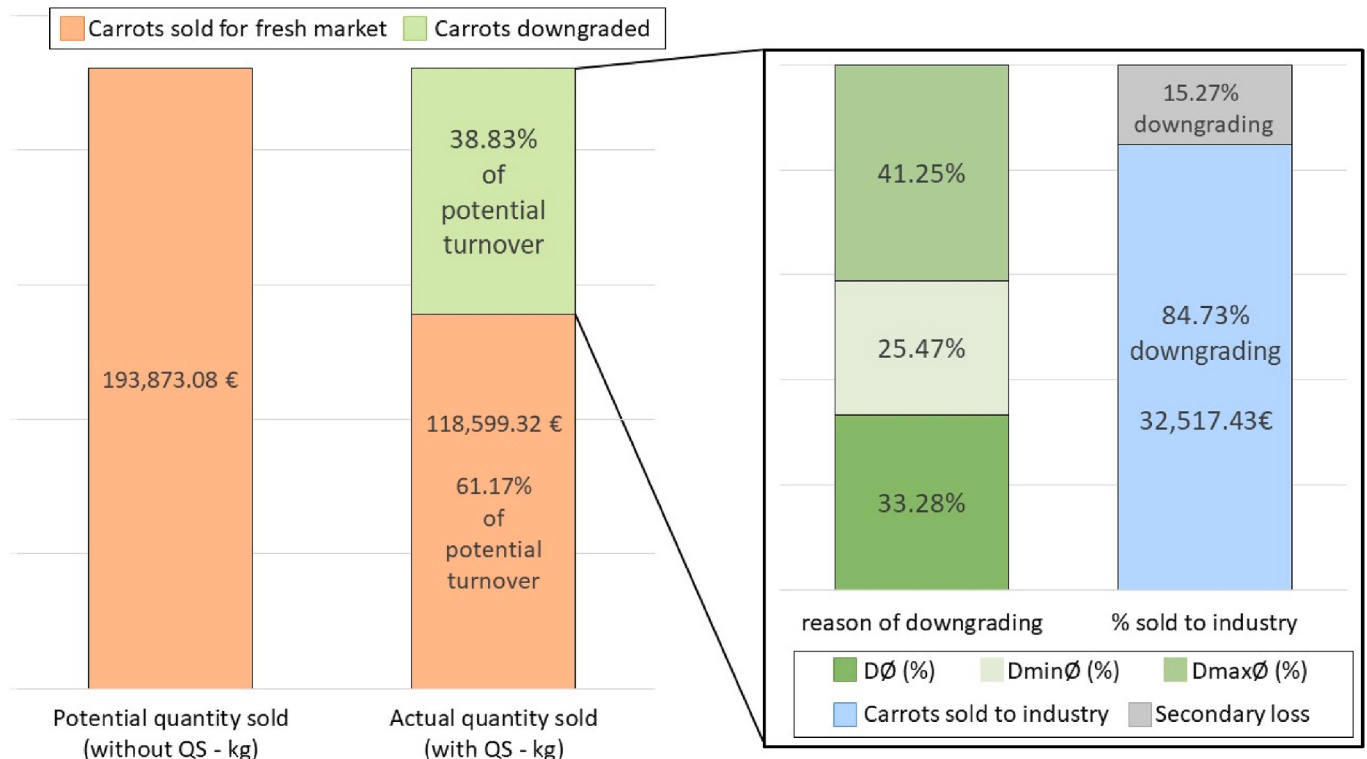


Fig. 6. Economic implications of private cosmetic quality standards on turnover. Potential turnover is compared to the current figure, where private cosmetic quality standards are applied.

decrease of 10% of DminØ. Also in this scenario, the quantity of carrots sold for the fresh market increases (+1.67%), and economic losses decrease (−2.04%); however, even if the quantity sold is higher, the turnover does not grow as much as in S1 (+0.58%) since smaller carrots weigh less and carrots are sold by the kilo. Secondary losses decrease by 2.55%.

3.3.3. Scenario 3 (S3)

Scenario 3 (S3) hypothesises a greater acceptance of carrots that are currently downgraded due to cosmetic defects (DØ), with a decrease of 10% of DØ. As a result, total turnover increases by 1.23% compared to the current situation, and the turnover from the fresh market increases by 2.48%. Secondary losses decrease by 3.33% in terms of mass, while economic losses decrease by 4.35%.

3.3.4. Scenario 4 (S4)

In Scenario 4 (S4), a 5% decrease in downgrading is modelled for all three reasons (DminØ; DmaxØ; DØ). In this scenario, turnover increases by 1.41%, while economic losses and secondary losses (kg) decrease by 5%.

Table 3 compares the four scenarios with the current situation. In the table, S1 corresponds to a 10% decrease in DmaxØ-downgraded carrots, increasing the quantity sold for the fresh market; S2 to a 10% decrease in DminØ-downgraded carrots and an increased quantity to be sold for the fresh market; S3 to a 10% decrease in DØ-downgraded carrots and increased quantity to be sold for the fresh market; and S4 is a 5% decrease in downgrading and the corresponding increase in the quantity sold for the fresh market. In each scenario, the first column shows data calculated, while the second column shows the difference compared to the current situation, expressed as a percentage (%). The highest overall turnover is shown in S4, with an increase of 1.41% compared with current turnover. It also shows the lowest losses in terms of mass following the hypothesised greater acceptance of all types of defects on the fresh market.

However, when a greater acceptance is hypothesised for only one defect (S1, S2 and S3), Scenario S2 shows the least change in terms of mass and value. In S3, the turnover is higher by 1.23% compared to the status quo, while in S1 (DmaxØ) turnover increases by 1.02%.

4. - Discussion

This study provides a direct assessment of the impact of private cosmetic quality standards imposed by retailers in the fruit and vegetable value chain. It measures the quantity of downgrading and loss in the carrot value chain at the post-harvest phase. There is an ongoing

discussion on whether cosmetic quality standards affect the extent of food losses in the fruit and vegetable sector, as suggested by initial evidence provided for other products (Fernandez-Zamudio et al., 2020; Opara et al., 2021; Commons, 2017; McKenzie et al., 2017; Tansuchat et al., 2023; Willersinn et al., 2015; Hartikainen et al., 2017). In this case, we measured and weighed the streams of carrots at a PO warehouse, where the carrots are processed after harvesting, prepared, and sold to buyers.

One key fact is that 12.6% of carrots processed at the PO are discarded because they are deemed unsuitable for human consumption. This result is in line with the losses of up to 9% recorded by Schneider et al. (2019) for potatoes, although in that case the primary losses were measured in the field, while in this study the selection of carrots only occurs at the PO warehouse. Fig. 4 suggests that the data is relatively stable across the 136 observations collected, even though the 2023 season was fairly challenging in the study area due to weather conditions. Such primary losses can hardly be prevented, but they can be used as inputs for other processes (Papargyropoulou et al., 2014), for example the production of animal feed and biogas (de Oliveira et al., 2021).

Focusing on the role of private cosmetic quality standards, 34.64% of the carrots processed are not considered suitable for the fresh market because they fail to meet the standards, and are therefore downgraded. This figure is in line with available data in the literature for carrots (FAO, 2021), potatoes, onions, and apples (Porter et al., 2018); while it seems lower when compared with tomatoes (McKenzie et al., 2017). More specifically, our results fall within the range of carrot loss estimated by FAO (2021), which suggested that between 25% and 30% of carrots are lost before retailing due to physical or cosmetic defects. However, FAO data are obtained through indirect measurement (Stuart, 2009).

The main reasons for downgrading are size (25.47% too small and 41.25% too large, in terms of mass) and cosmetic issues (33.28% of mass). In all these cases, carrots are perfectly edible from a food safety perspective; they merely lack the “right appearance” to be accepted at retail. The downgraded carrots are not lost, but re-processed within the PO, prepared for further industrial processing and sold to industry at a lower price. The food industry is an important marketing channel for POs operating in the fruit and vegetable sector; it is considered more stable than the fresh market in terms of price and demand, albeit less remunerative (Pietrangeli et al., 2023). However, during the re-processing of carrots, a secondary loss occurs, larger than expected in terms of quantity. Following the food hierarchy procedure (Papargyropoulou et al., 2014), this secondary loss is mostly used for animal feed or disposed of as waste. Another possible destination is biogas production, although this was not the case in our study because

Table 3

Comparison of the four scenarios compared with the current situation; FM = fresh market.

Total carrots processed and ready to be sold - without primary loss (kg)	263,755								
Potential quantity sold for FM (kg)	230,599								
Potential turnover (€)	193,873.08 €								
	Current situation	S1		S2		S3		S4	
Total turnover (€)	151,116.75 €	152,657.80	1.02%	151,989.99	0.58%	152,978.10	1.23%	153,254.57	1.41%
		€		€		€		€	
Qty sold to FM (kg)	139,223	142,992	2.71%	141,550	1.67%	142,264	2.18%	143,792	3.28%
Turnover from FM(€)	118,599.32 €	121,481.61	2.43%	120,300.76	1.43%	121,542.96	2.48%	122,363.01	3.17%
		€		€		€		€	
Qty carrots downgraded (kg)	91,376	87,607	−4.12%	89,048	−2.55%	88,334	−3.33%	86,807	−5.00%
Qty carrots re-processed and sold to industry (kg)	77,422	74,229	−4.12%	75,451	−2.55%	74,846	−3.33%	73,551	−5.00%
Turnover from industry (€)	32,517.43 €	31,176.19 €	−4.12%	31,435.14 €	−2.55%	31,435.14 €	−3.33%	30,891.56 €	−5.00%
Turnover loss compared with potential turnover (€)	42,756.33 €	41,215.28 €	−3.60%	41,883.09 €	−2.04%	40,894.98 €	−4.35%	40,618.51 €	−5.00%
Quantity of secondary loss (kg)	13,953	13,378	−4.12%	13,598	−2.55%	13,489	−3.33%	13,255	−5.00%

no facilities are available in the area.

The economic result of this situation is that the PO systematically loses part of its turnover because a significant portion of its production is diverted from the fresh market and reallocated to industry. The loss of turnover calculated in this study, for the sampled mass of carrots (around 1% of the PO's total yearly production), is 42,756.33 €, equal to 22.05% of the corresponding potential turnover. This value is higher than expected, which can probably be explained considering that 15.27% of the downgraded carrots are lost during re-processing (5.29% of the initial mass); this means not only that the downgraded carrots are sold to industry at a lower price, but also that the quantity available to be marketed for industry is lower due to losses during re-processing. As a consequence, the actual economic loss may even be higher, since products must be processed twice, with a corresponding increase in cost and effort.

However, commercial criteria vary from crop to crop and between individual buyers: everything is at the discretion of the buyer, and this results in significant variation. Depending on the buyer's preferences, it might reject a product that another buyer would accept. These criteria increase the difficulty for POs, as well as affecting logistics and production costs. This issue should be addressed through political bodies or trade regulations, such as those of the World Trade Organization.

Some studies argue that alternative marketing channels can be found for downgraded products and, more generally, products with minor defects. Some authors suggest that "ugly" carrots can be mixed with "beautiful carrots" in bunches to be sold on the fresh market (Qi et al., 2022), but many other alternative marketing channels are being developed. Online channels aiming to sell suboptimal products are growing (de Hooge et al., 2018), for example "*Belli dentro*" (<https://www.belladentro.org/>) in Italy. Another example is the reprocessing of 'misshapen' carrots into 'baby' carrots (Porter et al., 2018; Peterson et al., 2008). It was not the case in this particular study, but sometimes misshapen or out-of-size products are left in the field and not harvested; when this happens, creative marketing/processing/distribution of such produce could reduce avoidable on-farm loss, potentially increasing income and food availability (Delgado et al., 2021; Fernandez-Zamudio et al., 2020; Baker et al., 2019), for example through gleaning (Johnson et al., 2019; Kowalczyk et al., 2020).

But is it true that consumers would not accept misshapen and wrong-sized products if they were sold as fresh at retailers? Today's literature provides evidence that consumers might be willing to accept suboptimal products, especially if they are sold at a reduced price (de Hooge et al., 2017, 2018; Aschemann-Witzel et al., 2017; Hartmann et al., 2021; Tait et al., 2024; Tsalis et al., 2024).

Our results suggest that greater flexibility in private cosmetic quality standards could significantly reduce the loss of product and revenue at the PO/farm level. In this regard, the priority suggested by our analysis of scenarios is to increase the acceptability of wrong-sized carrots. Accepting 10% more oversized carrots could result in an increase of 1.02% in total turnover for producers, while accepting 10% more small carrots could result in an improvement of 0.58% in total turnover. Obviously, these are only theoretical scenarios, but they provide concrete evidence of the impact that a higher rate of acceptance of such products can make. Besides size, another important aspect to consider is the acceptance of carrots with small cosmetic defects. Accepting 10% more carrots that are in size, but are downgraded for cosmetic reasons, could result in an increase of 1.23% in total turnover. When greater acceptance is hypothesised on all the defects considered (S4), turnover increases by 1.41%. All these scenarios seem reasonable in the light of numerous studies suggesting that consumers are willing to buy products with minor defects, possibly sold at a lower price (Aschemann-Witzel et al., 2017; de Hooge et al., 2017).

In this study, we assume that the selling price at which buyers purchase carrots from the PO does not change when an additional volume of "lower quality" carrots is marketed. This can be considered realistic for

our specific case study, whose focus is on one PO which may be able to negotiate a good price for the additional carrots sold on the fresh market, despite their small defects in size, shape and appearance. However, if we extend our scenarios to other producers, it is possible that that price of carrots on the fresh market may decrease in response to the additional quantity delivered. Of course, in this situation the gains of POs due to reduced private quality standards could also decrease. However, we can also hypothesise that if the selling price of carrots decreases, the demand for carrots increases. For example, Henneberry et al. (1999) estimates an own-price demand elasticity of -1.653 for carrots with respect to their price, suggesting that a 10% decrease in the price of carrots would lead to a 16.53% increase in demand. Substitution effects between carrots and other vegetables may also occur (Henneberry et al., 1999), with potential impact on their markets. Another aspect that merits discussion is that, if private quality standards were made more flexible for all producers, the overall quality of carrots on the market would decrease, possibly affecting the willingness of consumers to pay for purchasing this product. Previous studies on this topic suggest that such a decline in the willingness to pay may not be linear. Qi et al. (2022) report that consumers' willingness to pay for carrots decreases even if only one carrot in a bunch is suboptimal; however, up to 40% of suboptimal carrots in a bunch, this willingness to pay does not decline further. In this situation, adding a promotional message linking the purchase of suboptimal produce with the reduction of food waste can partially offset the decreased willingness to buy these products, especially if combined with messages pointing out the authenticity and naturalness of "ugly" carrots (Qi et al., 2022).

Consumer acceptance of minor cosmetic defects could be further increased by raising the level of food literacy (Palumbo et al., 2019) obtained through exposure to food and its uses over time, which has been lost in developed countries, where consumers are increasingly far away from the supply chain and its operation (Porter et al., 2018).

In this study, 83.54% of the sampled carrots are organic. This product is mostly preferred by customers with a greater awareness of sustainability; these consumers are expected to be more environmentally responsible and more flexible regarding products with less stringent aesthetic requirements.

In any case, the extent to which increased consumer willingness to buy suboptimal products can push retailers to be more flexible in their acceptance of products that fall below current private cosmetic quality standards is not clear. In a study investigating retailers' cosmetic specifications, Herzberg et al. (2022) found that these companies do not perceive themselves as responsible for the food losses that arise earlier in the supply chain due to the quality standards they demand. However, such requirements are likely to become stricter when the product is abundant, while more flexibility is common in years of short supply (Herzberg et al., 2022).

Some retailers may also be hesitant to accept suboptimal products because they are afraid of the effects on the image of other products sold in the same store or with other competitors (Aschemann-Witzel et al., 2020). It appears clear that these actors have greater bargaining power and a more powerful position on the market than POs (Herzberg et al., 2022; Pietrangeli et al., 2023); therefore the focus of research and policy should remain the producer-retailer interface and the push for greater acceptance of products with minor defects on the fresh market. The results of this study suggest that even a small change can make a significant impact on the economic results of farmers and POs.

The sales price for the fresh market is negotiated differently for conventional and organic carrots, and agreed on a weekly basis. In this study we could only partially break down the results into conventional and organic carrots, but the downgrading of organic carrots can be considered to have an even higher impact than that of conventional ones: their production cost is higher, and their organic attributes are not considered when selling to industry. The economic loss of downgrading organic carrots is therefore likely to be higher. Future research may investigate further on this; in organic production, the restricted use of

fertilisers and pesticides may increase the frequency of cosmetic defects (Oosterkamp et al., 2019) possibly leading to a higher rate of downgrading for these products.

Lastly, increasing the acceptance of additional carrots sold on the fresh market could increase turnover for both POs and farmers, and at the same time reduce costs during the post-harvest phase.

This study has several limitations. The data collection was conducted during a single productive season; studying more seasons would certainly provide a more accurate assessment, especially with greater seasonal variation linked to climate change. However, field data collection is extremely demanding in terms of time and resources, so the value of the data collected remains high. Furthermore, the assessment refers to carrots, and it does not follow that other vegetables or fruit will show the same results.

5. Conclusions

Evidence on the quantity and composition of food loss at the producer-retailer interface is rather scarce in comparison with the bulk of literature available on food waste in the subsequent stages of the supply chain. In this study, we argue that private quality standards imposed by buyers generate a significant stream of suboptimal products, which producers must reallocate in other markets, with considerable economic loss and the additional burden of their further processing. By analysing a range of scenarios, we suggest that a small effort to increase acceptance of products with defects can result in a substantial increase of turnover for the PO.

For these changes to be feasible, one key point is to persuade consumers to buy imperfect products, perhaps at lower prices, which seems reasonable considering previous studies in the literature surrounding these issues. Another key point is to encourage buyers – especially retailers – to accept imperfect products as a “normal” part of the bulk of vegetables sourced from farmers. Currently, farmers and POs are the only actors bearing the cost of product imperfection, although the definition of such imperfection comes from other actors in the supply chain. Closer collaboration between producers and retailers to find appropriate and remunerative channels for imperfect products should be envisaged, especially targeting consumers who are willing to buy these products. Such collaboration would rebalance bargaining power in the supply chain and, at the same time, contribute to making supply chains more sustainable and fairer.

CRediT authorship contribution statement

R. Pietrangeli: Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **C. Cicatiello:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of Competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The data that has been used is confidential.

References

- Aschemann-Witzel, J., De Hooge, I., Amani, P., Bech-Larsen, T., Oostindjer, M., 2015. Consumer-related food waste: causes and potential for action. *Sustainability* 7 (6), 6457–6477. <https://doi.org/10.3390/su7066457>.
- Aschemann-Witzel, J., Jensen, J.H., Jensen, M.H., Kulikovskaja, V., 2017. Consumer behaviour towards price-reduced suboptimal foods in the supermarket and the relation to food waste in households. *Appetite* 116, 246–258. <https://doi.org/10.1016/j.appet.2017.05.013>.
- Aschemann-Witzel, J., Giménez, A., Ares, G., 2020. Suboptimal food, careless store? Consumer's associations with stores selling foods with imperfections to counter food waste in the context of an emerging retail market. *J. Clean. Prod.* 262, 121252. <https://doi.org/10.1016/j.jclepro.2020.121252>.
- Baker, G.A., Gray, L.C., Harwood, M.J., Osland, T.J., Tooley, J.B.C., 2019. On-farm food loss in northern and central California: results of field survey measurements. *Resour. Conserv. Recycl.* 149, 541–549. <https://doi.org/10.1016/j.resconrec.2019.03.022>.
- Brandi, 2021. Corriere ortofrutticolo. <https://fonteverde.com/wp-content/uploads/2021/03/CORRIERE-ORTOFRUTTICOLO-02-2021.pdf>. (Accessed 4 December 2023).
- Caldeira, C., De Laurentiis, V., Corrado, S., van Holsteijn, F., Sala, S., 2019. Quantification of food waste per product group along the food supply chain in the European Union: a mass flow analysis. *Resour. Conserv. Recycl.* 149, 479–488. <https://doi.org/10.1016/j.resconrec.2019.06.011>.
- Commons, H.O., 2017. Food waste in england. technical report, house of commons: Environment, food and rural affairs committee. Eighth Report of Session 2016–17. HC 429. Published on 30 April 2017 by authority of the House of Commons. <https://publications.parliament.uk/pa/cm201617/cmselect/cmenvfru/429/429.pdf>. (Accessed 10 November 2023).
- Corrado, S., Sala, S., 2018. Food waste accounting along global and European food supply chains: state of the art and outlook. *Waste Manag.* 79, 120–131. <https://doi.org/10.1016/j.wasman.2018.07.032>.
- Corrado, S., Caldeira, C., Eriksson, M., Hanssen, O.J., Hauser, H.E., van Holsteijn, F., Liu, G., Östergren, K., Parry, A., Secondi, L., et al., 2019. Food waste accounting methodologies: challenges, opportunities, and further advancements. *Global Food Secur.* 20, 93–100. <https://doi.org/10.1016/j.gfs.2019.01.002>.
- De Falco, E., Senatore, A., Roscigno, G., Pergola, M., 2022. The Artichoke “Bianco di Pertosa”: The Enhancement of Crop Residues through Environmentally Friendly Uses. *Horticulturae* 8 (10), 900. <https://doi.org/10.3390/horticulturae8100900>.
- de Hooge, I.E., Oostindjer, M., Aschemann-Witzel, J., Normann, A., Loose, S.M., Almlí, V. L., 2017. This apple is too ugly for me! Consumer preferences for suboptimal food products in the supermarket and at home. *Food Qual. Prefer.* 56, 80–92. <https://doi.org/10.1016/j.foodqual.2016.09.012>.
- de Hooge, I.E., van Dulm, E., van Trijp, H.C., 2018. Cosmetic specifications in the food waste issue: supply chain considerations and practices concerning suboptimal food products. *J. Clean. Prod.* 183, 698–709. <https://doi.org/10.1016/j.jclepro.2018.02.132>.
- de Oliveira, M.M., Lago, A., Dal'Magro, G.P., 2021. Food loss and waste in the context of the circular economy: a systematic review. *J. Clean. Prod.* 294, 126284. <https://doi.org/10.1016/j.jclepro.2021.126284>.
- Delgado, L., Schuster, M., Torero, M., 2021. Quantity and quality food losses across the value Chain: a Comparative analysis. *Food Pol.* 98, 101958. <https://doi.org/10.1016/j.foodpol.2020.101958>.
- FAO, 2019. Moving forward on food loss and waste reduction. In: *The State of Food and Agriculture. Food and Agriculture Organization of the United Nations, Rome, Italy*.
- FAO, 2021. Beauty (And Taste!) Are on the inside. Food and Agriculture Organization. <http://www.fao.org/fao-stories/article/en/c/1100391/>. (Accessed 14 November 2023).
- Fernandez-Zamudio, M.A., Barco, H., Schneider, F., 2020. Direct measurement of mass and economic harvest and post-harvest losses in Spanish persimmon primary production. *Agriculture* 10 (12), 581. <https://doi.org/10.3390/agriculture10120581>.
- Gunders, D., 2012. Wasted: how America is losing up to 40 percent of its food from farm to fork to landfill. NRDC Issue paper. <https://www.nrdc.org/sites/default/files/was-ted-food-IP.pdf>. (Accessed 15 November 2023).
- Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R., Meybeck, A., 2011. *Global Food Losses and Food Waste*.
- Hartikainen, H., Svanes, E., Franke, U., Mogensen, L., 2017. *Food Losses and Waste in Primary Production: Case Studies on Carrots, Onions, Peas, Cereals and Farmed Fish. Nordic Council of Ministers*.
- Hartmann, T., Jahnke, B., Hamm, U., 2021. Making ugly food beautiful: consumer barriers to purchase and marketing options for Suboptimal Food at retail level—a systematic review. *Food Qual. Prefer.* 90, 104179. <https://doi.org/10.1016/j.foodqual.2021.104179>.
- Henneberry, S.R., Piewthongngam, K., Qiang, H., 1999. Consumer food safety concerns and fresh produce consumption. *J. Agric. Resour. Econ.* 98–113.
- Herzberg, R., Schmidt, T., Keck, M., 2022. Market power and food loss at the producer-retailer interface of fruit and vegetable supply chains in Germany. *Sustain. Sci.* 17 (6), 2253–2267. <https://doi.org/10.1007/s11625-021-01083-x>.
- Hezarkhani, B., Demirel, G., Bouchery, Y., Dora, M., 2023. Can “ugly veg” supply chains reduce food loss? *Eur. J. Oper. Res.* 309 (1), 117–132. <https://doi.org/10.1016/j.ejor.2023.01.033>.

- Ishangulyev, R., Kim, S., Lee, S.H., 2019. Understanding food loss and waste—why are we losing and wasting food? *Foods* 8 (8), 297. <https://doi.org/10.3390/foods8080297>.
- Istat. http://dati.istat.it/Index.aspx?DataSetCode=DCSP_COLTIVAZIONI, 2023–. (Accessed 24 November 2023).
- Johnson, L.K., Bloom, J.D., Dunning, R.D., Gunter, C.C., Boyette, M.D., Creamer, N.G., 2019. Farmer harvest decisions and vegetable loss in primary production. *Agricul. Syst.* 176, 102672.
- Johnson, L.K., Dunning, R.D., Bloom, J.D., Gunter, C.C., Boyette, M.D., Creamer, N.G., 2018. Estimating on-farm food loss at the field level: a methodology and applied case study on a North Carolina farm. *Resour. Conserv. Recycl.* 137, 243–250. <https://doi.org/10.1016/j.resconrec.2018.05.017>.
- Kowalczyk, C.M., Taillon, B.J., Hearn, L., 2020. Gleaning: turning food waste at farms into marketable products. *Food waste management: Solving the wicked problem* 347–366. https://doi.org/10.1007/978-3-030-20561-4_13.
- McKenzie, T.J., Singh-Peterson, L., Underhill, S.J., 2017. Quantifying postharvest loss and the implication of market-based decisions: a case study of two commercial domestic tomato supply chains in Queensland, Australia. *Horticulturae* 3 (3), 44. <https://doi.org/10.3390/horticulturae3030044>.
- Oosterkamp, E., van der Sluis, A., van Geffen, L., Aramyan, L., Bos-Brouwers, H., 2019. Cosmetic Aspects in Specific Marketing Standards for Fruit and Vegetables: Removing Cosmetic Aspects from the EU Marketing Standards: Implications for the Market and Impact on Food Waste. Wageningen Economic Research. <https://doi.org/10.18174/503631> (Memorandum/Wageningen Economic Research; No. 2019-014).
- Opara, I.K., Fawole, O.A., Opara, U.L., 2021. Postharvest losses of pomegranate fruit at the packhouse and implications for sustainability indicators. *Sustainability* 13 (9), 5187. <https://doi.org/10.3390/su13095187>.
- Palumbo, R., Adinolfi, P., Annarumma, C., Catinello, G., Tonelli, M., Troiano, E., et al., 2019. Unravelling the food literacy puzzle: evidence from Italy. *Food Pol.* 83, 104–115. <https://doi.org/10.1016/j.foodpol.2018.12.004>.
- Papargyropoulou, E., Lozano, R., Steinberger, J.K., Wright, N., bin Ujang, Z., 2014. The food waste hierarchy as a framework for the management of food surplus and food waste. *J. Clean. Prod.* 76, 106–115. <https://doi.org/10.1016/j.jclepro.2014.04.020>.
- Peterson, T., 2008. Bringing up baby (carrots). *Gastronomica* 8, 55e59. <https://doi.org/10.1525/gfc.2008.8.4.55>.
- Pietrangeli, R., Herzberg, R., Cicatiello, C., Schneider, F., 2023. Quality standards and contractual terms affecting food losses: the perspective of producer organisations in Germany and Italy. *Foods* 12 (10), 1984. <https://doi.org/10.3390/foods12101984>.
- Porat, R., Lichter, A., Terry, L.A., Harker, R., Buzby, J., 2018. Postharvest losses of fruit and vegetables during retail and in consumers' homes: quantifications, causes, and means of prevention. *Postharvest Biol. Technol.* 139, 135–149. <https://doi.org/10.1016/j.postharvbio.2017.11.019>.
- Porter, S.D., Reay, D.S., Bomberg, E., Higgins, P., 2018. Avoidable food losses and associated production-phase greenhouse gas emissions arising from application of cosmetic standards to fresh fruit and vegetables in Europe and the UK. *J. Clean. Prod.* 201, 869–878. <https://doi.org/10.1016/j.jclepro.2018.08.079>.
- Qi, D., Penn, J., Li, R., Roe, B.E., 2022. Winning ugly: profit maximizing marketing strategies for ugly foods. *J. Retailing Consum. Serv.* 64, 102834. <https://doi.org/10.1016/j.jretconser.2021.102834>.
- Schneider, F., Part, F., Göbel, C., Langen, N., Gerhards, C., Kraus, G.F., Ritter, G., 2019. A methodological approach for the on-site quantification of food losses in primary production: Austrian and German case studies using the example of potato harvest. *Waste Manag.* 86, 106–113. <https://doi.org/10.1016/j.wasman.2019.01.020>.
- Stuart, T., 2009. *Waste – Uncovering the Global Food Scandal*. Penguin Books, London. ISBN: 978-0-141-03634-2.
- Suresh Kumar, M., Mohan, S., 2023. Selective fruit harvesting: research, trends and developments towards fruit detection and localization—A review. *Proc. IME C J. Mech. Eng. Sci.* 237 (6), 1405–1444.
- Tait, P., Saunders, C., Dalziel, P., Rutherford, P., Driver, T., Guenther, M., 2024. How much less? Estimating price discounts for suboptimal food with environmental and social credence attributes. *Appl. Econ.* 56 (13), 1581–1594.
- Tansuchat, R., Pankasemsuk, T., Panmanee, C., Rattanasamakarn, T., Palason, K., 2023. Analyzing food loss in the fresh longan supply chain: evidence from field survey measurements. *Agriculture* 13 (10), 1951. <https://doi.org/10.3390/agriculture13101951>.
- Tsalis, G., Jensen, B.B., Aschemann-Witzel, J., 2024. The relationship between retail price promotions and household-level food waste: busting the myth with behavioural data? *Waste Manag.* 173, 29–39.
- Willersinn, C., Mack, G., Mouron, P., Keiser, A., Siegrist, M., 2015. Quantity and quality of food losses along the Swiss potato supply chain: stepwise investigation and the influence of quality standards on losses. *Waste Manag.* 46, 120–132. <https://doi.org/10.1016/j.wasman.2015.08.033>.

PAPER III

Article

Exploring the Quality of Commercial Relations Between Producers and Buyers in the Fruit and Vegetable Supply Chain

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Abstract: The different bargaining power of actors is a long-standing problem in the fruit and vegetable supply chain, where buyers (e.g., retailers, industry, and wholesalers) have more power than agricultural producers and are, therefore, able to engage in commercial practices that may be perceived as unfavorable or even unfair by the weaker part. This study explores how producers perceive the quality of commercial relations. The methods include a focus group discussion with sales managers of producer organizations and a survey of agricultural producers in Italy. We measure their willingness to change buyer and their stated overall satisfaction with the commercial relation by analyzing ninety-eight commercial relations and five dimensions of quality in the relationship. We identify four clusters of relationships characterized by different quality levels. The satisfaction and willingness to change buyers significantly differ across the clusters; economically favorable commercial relations are associated with a low willingness to change buyers, even when the producer is not satisfied with the overall quality of the relationship. The highest levels of satisfaction and the lower willingness to change buyers are reached for commercial relations that are not only economically favorable but also include positive relational aspects such as trust and mutual commitment.

Keywords: commercial relations; quality of relations; retailers; agricultural producers; supply chain; cluster analysis



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1. Introduction

In the fruit and vegetable supply chain, large buyers, intended as retailers, processing industries, and wholesale markets, have an increasing share of bargaining power [1,2], which might generate issues related to the governance and coordination of the chain [3]. In this context, establishing high-quality commercial relations becomes crucial for producers to counterbalance the growing power of buyers [4–6]. The quality of commercial relations between producers and buyers has been extensively analyzed from a theoretical perspective, but only a few empirical studies have explored how the involved parties perceive these relationships.

In this paper, we explore how fruit and vegetable producers perceive the commercial relations they have with buyers, considering their position as the “weaker party” in these transactions. The objective of this paper is (I) to understand the economic and relational factors shaping the commercial relation between producers and buyers in the Italian fruit and vegetable supply chain and (II) to examine how these factors are related to the quality of commercial relations, as perceived by agricultural producers.

2. Literature Background on Quality of Commercial Relations

The fruit and vegetable value chain is characterized by farmers selling fresh, perishable products to buyers who centralize demand, and it shows a crucial dependence on the distribution sector [7], which owns a superior position in negotiations, allowing for control of contractual terms and conditions, such as trading practices, standards and specifications of the product. To minimize economic costs and risks arising from commercial transactions, retailers often shift the related costs upstream in the supply chain actors, placing the burden on weaker players, such as individual farmers [8–11]. Large buyers exert significant pressure on suppliers through modifications and stricter requirements regarding quality and the underpricing of products because of their oligopolistic control [8,12], as product pricing is a key factor for retailers [13].

The different bargaining power of the actors might generate inefficiencies in the fruit and vegetable supply chain, such as inefficient allocation of economic risk and distortion of incentives [14,15]. In this context, unfair trading practices (UTPs) are experienced by a majority of producers (especially farmers) [16]. UTPs are usually described as practices that deviate from good commercial conduct, imposed by a trading partner over a weaker one, and that are in opposition to fair trade and trustworthiness [17]. UTPs include pressure tactics, where suppliers are forced to accept unfavorable terms of contract, unilateral changes by retailers and food processors, payment delays or price undercutting, as well as lack of information sharing and punitive commercial practices over suppliers that refuse to comply with unfair contract conditions [16]. In 2019, the European Union adopted a specific directive to limit UTPs, Directive (EU) 2019/633, which has also been implemented in Italy (D.L. 198/2021). Nevertheless, several UTPs still occur, and their impact is still unclear [18].

To counterbalance the growing power of buyers, farmers are forming collaborations [19], and the European legal framework [16–19] is supporting the creation of producer organizations (POs). POs enhance their position and bargaining power of farmers by concentrating the supply of agricultural commodities, negotiating contracts collectively, supporting farmers’ production, and reducing the number of brokers in the supply chain [14]. POs take care of negotiating prices and agreeing on contracts with retailers, quality and production standards, logistics, delivery schedules, payment terms, promotions, risk-sharing, and other details [17,20–22]. Joining POs seems to provide benefits to farmers in terms of achieving higher profitability and added value for their products [23] with respect to negotiating with buyers alone. Additionally, cooperation among farmers within POs strengthens horizontal integration to increase bargaining power [24]. Collective initiatives, such as POs, may offer perceived benefits in terms of price and quality setting, but there is no theoretical expectation that exerting countervailing power will necessarily reduce UTPs, as all contract terms are negotiated at once [18].

The quality of commercial relations is defined as the degree to which parties are engaged in active, long-term relations characterized by trust, social satisfaction, non-coercive power, and reputation [4–6]. There is evidence that the quality of a commercial relationship exerts an influence on the overall performance and sustainability of the supply chain [4,25,26]. However, the way this influence applies and its extent have seldom been

investigated in the agri-food supply chain [6,27], where establishing close relations between producers and buyers is more complex [28].

In any interaction between actors in the supply chain, there is a diversity of situations ranging from a transaction-based to a relationship-based approach, corresponding to different levels of quality of the commercial relation [29]. The transactional approach is characterized by discrete, short-term exchanges, where the most important elements are availability, timeliness, and price. Here, neither minimal personal relations nor future interactions beyond the immediate transaction are expected, and there is no relation with the commodities offered. On the other hand, the key features of a relational approach are long-term relations built on trust, commitment, and mutual benefit; both parties cooperate, share information, and work together to reach common goals over time. The relational approach generates long-term value and competitive advantage [5,6,29], building satisfaction, trust, and commitment among the actors involved. The intention to cooperate—such as improved access to information and the ability to evaluate performance—positively influences satisfaction, continuity, and the capacity to adapt the relation to changing external circumstances [5,6,27]. Trust and commitment are highlighted as fundamental elements in successful business relations [28]. Trust refers to the belief in the integrity and reliability of the commercial partner, while commitment represents the desire to maintain this valued relationship [30,31]. These factors are critical for the quality of the relationship between suppliers and buyers [4,31–33]. For example, Gajdić et al., 2021 [6] found that trust has an impact on the overall performance of perception of quality of commercial relations, according to their duration. The quality of commercial relations may also be linked to the fairness of the practices existing between the parties, as low-quality commercial relations are more likely to result in the application of UTPs by the stronger actor of the supply chain over the weaker one [16] and, in turn, producers' perception of unfair practices is likely to reduce their satisfaction for the commercial relation.

3. Materials and Methods

A mixed method is used here to investigate the factors influencing commercial relations in the Italian fruit and vegetable supply chain and their quality from the producer's perspective:

- A qualitative analysis using focus groups, which aims to identify the factors that shape the producer-buyer commercial relation from the point of view of the POs;
- A quantitative analysis, where a survey is developed and administered to producers, with the aim to disclose the influence of these factors on the quality of the commercial relations they establish with buyers.

3.1. Focus Group

The first part of the methodology is included in a wider study on the analysis of UTP (Directive EU 2019/633) in the fruit and vegetables supply chain in Italy. The general objective of the project PRIN AGREF (project code 2022FARZPJ, funded by the Italian Ministry of University and Research) is to investigate commercial practices perceived as unfair by suppliers in the fruit and vegetable supply chain in Italy and attempting an estimation of the impact of such practices on farmers and POs. A focus group is organized in February 2024, involving 24 representatives—in most cases, the sales managers—of Italian POs operating in the fruit and vegetable sector, divided into two parallel sessions: an online session in which 22 POs joined and an in-presence session, in which 2 POs joined. Such POs are located in different areas of Italy, and they are of different sizes in terms of turnover and number of employees, as described in Table 1.

Table 1. Description of the POs involved in this study.

Num	Region (Noth, Centre, Sud)	Range of Turnover (€ per Year)	Last Available Data on Total Activity (€)	Number of Employees	Presence/Online
1	North	<10 mln €	2023	7	O
2	Centre	<10 mln €	2022	15	P
3	South	10–20 mln €	2022	93	O
4	South	<10 mln €	2022	23	O
5	South	<10 mln €	2022	106	O
6	South	>20 mln €	2022	158	O
7	Centre	10–20 mln €	2022	2	P
8	South	10–20 mln €	2022	154	O
9	South	<10 mln €	2021	57	O
10	Centre	10–20 mln €	2022	212	P
11	Centre	<10 mln €	2023	11	O
12	South	10–20 mln €	2022	28	O
13	South	10–20 mln €	2021	4	O
14	South	10–20 mln €	2021	71	O
15	South	<10 mln €	2022	3	O
16	South	10–20 mln €	2022	8	O
17	Centre	<10 mln €	2022	140	O
18	North	<10 mln €	2021	3	O
19	South	>20 mln €	2022	73	O
20	South	>20 mln €	2021	95	O
21	North	>20 mln €	2023	101	O
22	South	10–20 mln €	2022	91	O
23	South	<10 mln €	2022	1	O
24	South	10–20 mln €	2022	105	O

The two focus groups are conducted following the same guidelines to contribute to the objectivity and trustworthiness of this study [34]. The structure of each focus group includes different topics of discussion, with a focus on negotiation, pricing, commercial practices perceived as unfair, and the overall quality of commercial relations that POs establish with buyers. The duration of the focus group discussion is approximately 120 min. The discussion is facilitated by a researcher who invites participants to use sticky notes to point out specific issues. Both focus group sessions are recorded and transcribed. We apply a structured content analysis for qualitative data following Kuckartz [35], using deductive and inductive coding in Excel. The deductive coding is performed by identifying four categories that represent the main issues in a commercial relationship, based on the theories and the literature: (i) Relation in the value chain, (ii) Contracts and negotiations, (iii) Flexibility and scheduling, and (iv) External factors. Then, during inductive coding, each sentence is allocated to one of the codes, considering the affinity of the sentence's topic with the codes. Each sentence is allocated to only one code.

Among all the sentences transcribed from the focus group, this study limits the analysis to those referring to factors that affect the quality of the commercial relation from the perception of the POs.

3.2. Survey

As a second step of the methodology, a survey is administered to farmers and POs, aimed at assessing the perceived quality of the commercial relations they have with buyers and rating a set of factors that may influence such relations. The survey is constructed following the framework developed by Schulze [28], integrated with the results emerging from the focus groups.

The survey is structured in three parts: (I) an introduction section with general questions about the respondent; (II) a second section where respondents are asked to rate a set of factors related to commitment, price satisfaction, flexibility, trust, and cooperation; (III) a final section where respondents rate the overall satisfaction for the commercial relation.

Respondents are asked to rate all the items with reference to the commercial relation they have with the first and the second most important buyers; therefore, every response generates two sets of answers. Section II includes the 14 items (F1–F14) that belong to the following dimensions and are listed in Tables 2 and 3:

- D1 “Long-term commitment”, which refers to the willingness of actors to exert effort on behalf of the relations, where they perceive to benefit mutually [5,31,36], and includes F1, F2, F3;
- D2 “Price satisfaction”, intended to assess the extent to which the economic outcome is important for the evaluation of the relations [28]; this dimension includes an evaluation of prices (in comparison with other buyers) [28] and margins, with F4 and F5;
- D3 “Adaptation on quality standards”, which assesses the flexibility of buyers and suppliers to mutually adapt to each other’s needs and capabilities regarding quality standards [5,37], expressed by F6, F7, F8;
- D4 “Relational quality and trust”, summarizing the degree of mutual trust, good personal relations, and transparency of communication between supplier and buyer [6], expressed by F10, F11, F12;
- D5 “Cooperation in case of issues”, referring to situations where actors work conjointly to achieve mutual goals [5,38], including F13 and F14.

Table 2. Descriptive statistics of numerical survey items (N = 98).

Cod	Dim.	Variable	Units	Mean	St. Dev.	Min	Max
F1	D1	This buyer gives me the certainty of being able to sell a large part of my production	Likert 1–7	4.48	1.81	1	7
F2	D1	This buyer gives me the certainty of having a medium–long-term sales channel	Likert 1–7	4.57	1.53	1	7
F3	D1	With this buyer, the contractual conditions are clear from the beginning of the season	Likert 1–7	4.1	1.84	1	7
F4	D2	This buyer offers me good prices for my products	Likert 1–7	4.16	1.45	1	7
F5	D2	This buyer gives me the possibility of making good margins on the products	Likert 1–7	4.1	1.55	1	7
F6	D3	The quality standards (aesthetic aspects, size, shape, color, etc.) required by this buyer are strict (compared with others)	Likert 1–7	4.81	1.67	1	7
F7	D3	The control of quality standards upon delivery is rather flexible	Likert 1–7	3.86	1.61	1	7
F8	D3	It often happens that the products we deliver to this buyer are rejected	Likert 1–7	3.48	1.68	1	7
F9	-	The buyer does not appropriately consider the uncertainty of the weather and seasonal conditions of the last period	Likert 1–7	4.39	1.91	1	7
F10	D4	There is no dialogue with this buyer	Likert 1–7	3.68	1.82	1	7
F11	D4	I have a good relationship with the person with whom I contract the sale of the products	Likert 1–7	4.72	1.61	1	7
F12	D4	This buyer considers us to be reliable	Likert 1–7	5.35	1.43	1	7
F13	D5	If we make a mistake, this buyer is available to help us out.	Likert 1–7	4.39	1.55	1	7
F14	D5	If they (the buyer) make a mistake, they are willing to fix it	Likert 1–7	4.28	1.68	1	7
F15		I would prefer to replace this buyer with another	Likert 1–7	3.19	1.66	1	7
F16		Overall, I am satisfied with the commercial relations with this buyer	Likert 1–7	4.76	1.61	1	7

Table 3. Descriptive statistics of categorical survey items (N = 98).

Variable	Type of Categories	Category	Description	Observations %
Is the farmer joining a PO or a cooperative	Dummy	0	No	42.55
		1	Yes	57.45
Localization in Italy	Categorical	1	North	26.60
		2	Centre	41.49
		3	South	31.91
		1	Retailers	24.47
Which is the commercial channel?	Categorical	2	Wholesalers	27.66
		3	Food processors	12.77
		4	Wholesale markets	14.89
		5	Other (specify	20.21
% of turnover with the buyer	Dummy	0	<40% of the total turnover	50.00
		1	>40% of the total turnover	50.00
How many years have you been working with this buyer? ¹	Categorical	1	less than 2 years	9.57
		2	Between 2 and 5	27.66
		3	Between Tra 5 and 10	12.77
		4	More than 10	50.00
F15—I would prefer to replace this buyer with another	Dummy	0	Lower than the median value	55.10
		1	Higher than the median value	44.89
F16—Overall, I am satisfied with the commercial relations with this buyer	Dummy	0	Lower than the median value	66.33
		1	Higher than the median value	33.67

¹ The original formulation of this item is “Please indicate the % of your total turnover depending on this buyer” and the respondents had to choose between the following answers: <20%; 20–40%; 40–60%; 60–80% and >80%. These categories were then grouped during the elaborations, as indicated in Table 2.

Section III includes two summary variables to measure the overall perceived quality of the commercial relations:

- F15: “In the next 2–3 years, I would prefer to replace this buyer with another”
- F16: “Overall, I am satisfied with the commercial relations with this buyer”

A 1–7 Likert scale is used for all items to rate respondents’ level of agreement with the statements (1—not at all; 7—at all).

The survey is developed in Qualtrics, and the time needed to complete it is approximately 10 min. All respondents are asked to approve an informed consent form before starting the survey; no personal data or data that could lead to identifying the farms and POs answering the survey is collected. Tables 2 and 3 report the list of items and the related descriptive statistics.

The survey is administered between April and October 2024 to POs, individual farmers, and agricultural technicians contacted through agricultural networks, agricultural associations, extension services, and professionals operating in the fruit and vegetable sector. The total number of responses is 99. After data cleaning, 42 responses are considered invalid as the respondent did not complete the questionnaire for even one of the two buyers requested. A total of 57 responses are retained, among which 16 provided the assessment of only one buyer, and 41 referred to two different buyers. The database is, therefore, composed of 98 observations, each one referring to the assessment of one buyer by one

respondent. These data are analyzed with the XLStat 2024.3 statistical software, which operates in a Microsoft Excel environment.

Descriptive statistics are performed for these variables to summarize the intention to change buyers and the level of satisfaction. Additionally, the correlation matrix is used to evaluate the quality of commercial relations between items F15 and F16 and the variables related to the type of buyer, % of turnover, and long-term relations (expressed in years).

The individual variables for which higher rates in the Likert scale correspond to a lower quality of the commercial relation have been rotated, and then a total rating is obtained for each dimension by summing up the ratings of the individual items. The resulting 5 variables (D1, D2, D3, D4, and D5) express the rating of each dimension; they are standardized and used to feed a k-means cluster analysis to classify different types of commercial relations. Four clusters are obtained.

A Kruskal–Wallis nonparametric test is used to examine whether the overall perceived quality of commercial relations differs across the clusters of commercial relations. The choice of this test is due to the non-normality of the dependent variables F15 and F16, tested with the Shapiro–Wilk test and resulting in $\alpha < 0.05$. In the Kruskal–Wallis test, F15 and F16 are used as dependent variables, with the aim of analyzing any significant difference in the perceived quality of commercial relations among the clusters.

As a last step, multiple correspondence analysis is developed to detect correspondence between high-low levels of perceived quality of the commercial relation and belonging to a specific cluster, also considering the importance of commercial relations in terms of turnover.

4. Results

4.1. Results of the Focus Group

Figure 1 shows the factors that may influence the perceived quality of the commercial relations between producers and buyers as they emerged from the focus groups. We coded a total of 75 sentences, which are grouped into four categories: external factors, flexibility and scheduling, contracts and negotiations, and relations in the value chain.

A total of 70.67% of the sentences are related to retailers, 6.67% concern general marketing and food processors, and 5.33% relate to wholesalers, while 10.67% are not directly linked to any specific buyer.

From the focus group, it emerged that POs perceive the practices related to negotiations and bargaining power as factors that can negatively affect the quality of the commercial relations they have with buyers. One of the main features is that “*retailers disconnect from the reality of production*”, which means that they do not take into consideration the seasons and the fluctuations that are typical of agricultural production, and therefore, they do not demonstrate the necessary flexibility. Instead, they follow a plan of prices, promotions, and quantity of orders that sometimes do not fit with the seasonal trend of fruits and vegetables. In this sense, a sentence that is repeated many times is: “*sometimes retailers do not give us [POs] the possibility to explain reasons. . .*”. In addition, with reference to contracts and negotiations, we find that “*retailers are more punctilious when the market goes down, they become overly attentive on quality standards. . .*”; for example, at times of the season that is potentially positive for POs (in terms of availability of product, higher prices etc.), the retailers tend to react with tighter control of quality standards, promotions, prices and timing of the deliveries, thus increasing the frequency of rejection of products, controversies, with additional costs for producers.

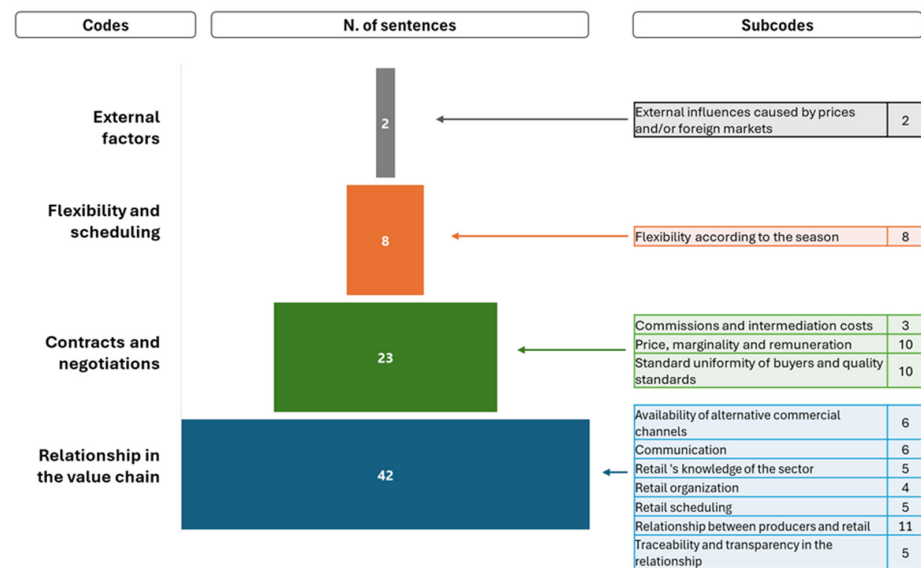


Figure 1. Factors related to the perception of the commercial relations emerging from the focus groups (N = 75).

Building on these results, we investigate the overall quality of the commercial relationship between producers and buyers and the factors that may exert an influence on it by analyzing the results of the survey.

4.2. Results of the Survey

The survey responses are mostly from individual farmers, accounting for 80.85%, while 9.57% come from POs. Among farmers, 57.45% are members of a PO or cooperative. These data are evenly distributed across different regions of Italy, with 26.60% of responses from the North, 41.49% from the Centre, and 31.91% from the South. The observations refer to various types of buyers, primarily retailers and wholesalers, which account for 24.47% and 27.66% of the responses, respectively. Most responses relate to long-term commercial relations, with 50% having been established for more than 10 years.

In terms of the quality of the overall commercial relation, the average satisfaction score is 4.76 on a 1–7 Likert scale, while the average willingness to replace the buyer with another channel is 3.19 (Table 2). Figures 2 and 3 illustrate the distribution of responses for these two variables, which are both non-symmetric. While F15 shows that the frequencies of the answers are concentrated on the left side, F16 shows an opposite distribution, with answers showing a higher frequency of satisfaction in commercial relations.

The distributions of 14 items related to factors that may influence the perceived quality of the commercial relation (F1 to F14) are almost all unimodal and approximatively symmetric, with the central values of the scale having more observations. Median values are 4 or 5 (on a 1–7 Likert scale) for all items, except for F8 (rejection of products; median = 3) and F12 (concerning the perceived reliability of the supplier; median = 6).



Figure 2. Distribution of answers concerning the overall assessment of the commercial relations quality by respondents, in terms of willingness to replace buyer (F15) and overall satisfaction for the commercial relation (F16).

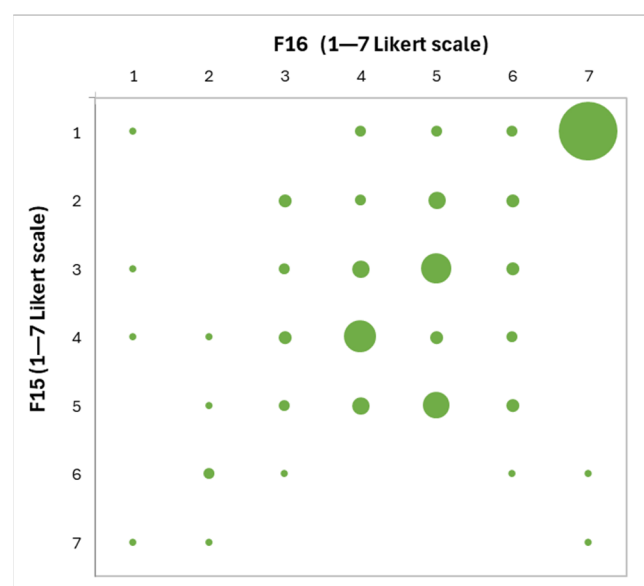


Figure 3. Bubble diagram of F15 and F16 showing the cross-distribution of answers; the size of the bubble is proportional to the number of observations.

Figure 4 shows the correlation matrix between the dimensions of quality of commercial relations, broken down by type of buyer. There is a recurrent correlation between *D1—Long-term commitment* and *D2—Price satisfaction* (top-left side of the matrixes) for all buyers except wholesale markets, suggesting that this channel may be activated on a short-term basis. Another common pattern (bottom-right side of the matrixes) is the correlation between *D4—Relation quality and trust* and *D5—Cooperation in case of issues*, which is observed for all buyers except retailers. We also observe that *D3—Adaptation on quality standards* is not correlated with other dimensions when the buyer is a food processor; this is probably linked to the fact that this channel typically accepts products that are rejected by other channels with stricter standards. In addition, for wholesale markets, a negative correlation (blue color) is observed between *D3* and *D1—Long-term commitment*, showing that the shorter the timeframe of the commercial relation, the more flexible the standards for the products.

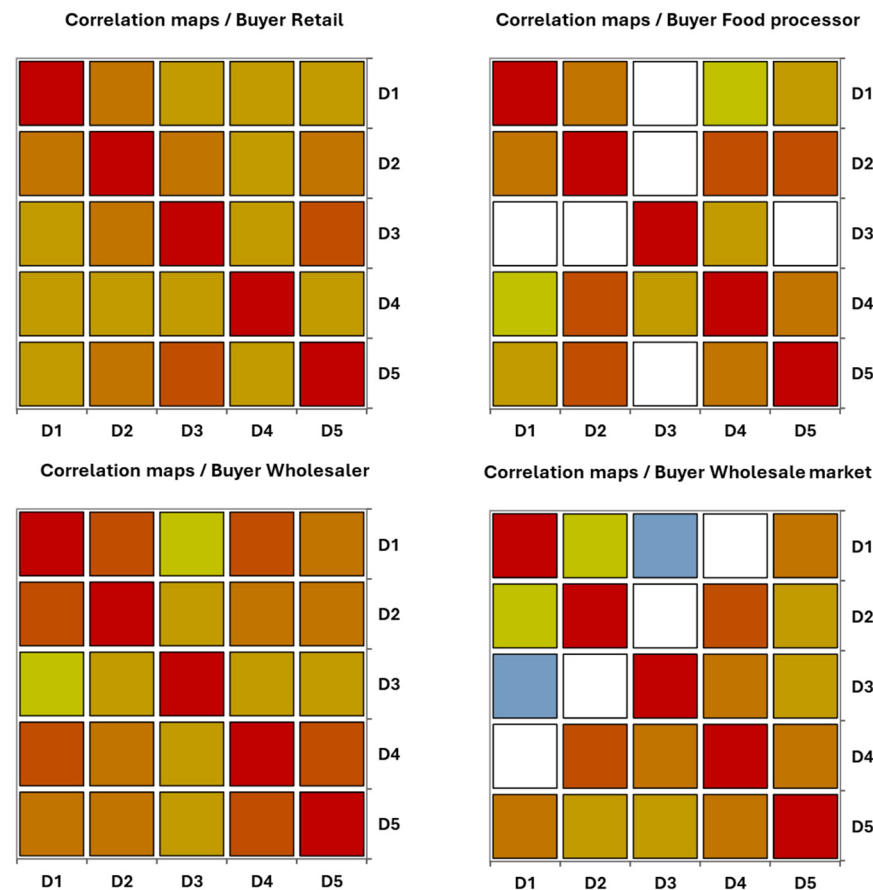


Figure 4. Correlation matrix between the dimensions of quality of commercial relations, broken down by type of buyer; colors from red to white reflect a strong to weak positive correlation; color from blue to white reflects a strong to weak negative correlation. The dimensions are: D1 “Long-term commitment”, D2 “Price satisfaction”, D3 “Adaptation on quality standards”, D4 “Relational quality and trust”, and D5 “Cooperation in case of issues”.

4.2.1. Cluster Analysis with Aggregate Variables

The aggregate variables summarizing the five dimensions of commercial relations are used to perform a cluster analysis. The Cronbach alpha of the five dimensions is as follows: D1 and D2 have $\alpha = 0.833$; for D3 $\alpha = 0.525$; for D4 $\alpha = 0.651$; for D5 $\alpha = 0.805$. The optimal number of clusters is identified through hierarchical clustering, suggesting an optimal partition of observations in four clusters. A K-means cluster analysis is then used to group the observations into the four clusters. The between-cluster variance is 53.90%, while the within-cluster variance is 46.10%.

The features of each cluster are analyzed by looking at the centroids (Figure 5).

Cluster 1 (29% of observations): buyers are stable and reliable; they do not have strict quality standards and are felt as quite detached from the agricultural sector; these relations are characterized by high satisfaction of producers for the price and margins and by a good atmosphere and cooperation between supplier and buyer.

Cluster 2 (33% of observations): buyers are stable and reliable, and the suppliers' satisfaction with the economic aspects of the commercial relation is slightly above average, but they are very strict in the application of quality standards on products.

Cluster 3 (25% of observations): commercial relations belonging to this cluster are characterized by high flexibility in the application of quality standards, while the other aspects are rated lower than in other clusters.

Cluster 4 (11% of observations): this cluster groups commercial relations that are perceived as negative by the producers for all the aspects considered; long-term commitment, relational quality, trust, and cooperation are scored lower than the other clusters.

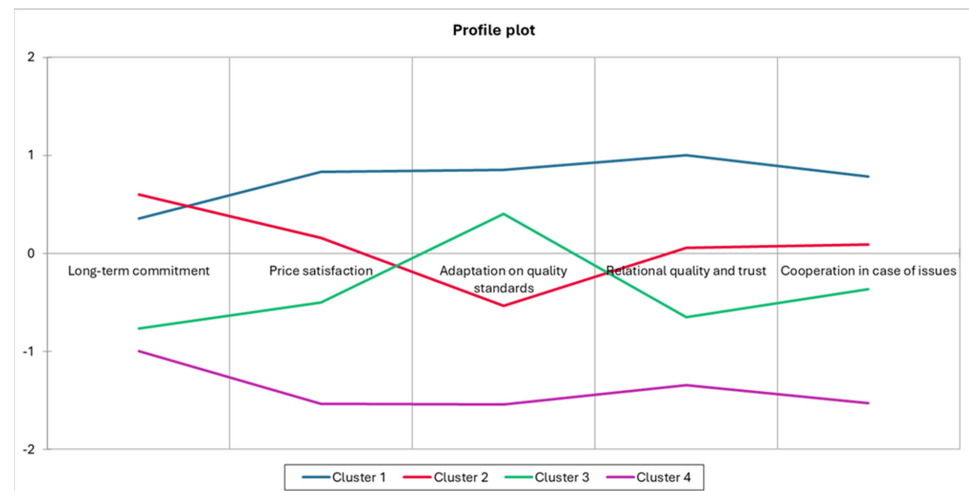


Figure 5. Centroids of the four clusters in relation to the five variables considered (standardized value; 0 = average of the dimension, positive values = above average, negative values = below average).

A Kruskal–Wallis test is performed to compare the average values of F15 and F16 across the clusters (Figure 6). As expected, satisfaction for the commercial relation (F16) is significantly higher in Cluster 1 and Cluster 2 with respect to Cluster 4. This is not reflected in the willingness to change buyer (F15), where a significant difference is only observed between Cluster 1 and Cluster 4, although a less significant difference can also be observed between Cluster 1 and Cluster 2 (with p -value 0.024) and Cluster 3 (p -value 0.011). It appears that when the relation is perceived as highly negative, there may be a driver for change: producers pursue an exit strategy after realizing that they have no voice to change things; otherwise, other factors tend to dominate the decision to remain in a commercial relation with the buyer.

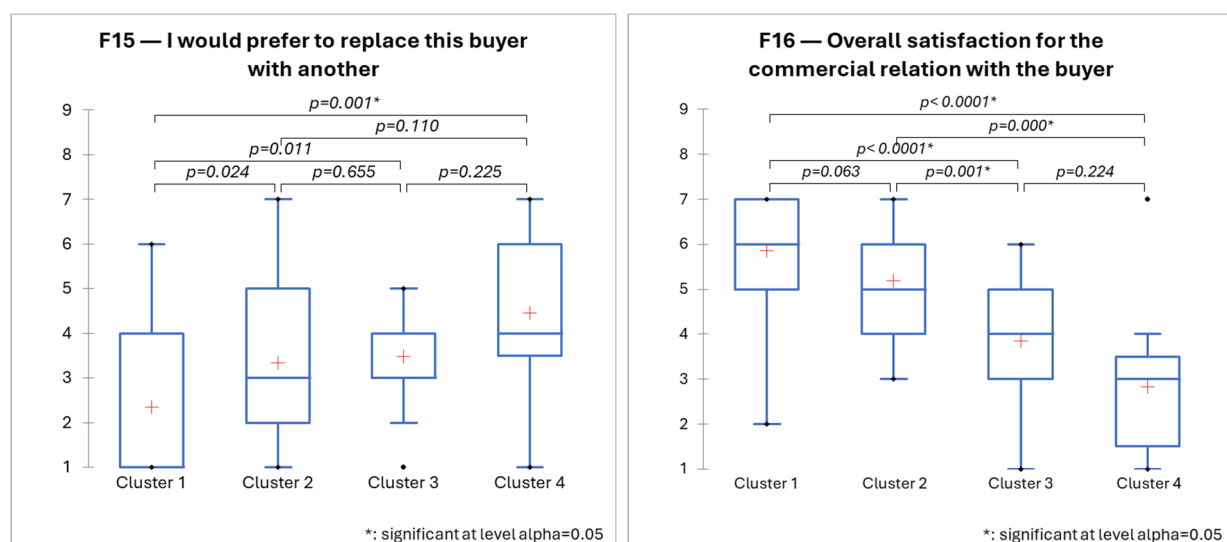


Figure 6. Results of the Kruskal–Wallis test to compare the average values of F15 and F16 across the clusters.

Another interesting result concerns the frequency of observations related to each buyer across the clusters. Figure 7 shows that Cluster 3 is mainly composed of commercial relations with wholesalers and wholesale markets, while Cluster 1 is characterized by

relations with wholesalers and other buyers (among which, the most frequently cited are short supply chains with products marketed directly to consumers, restaurants and delivery to cooperatives and POs). Cluster 2 mostly represents commercial relations between agricultural producers and retailers. Cluster 4 does not show a particular orientation towards a specific channel and seems to be spread across all of them.

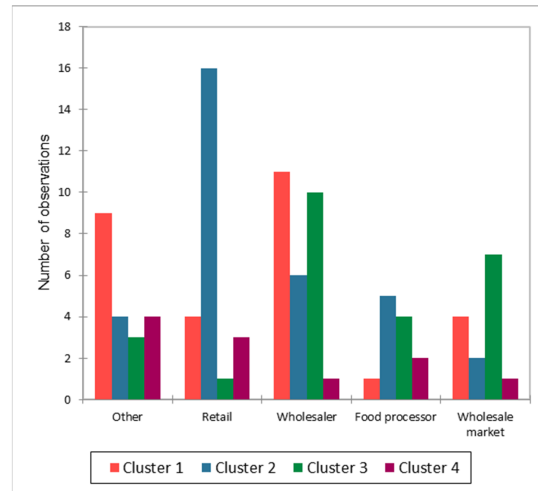


Figure 7. Frequencies of different types of buyers across the clusters.

4.2.2. Multiple Correspondence Analysis

A multiple correspondence analysis is conducted to examine the relations between clusters of commercial relations, the percentage of turnover generated through those relations, and the values of F15 and F16, both above and below the median for each item. Figure 8 illustrates the correspondence between the categories of these variables, revealing that commercial relations with high satisfaction (F16_HIGH) and a low willingness to change buyers (F15_LOW) are associated with Cluster 1. This cluster is also closely linked to commercial relations characterized by a low turnover share. Cluster 2, representing commercial relations with retailers, is positioned near high turnover and low willingness to change buyers. Additionally, Cluster 3, which primarily represents commercial relations with wholesalers and wholesale markets, is characterized by low satisfaction and a high intention to change buyers. The same is valid, though to a lesser extent, for Cluster 4.

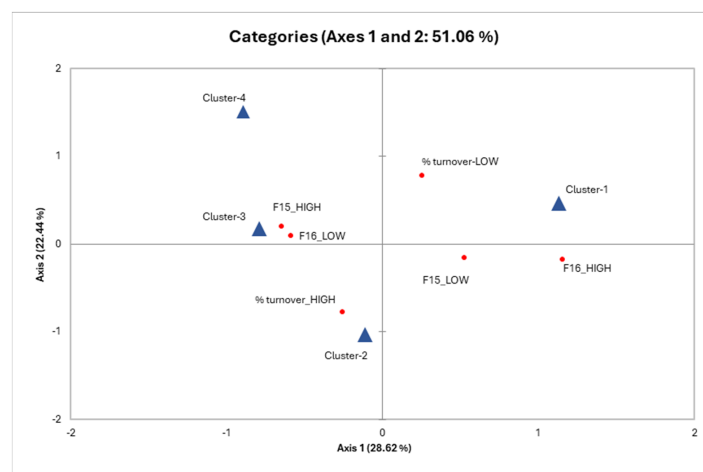


Figure 8. Correspondence between perceived quality of commercial relation, turnover, and clusters.

5. Discussion

This article examines the quality of commercial relations between producers and buyers within the Italian fruit and vegetable supply chain. The content analysis on the focus group transcripts discloses four main factors influencing the quality of commercial relations: external factors, flexibility and scheduling, contracts and negotiations, and relations in the value chain. The latter collects the highest number of sentences, which highlight the importance of long-term commitment, transparency of information, and trust to build a high-quality commercial relationship between agricultural producers and buyers [4–6]. Based on the perception of the POs that joined the focus groups, there are several commercial practices that affect the quality of the commercial relation, mainly related to negotiation and bargaining power. Buyers, and in particular retailers, follow a plan of prices, promotions, and quantity of orders, which do not always fit in the fruit and vegetable seasonal trend and agricultural production reality and, therefore, influence the actors of the supply chain [39]. This represents a burden in commercial relations that could be mitigated by a better ability of buyers to adapt to suppliers' capabilities [5]. This lack of flexibility is also relevant with respect to the application of quality standards, promotions, pricing, and delivery schedules, possibly leading to high rates of product rejections, disputes, and, consequently, increased costs for producers for the management of rejected products [40]. The focus group participants also reported that some of these practices may even result in unfair practices, possibly categorized as UTPs by the current EU and national legislation.

These results are complemented by the evidence provided by the survey, which was used to analyze 98 commercial relations. To this respect, we investigated the perception of producers towards five dimensions of quality of commercial relations—D1 “Long-term commitment”, D2 “Price satisfaction”, D3 “Adaptation on quality standards”, D4 “Relational quality and trust”, and D5 “Cooperation in case of issues”—exploring their relations with the willingness to change buyer and the overall satisfaction for the commercial relation. The correlation matrix shows the link between the dimensions of quality of commercial relations broken down by type of buyer. We detect a correlation between D1 “Long term commitment” and D2 “Price satisfaction”, except for wholesale markets, which may indicate that this channel is mainly chosen on a short-term basis. In fact, producers and POs may choose this channel to reallocate products that are not accepted by other buyers, similar to what happens in the reallocation of suboptimal vegetables to the food industry [9]. Another element supporting this interpretation is the negative correlation observed between D1 “Long term commitment” and D3 “Adaptation on quality standards” for wholesale markets, indicating that standards are more flexible when the timeframe of the commercial relation is short. In this case, the commercial relation is likely to be more oriented towards a transactional approach, where the main driver is the economic outcome [29].

As expected, all buyers show a positive correlation between D4 “Relation quality and trust” and D5 “Cooperation in case of issues”. Interestingly, this correlation is weaker for commercial relations between producers and retailers than for other buyers, confirming the results from the focus groups, where a lack of communication between producers and retailers is reported. Indeed, communication represents a key element in improving the quality of commercial relations [4], which may also be enhanced by the adoption of technological innovations that allow for improving the relationship between actors, as shown, also with reference to the fruit and vegetables supply chain [41–43].

Looking at D3 “Adaptation on quality standards” for commercial relations with processors, we observe that this dimension is not correlated with any other. This suggests that the quality standards required by food processors are not relevant to defining the overall

quality of the commercial relation. This may be one of the reasons why producers often consider the food industry a reliable commercial channel despite the lower prices [7].

Looking at clusters of commercial relations, Cluster 2, which mainly includes commercial relations with retailers, shows high ratings for all dimensions except for D3, “*Adaptation for quality standards*”. In contrast, Cluster 3 demonstrates an opposite trend, with negative performance across all dimensions except for D3; this indicates a high level of adaptation to quality standards on the products; it is predominantly represented by wholesalers and wholesale markets, confirming the results of the correlation analysis presented above. Cluster 1 groups commercial relations that are rated high for all dimensions, and it includes different buyers, especially wholesalers, and buyers falling under the category “other”. “Other” buyers include restaurants and local-based supply chains, which seem to perform very well in terms of establishing relations of high quality. This may be because, in local chains, relational patterns are the most frequent ways of interaction between producers and buyers [44], therefore possibly increasing commitment and trust, which are fundamental to a high-quality commercial relationship [5,28,45].

The analysis of the survey results also discloses that the willingness to change buyers and the overall satisfaction for the commercial relation significantly differ across the clusters, but also that they show different patterns. Commercial relations between producers and buyers often unfold in contexts marked by unbalanced bargaining power distribution [1]. This means that producers might be willing to continue a commercial relationship with buyers because of economic necessity or the lack of alternatives, even if they are not satisfied with the conditions. The economic outcome of commercial relations established with retailers remains positive, even if they apply strict conditions and requirements [46]; retailers represent a large share of their total turnover, which may exceed in importance the perception of fairness or satisfaction. Therefore, it is difficult to identify a clear distinction between transactional or relational approach for these commercial relations, since economic and relational aspects are blended that tie up the parties and, at the same time, may not be satisfactory for both. This is particularly evident when relations are long-term and ensure high turnover over the years. Furthermore, this may suggest that the willingness to change buyers is not an indicator of the quality of commercial relations, as it encompasses the necessity of the supplier to adapt to market opportunities. This mechanism may also be interpreted considering the Hirschman paradigm [47], suggesting that in some cases, producers may be entrapped in commercial relations—especially with retailers—despite their dissatisfaction since they feel to have no voice to express [48]. The lack of alternative markets and the difficulty in diversifying sales channels clearly play a role in this situation.

The multiple correspondence analysis confirms that a crucial aspect influencing the willingness of producers to change buyers is the share of that commercial relation for their turnover. Commercial relations with retailers (Cluster 2) are not perceived as of higher quality than others, but they are still very important as they deliver a high share of the turnover to the producer. One particularly problematic aspect of these relations is the rigid application of quality standards, which sometimes may be used opportunistically. In such cases, a stricter approach may be applied, and products may be rejected more frequently when there is an abundance in the market, possibly resulting in unfair trading practices [18]. A strict application of quality standards may also deliver undesirable impacts, for example, in terms of food loss or economic loss [49–51], since there is evidence in the literature showing that UTPs represent a leading factor that generates food loss and waste across the supply chain [52,53]. It is also interesting to interpret the result of commercial relations belonging to Cluster 3, in which quality is perceived to be much worse than in other clusters (high intention to change buyers and low overall satisfaction). The rationale behind the continuation of these relations is probably related to the flexibility that these buyers

show in the acceptance of products that do not comply with quality standards requested by retailers.

6. Conclusions, Limitations, and Recommendations for Future Research

By investigating producers' perception of the quality of their commercial relations, this study suggests that the collaboration among different supply chain actors is a key factor in improving efficiency, quality management, and sustainability in fruit and vegetable supply chain operations. The results from the focus groups and a survey conducted with producers support the idea that trust and long-term cooperation between suppliers and buyers are key factors for a high-quality commercial relationship. Commercial relations that are unsatisfactory for producers persist because of a lack of better alternatives or an entrapment mechanism that keeps them tied to buyers that have a stronger position in the relation.

In interpreting the results of this study, its limitations should also be considered. First, this study focuses on the perspective of the producers and POs; it would be interesting to assess the perceived quality of commercial relations with agricultural producers from the perspective of buyers, especially retailers. Second, despite the efforts to spread the survey and the good number of answers, the number of observations collected does not support more in-depth statistical analyses, which might be used with larger sets of data to investigate the causal link between the quality of commercial relations and its underlying factors.

Future research could explore the link between the quality of commercial relations and the emergence of UTPs. At the same time, an analysis of the assessment of the impact of UTPs on producers could help in improving the sustainability and equity of the supply chain. Investigating these aspects could provide valuable insights to develop more equitable supply chain practices, as well as long-term and satisfactory commercial relations for producers.

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Abbreviations

The following abbreviations are used in this manuscript:

PO(s) Producer Organisation(s)
UTP(s) Unfair Trading Practice(s)

References

1. Bonanno, A.; Russo, C.; Menapace, L. Market power and bargaining in agrifood markets: A review of emerging topics and tools. *Agribusiness* **2018**, *34*, 6–23. [\[CrossRef\]](#)
2. Sexton, R.J.; Xia, T. Increasing concentration in the agricultural supply chain: Implications for market power and sector performance. *Annu. Rev. Resour. Econ.* **2018**, *10*, 229–251. [\[CrossRef\]](#)
3. Carbone, A. Foods and places: Comparing different supply chains. *Agriculture* **2018**, *8*, 6. [\[CrossRef\]](#)
4. Kühne, B.; Gellynck, X.; Weaver, R.D. The influence of relationship quality on the innovation capacity in traditional food chains. *Supply Chain. Manag. Int. J.* **2013**, *18*, 52–65. [\[CrossRef\]](#)
5. Razavi, S.M.; Abdi, M.; Amirnequiee, S.; Ghasemi, R. The impact of supply chain relationship quality and cooperative strategy on strategic purchasing. *J. Logist. Manag.* **2016**, *5*, 6–15. [\[CrossRef\]](#)
6. Gajdić, D.; Mesić, Ž.; Petljak, K. Preliminary research about producers' perceptions of relationship quality with retailers in the supply chain of organic food products in Croatia. *Sustainability* **2021**, *13*, 13673. [\[CrossRef\]](#)
7. Herzberg, R.; Schmidt, T.; Keck, M. Market power and food loss at the producer-retailer interface of fruit and vegetable supply chains in Germany. *Sustain. Sci.* **2022**, *17*, 2253–2267. [\[CrossRef\]](#)
8. Mondliwa, P.; Roberts, S.; Ponte, S. Competition and power in global value chains. *Compet. Change* **2021**, *25*, 328–349. [\[CrossRef\]](#)
9. Pietrangeli, R.; Herzberg, R.; Cicatiello, C.; Schneider, F. Quality Standards and Contractual Terms Affecting Food Losses: The Perspective of Producer Organisations in Germany and Italy. *Foods* **2023**, *12*, 1984. [\[CrossRef\]](#)
10. Devin, B.; Richards, C. Food waste, power, and corporate social responsibility in the Australian food supply chain. *J. Bus. Ethics* **2018**, *150*, 199–210. [\[CrossRef\]](#)
11. Skorbiansky, S.R.; Ellison, B. Contracting and quality standards in fresh produce markets and how they impact food loss. In *The Economics of Food Loss in the Produce Industry*; Routledge: London, UK, 2019; pp. 250–262.
12. Corrado, A.; Caruso, F.S.; Lo Cascio, M.; Nori, M.; Palumbo, L.; Triandafyllidou, A. Is Italian Agriculture a 'Pull Factor' for Irregular Migration—And, If So, Why? 2018. Available online: <https://www.opensocietyfoundations.org/uploads/ba12312d-31f1-4e29-82bf-7d8c41df48ad/is-italian-agriculture-a-pull-factor-for-irregular-migration-20181205.pdf> (accessed on 10 August 2024).
13. Cacchiarelli, L.; Sorrentino, A. Market power in food supply chain: Evidence from Italian pasta chain. *Br. Food J.* **2018**, *120*, 2129–2141. [\[CrossRef\]](#)
14. Sorrentino, A.; Russo, C.; Cacchiarelli, L. Market power and bargaining power in the EU food supply chain: The role of Producer Organizations. *New Medit* **2018**, *17*, 21–31. [\[CrossRef\]](#)
15. Dallas, M.P.; Ponte, S.; Sturgeon, T.J. Power in global value chains. *Rev. Int. Political Econ.* **2019**, *26*, 666–694. [\[CrossRef\]](#)
16. Falkowski, J.; Ménard, C.; Sexton, R.; Swinnen, J.; Vandeveld, S.; Di Marcantonio, F.; Ciaian, P. (Eds.) *Unfair Trading Practices in the Food Supply Chain: A Literature Review on Methodologies, Impacts and Regulatory Aspects*; EUR 28791 EN; JRC108394; Publications Office of the European Union: Luxembourg, 2017; ISBN 978-92-79-73831-9. [\[CrossRef\]](#)
17. European Commission. *European Commission. EU Regulation 2013/1308 and the Commission Delegated Regulation 2016/232*; European Commission: Brussels, Belgium, 2016.
18. Russo, C.; Di Marcantonio, F.; Cacchiarelli, L.; Menapace, L.; Sorrentino, A. Unfair trading practices and countervailing power. *Food Policy* **2023**, *119*, 102521. [\[CrossRef\]](#)
19. Christy, R.D. The role of farmer cooperatives in a changing agricultural economy. *J. Agric. Appl. Econ.* **1987**, *19*, 21–28. [\[CrossRef\]](#)
20. EU 2013 EU. Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 Establishing a Common Organisation of the Markets in Agricultural Products and Repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No1037/2001 and (EC)No1234/2007. 2013. Available online: <https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32013R1308> (accessed on 10 September 2024).
21. European Commission: Directorate-General for Agriculture and Rural Development; Montanari, F.; Chlebicka, A.; Szabo, G.; Amat, L.; Traon, D.; Sorrentino, A.; Russo, C.; Ferreira, I. *Study of the Best Ways for Producer Organisations to be Formed, Carry out Their Activities and Be Supported—Final Report*; Publications Office of the European Union: Luxembourg, 2019; Available online: <https://data.europa.eu/doi/10.2762/034412> (accessed on 6 April 2024).

22. Van Herck, K. *Assessing Efficiencies Generated by Agricultural Producer Organizations* (No. 473441); KU Leuven, Faculty of Economics and Business (FEB), LICOS-Centre for Institutions and Economic Performance: Leuven, Belgium, 2014; Available online: <http://bookshop.europa.eu/it/assessing-efficiencies-generated-by-agricultural-producer-organisations-pb-KD0214739/> (accessed on 20 April 2024).
23. Nucera, M.; Ferrari, G.M.; Finizia, A.; Merciai, S.; Sorrentino, A. The role of Producer Organisations in the vegetable value chain: An application to the red chicory from Veneto. *Ital. Rev. Agric. Econ.* **2016**, *71*, 100–114. [\[CrossRef\]](#)
24. Velázquez, B.; Buffaria, B.; European Commission. About farmers' bargaining power within the new CAP. *Agric. Food Econ.* **2017**, *5*, 16. [\[CrossRef\]](#)
25. Molnár, A.; Van Lembergen, K.; Tarantini, F.; Heene, A.; Gellynck, X. Price transparency as a prerequisite for fair competition: The case of the European food prices monitoring tool. In *The Ethics and Economics of Agrifood Competition*; Springer: Dordrecht, The Netherlands, 2013; pp. 243–261. [\[CrossRef\]](#)
26. Caviccholi, D. Detecting market power along food supply chains: Evidence and methodological insights from the fluid milk sector in Italy. *Agriculture* **2018**, *8*, 191. [\[CrossRef\]](#)
27. Bandara, S.; Leckie, C.; Lobo, A.; Hewege, C. Power and relationship quality in supply chains: The case of the Australian organic fruit and vegetable industry. *Asia Pac. J. Mark. Logist.* **2017**, *29*, 501–518. [\[CrossRef\]](#)
28. Schulze, B.; Wocken, C.; Spiller, A. Relationship quality in agri-food chains: Supplier management in the German pork and dairy sector. *J. Chain. Netw. Sci.* **2006**, *6*, 55–68. [\[CrossRef\]](#)
29. Grant, D.B. The Transaction—Relationship Dichotomy in Logistics and Supply Chain Management. *Supply Chain Forum Int. J.* **2005**, *6*, 38–48. [\[CrossRef\]](#)
30. Anderson, E.; Weitz, B. The use of pledges to build and sustain commitment in distribution channels. *J. Mark. Res.* **1992**, *29*, 18–34. [\[CrossRef\]](#)
31. Morgan, R.M. The commitment-trust theory of relationship marketing. *J. Mark.* **1994**, *58*, 20–38. [\[CrossRef\]](#)
32. Ganesan, S. Determinants of long-term orientation in buyer-seller relationships. *J. Mark.* **1994**, *58*, 1–19. [\[CrossRef\]](#)
33. Geyskens, I.; Steenkamp, J.B.E. Economic and social satisfaction: Measurement and relevance to marketing channel relationships. *J. Retail.* **2000**, *76*, 11–32. [\[CrossRef\]](#)
34. Kallio, H.; Pietilä, A.-M.; Johnson, M.; Kangasniemi, M. Systematic methodological review: Developing a framework for a qualitative semi-structured interview guide. *J. Adv. Nurs.* **2016**, *72*, 2954–2965. [\[CrossRef\]](#)
35. Kuckartz, U. Qualitative content analysis: From Kracauer's beginnings to today's challenges. *Forum Qual. Sozialforschung/Forum Qual. Soc. Res.* **2019**, *20*, 20. [\[CrossRef\]](#)
36. Gundlach, G.T.; Achrol, R.S.; Mentzer, J.T. The structure of commitment in exchange. *J. Mark.* **1995**, *59*, 78–92. [\[CrossRef\]](#)
37. Håkansson, H.; IMP Project Group. *International Marketing and Purchasing of Industrial Goods: An Interaction Approach*; Wiley: Hoboken, NJ, USA, 1982.
38. Anderson, J.C.; Narus, J.A. A model of distributor firm and manufacturer firm working partnerships. *J. Mark.* **1990**, *54*, 42–58. [\[CrossRef\]](#)
39. Gu, J.; Shi, X.; Wang, J.; Xu, X. Examining the impact of market power discrepancy between supply chain partners on firm financial performance. *Int. J. Prod. Econ.* **2024**, *268*, 109100. [\[CrossRef\]](#)
40. Eriksson, M.; Ghosh, R.; Mattsson, L.; Ismatov, A. Take-back agreements in the perspective of food waste generation at the supplier-retailer interface. *Resour. Conserv. Recycl.* **2017**, *122*, 83–93. [\[CrossRef\]](#)
41. Nasso, M.; Blasi, E.; Pezzoli, F.; Cicatiello, C. Investigating Co-Innovation strategies to prevent food loss in the fruits and vegetables sector. *J. Clean. Prod.* **2024**, *467*, 142984. [\[CrossRef\]](#)
42. Giua, C.; Materia, V.C.; Camanzi, L. Smart farming technologies adoption: Which factors play a role in the digital transition? *Technol. Soc.* **2022**, *68*, 101869. [\[CrossRef\]](#)
43. Mozzato, D.; Gatto, P.; Defrancesco, E.; Bortolini, L.; Pirotti, F.; Pisani, E.; Sartori, L. The role of factors affecting the adoption of environmentally friendly farming practices: Can geographical context and time explain the differences emerging from literature? *Sustainability* **2018**, *10*, 3101. [\[CrossRef\]](#)
44. Brunori, G.; Galli, F.; Barjolle, D.; Van Broekhuizen, R.; Colombo, L.; Giampietro, M.; Kirwan, J.; Lang, T.; Mathijs, E.; Maye, D.; et al. Are local food chains more sustainable than global food chains? Considerations for assessment. *Sustainability* **2016**, *8*, 449. [\[CrossRef\]](#)
45. Assis, M.T.; Lucas, M.R.; Rainho, M.J.M. A meta-analysis on the trust in agrifood supply chains. *Food Front.* **2022**, *3*, 413–427. [\[CrossRef\]](#)
46. Camanzi, L.; Malorgio, G.; Azcárate, T.G. The role of producer organizations in supply concentration and marketing: A comparison between European countries in the fruit and vegetable sector. *J. Food Prod. Mark.* **2011**, *17*, 327–354. [\[CrossRef\]](#)
47. Hirschman, A.O. *Exit, Voice, and Loyalty: Responses to Decline in Firms, Organizations, and States*; Harvard University Press: Cambridge, MA, USA, 1970.

48. Alpmann, J.; Bitsch, V. Exit, voice, and loyalty in the case of farmer associations: Decision-making of dairy farmers during the German milk conflict. *Int. Food Agribus. Manag. Rev.* **2015**, *18*, 61–84. [[CrossRef](#)]
49. Herzberg, R.; Trebbin, A.; Schneider, F. Product specifications and business practices as food loss drivers—A case study of a retailer’s upstream fruit and vegetable supply chains. *J. Clean. Prod.* **2023**, *417*, 137940. [[CrossRef](#)]
50. Pietrangeli, R.; Cicatiello, C. Lost vegetables, lost value: Assessment of carrot downgrading and losses at a large producer organisation. *J. Clean. Prod.* **2024**, *478*, 143873. [[CrossRef](#)]
51. Fernandez-Zamudio, M.A.; Barco, H.; Schneider, F. Direct measurement of mass and economic harvest and post-harvest losses in Spanish persimmon primary production. *Agriculture* **2020**, *10*, 581. [[CrossRef](#)]
52. Piras, S.; Herrero, L.G.; Burgos, S.; Colin, F.; Gheoldus, M.; Ledoux, C.; Parfitt, J. Unfair Trading Practice Regulation and Voluntary Agreements Targeting Food Waste. A Policy Assessment in Select EUMember States. REFRESH. 2018. Available online: <https://eu-refresh.org/unfair-trading-practice-regulation-and-voluntary-agreements-targeting-food-waste.html> (accessed on 18 October 2024).
53. Sinclair Taylor, J.; Parfitt, J.; Jarosz, D. Regulating the Role of Unfair Trading Practices in Food Waste Generation. 2019. Available online: https://eu-refresh.org/sites/default/files/REFRESH%20Policy%20Brief%20on%20UTPs_2019_FINAL.pdf (accessed on 20 September 2024).

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