

Article

Market, Policies and Local Governance as Drivers of Environmental Public Benefits: The Case of the Localised Processed Tomato in Northern Italy

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Abstract: This article explores the role of a specific Localised Agri-food System (LAFS) in the provision of Environmental and social benefits (ESBs) in densely cultivated, industrialised, and populated areas by analysing the core of the processing tomato supply chain of northern Italy (Parma and Piacenza). The research examines how the interplay of market drivers, public policies, and collective actions favoured farming, technological, and organisational innovations geared to support long-term economic growth and tackle, at the same time, environmental challenges. The tomato supply chain is characterised by a favourable convergence of attitudes, policies, and market conditions that over time allowed for fruitful interactions between private stakeholders and between the supply chain and public players. Decades of key stakeholders' interconnections within the tomato supply chain led to a success story of economic growth and attention to a new balance between agro-industry and environment, for the benefit of producers/processors, consumers, and natural resources. Profitability strategies inevitably imply intensification of farming in order to maximise profit levels per hectare, however, the tomato supply chain found a collective motivation that could grant profitability and concurrently reward producers and processors for attention paid to safeguarding the environment—giving evidence that intensification does not necessarily conflict with requirements in support of sustainability.

Keywords: localised agri-food systems; governance; quality schemes; sustainable agriculture; sustainable water management; water footprint; water use; water pollution

1. Introduction

This study focuses on the provision of public benefits from a particularly structured and complex localised agri-food chain in Italian agriculture: the processed tomato supply chain of Northern Italy is a market-driven case study, characterised by an innovative governance system (Inter-branch Organisation) guaranteeing both vertical and horizontal cooperation, coordination within the supply chain, and production and processing adaption to environmental and economic sustainability requirements. Main public environmental and social benefits (ESBs) investigated are healthy functioning soil and water quality and quantity, whose provision is driven mainly by increasing demand for sustainable food products and for quality, social, and environmental certifications, but also supported by policies with indirect and direct focus.

In this paper, we tried to combine the concept of Localised Agri-food Systems (LAFS) developed first by the French school [1,2] and the concept of social-ecological system developed by the Ostrom school of thought [3–6].

More recently, the concept of LAFS has been more closely linked to the local characteristics of products, people, institutions, and social relationships that connect food and place. This research line focused on the relationship between LAFS and the qualification of local products, where collective action often seeks the Designations of Origin (DO) and/or more generally production standards which are sustainable and consistent with the increasing demand of quality products. The tomato supply chain of northern Italy is a localised agri-food system characterised by geographical proximity, long and consolidated relations between agricultural production and local industrial sector, historical traditions and local identity, and a distinctive governance influencing the economic performance and the development pattern at the local level [7–9]. In this respect, the development of this system is based on strong local governance, defined as “the process of building agreements to increase wellbeing by managing a territory’s tangible and intangible resources” [10].

LAFS is a model that is capable of evolving according to the emergence of new requirements for rural development, such as sustainability, multi-functionality, and product quality etc. LAFS is defined as “a process under construction, a spatial area comprising relationships between players sharing interests in one or more rural agri-food sectors” [11]. LAFS can be a powerful institution delivering public benefits alongside private ones, in a more efficient and durable way than public policies can do. At the same time, there can be a fruitful interplay between private mechanisms and public policies that is usually quite neglected in literature and this article aims to investigate the nature of this interplay.

Which are the main drivers influencing the provision of public benefits from the processed tomato LAFS? The Ostrom school of thought emphasises the holistic notion of social-ecological system (SES), providing a comprehensive view of possible factors and drivers at territorial level in the provision of public goods. According to the SES framework, the provision of specific environmental and social outcomes in the management of public goods is influenced by the interaction between different types of drivers, including market drivers, social drivers, and public policies. To understand the complexity of these interactions, a crucial role is played by the collective action: how do actors at different scale of action collaborate/cooperate and create collective action to solve dilemmas related to land use and contribute to the provision of ESBs?

Starting from these turning points in the literature, the objectives of this study are as follows:

1. To analyse the whole supply chain in the processed tomato area and inner relations between the phases of the chain;
2. To investigate relations between the most relevant public goods and the strategies implemented in the localised supply chain;
3. To identify the role of market, policies and local governance factors within the processing tomato chain in the provision of public benefits.

Governance arrangements [12] ensued from the development of new organisations and new rules and contractual arrangements between producers and processors of the tomato supply chain are the key elements in the improvement of the provision of environmental and social beneficial outcomes in the localised agri-food system examined.

Institutional change and contractual agreements, as confirmed by all the stakeholders interviewed, have direct and indirect effects on public goods. They both have comparable direct effects on soil and water, since direct effects ensue from the adoption of innovative and environmentally-friendly farming and water-saving practices that resulted in improved soil and water conditions. Indirect effects, instead, ensue from different processes: inter-branch cooperation in the case of institutional arrangements and market/price stabilisation in the case of the agreed rules and contracts.

The LAFS was initially centred on Producers Organisations that provided support services to their associates, organised tomato supply, and guaranteed relationships between producers and processors. However, over the past years, mutual cooperation agreements and networks among producers and between producers and processing firms evolved in nature and became the basis over which the present Inter-branch organisation (IO) has been built. The IO represents the supply chain by providing

assistance, common identity and united voice, by defining and managing fair rules of conduct with regard to exchange of information and cooperation.

Public policies do also represent a key support to change in the tomato supply chain attitude towards sustainability. In the last two decades, policies have played a very relevant role, in promoting and supporting collective actions within producers and between producers and processing firms, in complementing private schemes and in supporting individual actions. These policies have also fostered the adoption of more environmentally-friendly practices and innovations, and influenced beneficial outcomes on soil and water resources both in a direct and indirect way. This support was firstly regulatory through the agricultural policy of the region; secondly, it was of financial type through the different measures of Rural Development Plan [13] (direct and indirect focus on public goods' provision); and thirdly, it was conveyed also with the provision of research and technical advice through specific research programmes and the technical advisory structures and services of the region. As we will see, this specific LAFS benefitted greatly from the support of collective action within the IO framework, especially facilitating the cooperation among producers and establishing common rules of governance. Recently, the RDP support has included some measure to sustain cooperative approaches (see for example Measure 16, Cooperation), following the Leader model.

All these policies were consistent and complementary with the strategies emerging from the collective action and the attitude change of the private sector towards safety, quality, and reliability of production aimed at differentiating northern Italian tomato. Conflicts and contradictions emerged in the last years due to the increasing competition on the international product markets, but the system managed to reach consensus on new terms, having regard to considerations of efficiency and economic balance.

2. Materials and Methods: The Structure of the Localised Agri-Food System (LAFS)

The study follows the conceptual framework underpinning the Project H2020 PROFECY [14,15] and attempts to investigate the delivery of public goods in the tomato supply chain of Northern Italy by analysing components, relationships, properties, and attributes of the tomato system, and identifying the turning points that marked the improvement of practice and policies for sustainability and the drivers underlying the provision of environmental and social beneficial outcomes (ESBs). The work carried out in the paper stems from a literature review, a qualitative investigation, and a quantitative stage.

Primary data were mainly collected through semi-structured interviews with targeted prominent stakeholders in the area, such as the representatives of the Association of Producers' Organisations (the Interregional Fruit and Vegetables Consortium—CIO), the Association of private processing firms (AIIPA), the leading Italian processing firm (Mutti Spa), the Inter-branch Organisation (IO) gathering all the stakeholders of the supply chain, local and regional governments (Province of Parma and Emilia Romagna Region), and local universities and research centres (University of Piacenza, the regional territorial development agency Emilia-Romagna Valorizzazione Economica Territorio-ERVET).

The stakeholders were asked to select the most relevant ESBs for the supply chain from a list prepared by the interviewees and to discuss on farming and processing methods and practices adopted to provide the ESBs selected, identifying: (a) the technical relationship between the different phases of the supply chain and the preservation/improvement of ESBs; (b) the major innovations marking the transition from deterioration to preservation/valorisation of ESBs; (c) the mechanisms and/or actions supporting these radical shifts (organisational/technical/policy); (d) main impacts generated on ESBs in the different phases of the supply chain evolution, possibly on the basis of the evidences collected over time; (e) the motivations (economic and/or non-economic) leading the different stakeholders to preserve/improve the ESBs; (f) rules, policies, and organisational settings that forced/spurred them to adopt innovative conservative/beneficial practices, whether/how they influenced (or hindered) the provision of ESBs and what they believed to have not worked, why, and what could have been done differently. The interviewees were also asked to identify which stakeholders were mainly

involved in the process leading to the provision of environmentally and socially beneficial outcomes, to explain the position/role played by each of them, the choices made and difficulties encountered, and the solutions/mediations adopted, to describe what brought about the composition of different interests/points of view in a cooperation for a common aim (the provision of ESBs). Stakeholders were also asked to highlight the existence/lack of empirical comprehensive quantification of improvements at supply chain level compared to given starting points.

The results presented in this paper are also based on quantitative and qualitative data collected from the 2010 Agricultural Census and the regional Payment Agency (Agenzia Regionale per le Erogazioni in Agricoltura-AGREA). Particularly relevant, however, have been the data referred to production, processing and prices collected by the Inter-branch Organisation. Moreover, the findings of other research projects specifically focused on the measurement of the sustainability of the tomato supply chain of northern Italy, such as the World Wide Fund for Nature WWF-Mutti Water Footprint, have been used to support the investigation of the provision of public goods selected by the stakeholders interviewed.

The unit of analysis is the territory where the processed tomato supply chain of northern Italy is located, and is characterised by a conceptual frame consisting of three specific notions [8]:

1. Specialty food involving specific local resources, local identity, collective knowledge;
2. Economic linkages between local agri-food activities and resources and activities outside the agricultural sector;
3. Supply chain governance influencing economic performance and local development pattern.

The whole processed tomato supply chain of northern Italy covers four Regions (Emilia-Romagna, Lombardy, Piedmont, Veneto) and an autonomous Province (Bolzano) (Figure 1). It accounts for 39,000 hectares under tomato, comprises around 2000 producers grouped in 15 Producers Organisations (POs) and 24 processing companies operating in 29 plants, processes almost 3 million tons of tomatoes into concentrate, pulp and paste that represent 50% of the overall Italian processing tomato, 25% of the European production, and nearly 7% of world production. Italy is a world leading processed tomato producer.

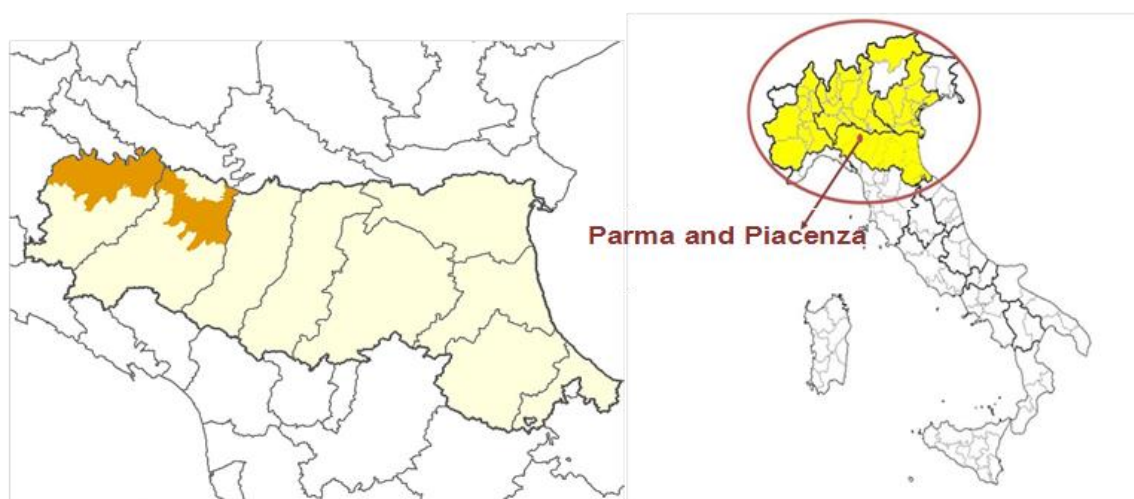


Figure 1. The case study area (in orange) and the supply chain area (in yellow).

In 2016, with a production of 5.2 million tons of processed tomato and a 13.6% share of the global market, Italy was the second largest world tomato producer after California (30%) and China (13.5%) and the first in Europe (50% of the market), far ahead of Spain and Portugal (around 40% altogether). Half of the Italian tomato was produced and processed in northern Italy. Three quarters of the total

area belongs to Emilia Romagna, where industrial tomato is the major horticultural crop, mainly in the area of Parma, Piacenza, and Ferrara.

Our analysis is limited to 37 municipalities belonging to the Provinces of Parma and Piacenza where historical roots and core business are mainly located (Figure 1). Parma and Piacenza (together with Ferrara) are the leading producing provinces in the North Italy (almost 40% of the whole northern Italian tomato cultivations, around 600 producers and 14,000 hectares), and include most of the processing firms of the supply chain, representing more than 60% of processed tomato (1.7 million tons).

The economic dynamic of the tomato supply chain is significant. It is composed by large and very large producing and processing companies with a substantial workforce and a high turnover (Table 1). Tomato farms have quite a large size: 40% of the tomato area is cultivated by 15% of the farms. Average farm size is more than 20 hectares and 40% of farms exceed 20 hectares, while just 28% are of less than 10 hectares. Value of tomato production per farm is relevant also for smaller farms, where the contribution to family income is adequate to employ one full time working unit and the value is more and more remarkable as farm dimension increases.

Most of the tomato farms are highly capital, labor, and technology intensive and the employment generated is of crucial importance. In general, family labor is prevalent in all farms, but is negatively correlated to size. The use of other typologies of labor (seasonal) increase as sizes increase; therefore, the percentage distribution of agricultural working days among farm sizes classes and the annual working days per Utilised Agricultural Area (UAA) decrease as farm size increases.

Table 1. Tomato farms in the study area.

Farm Size (Hectares of Tomato)	Tomato Farms		% Utilised Agricultural Area (UAA)	% Tomato Area	Value of Tomato Production		Value of Tomato Production per Farm	% Working days	Annual Working days/UAA
	Number				€		€		
<=10	171	28%	13%	7%	5,852,589	7%	34,226	24%	9.8
>10–20	190	32%	25%	21%	16,228,716	21%	85,414	31%	6.7
>20–40	150	25%	32%	31%	24,674,044	31%	164,494	26%	4.4
>40	90	15%	30%	41%	32,154,057	41%	357,267	19%	3.3
Total	601				78,909,407		131,297		

Source: our elaborations from Agricultural Census data (2010).

In the case study area, production and processing experienced constant growth until 2016 (Table 2). Piacenza is the area most involved in the tomato production (25% of the supply chain, 37% of Emilia Romagna). Tomato processing, instead, is concentrated in the area of Parma, where more than half of the private processing firms and half of the processing producers' cooperatives are located.

Table 2. Tomato production and processing in northern Italy (hectares, tons).

Industrial Tomato	2011	2012	2013	2014	2015	2016
Tomato cultivated area (hectares), of which:	35,975	33,464	29,175	35,681	38,948	38,594
Emilia Romagna	24,403	22,144	20,015	24,534	26,195	26,504
Case study area, of which:	13,909	12,837	11,065	13,905	14,610	14,507
Parma	9625	8608	7127	9140	9822	9840
Piacenza	4284	4229	3938	4765	4788	4667
Tomato production (tons)	2,562,828	2,370,917	1,889,374	2,322,065	2,623,514	2,773,146
Yield per hectare (tons/hectares)	71.24	70.85	64.76	65.08	67.36	71.85
Tomato processed (tons), of which:	2,491,878	2,289,368	1,883,434	2,357,939	2,651,045	2,813,638
Parma and Piacenza	1,548,455	1,469,329	1,185,700	1,429,671	1,610,889	1,740,656

Source: our elaborations on data from the Inter-branch Organisation of processed tomato of northern Italy.

The processed tomato LAFS, as we stressed earlier, is characterised by a very complex structure (Figure 2), which is the result of different factors interacting over time. The underlying supply chain encompasses a well-articulated system of functional, technological, and organisational relationships between the various players representing the production, processing stages, institutions, research centres, and providers of technical means. From the 1980s, the pivotal role was played by Producers Organisations. Although European agricultural policies required the grouping of tomato supply to have access to CMO aid, in the tomato area Producers organisations have been already pre-existed in the supply chain, since they led the negotiations with the processing industry, organised collective purchases of production inputs, offering tailored-made consultancy services and technical support. Further on, in order to pre-emptively tackle the new European Common Agricultural Policy (CAP) reform and the challenges related to the decoupling and the support cuts, the stakeholders in 2007 decided to set up the association “District of industrial tomato” between Producers Organisation, processing firms, local institutions, and local research centres.

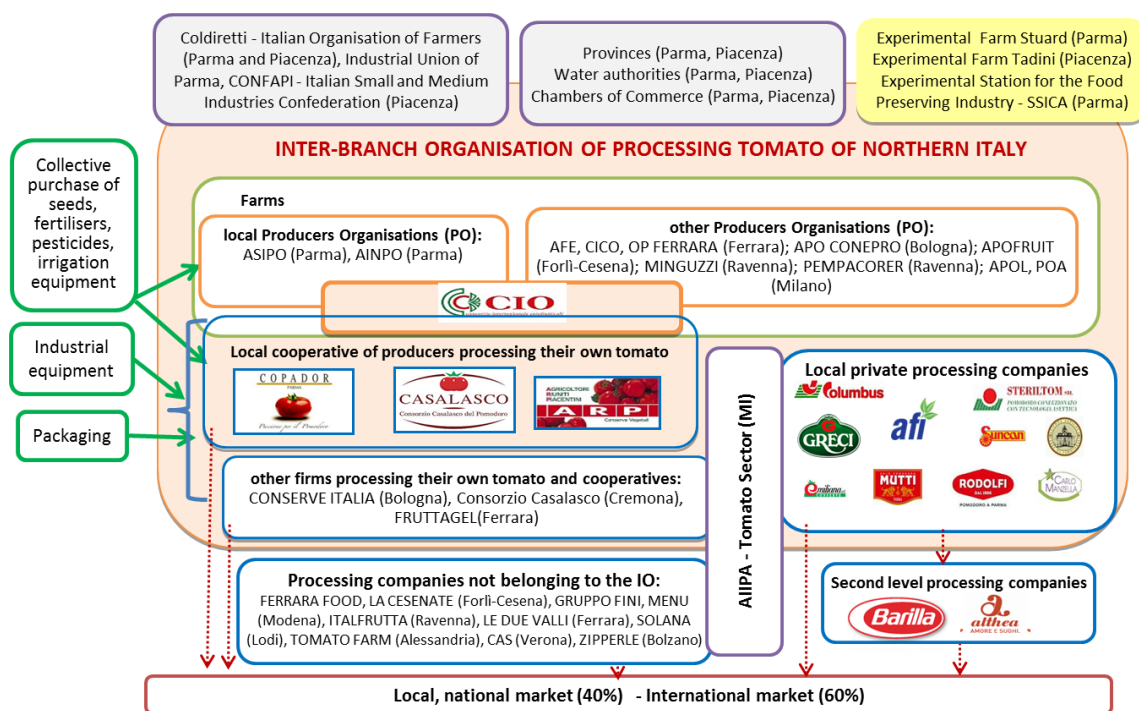


Figure 2. Governance structure of the processed tomato of northern Italy (adapted from Daraio, 2014) [16].

The creation of the District was promoted by the province of Parma and enjoyed a wide consensus among the main sectoral stakeholders in the provinces of Parma, Piacenza, and Cremona. Soon afterwards, the consensus spread over the territory of other provinces, and the association enlarged its borders to include also other tomato areas in the nearby Regions (Lombardia, Piedmont, Veneto, Province of Bolzano). Finally, in 2011, it evolved into the present Inter-branch Organisation (IO) of processed tomato on northern Italy, soon afterwards recognised by the Region and the European Union. The IO is composed by producers, all associated in POs and Associations of POs (APOs), and by processing firms, partly private and partly cooperatives—all of them associated as well. Decisions are adopted by a majority of three-quarters of the ordinary members, but decision-making power is allocated 50% to producers and 50% to processors and each single member’s vote has a weight proportional to its productive weight.

Another important aspect is the relevant presence in the case study area of all the upstream and downstream phases of the supply chain, such as: an advanced mechanical engineering industry,

specialised in agricultural machineries; food processing lines, and packaging lines, services (research and experimentation, but also transports and logistics); and international promotion events specialised in agri-food (the international food exhibition “CIBUS”, the international food processing and packaging technologies exhibition “CIBUS TECH”).

The cooperative culture characterising the Emilia Romagna area is the expertise and long-sightedness of the supply chain stakeholders and the financial support of European and regional funds (Common Market Organisation (CMO), Regional Development Plans (RDP), other funds) consolidated collaboration, coordination, and organisational and technical innovation. Cooperation is well-developed at the producers’ level: in the area of Parma and Piacenza, tomato producers are members of local and/or interregional Producers Organisations (the Interprovincial associations of fruit and vegetables producers A.In.P.O. and As.I.P.O., and the Interregional Fruit and Vegetables Consortium of Producers Organisations C.I.O.) or of cooperatives that produce and process tomato by themselves (Consorzio Padano Ortofrutticolo-CO.PAD.OR., Consorzio Casalasco del Pomodoro, Agricoltori Riuniti Piacentini-ARP), through which they make collective purchase of means of production, receive agronomic and technical assistance, and sell to processing industries (Figure 2).

Processing is made partly in private firms and partly in producers’ cooperatives—some of them are specialised in semi-finished products, some others in processing fresh tomato and/or semi-finished tomato in finished products to be sold under own private label or for third parties, and some others only process semi-finished products. Big producers’ cooperatives processing their own tomato (Consorzio Padano Ortofrutticolo-CO.PAD.OR., Consorzio Casalasco del Pomodoro, Agricoltori Riuniti Piacentini-ARP) account for 40% of the processing of the supply chain. The biggest private processing firms (turnover of more than 50 billion Euros and more than 100 permanent employees) are located in Parma and Piacenza and most of them still belong to the founder families, such as Mutti, Rodolfi, Greci Alimentari, and Emiliana Conserve. They represent nearly half of the entire processing of the supply chain. Relevant are also the medium and little processing firms, with less than 100 employees, among which we find well-structured old family business, small tomato processing businesses, and businesses that process mainly other fruit and vegetables than tomato.

The research system plays a relevant role in the LAFS: the Experimental Station for the Food Preserving Industry (SSICA) and the experimental farms Tadini and Stuard are vital members of the IO. They carry on targeted research projects and experimentation in individual farms and make a valuable contribution to supporting the implementation of regional guidelines for integrated production.

The lead actor in the coordination of the LAFS is the Inter-branch Organisation. It does not intervene in trade within the supply chain; nevertheless, it exerts a key influence on market stabilization. It manages vertical relationships between producers and processing firms, acts as a guarantor of the respect of the agreed rules, monitors the obligation to use only tomato produced in the area, supports producers and processors to manage in a transparent way the general framework contract and the reference price agreed, facilitates the implementation and the respect of the single supply/delivery contracts as for price and terms of payment, and handles the exchange of data concerning the tomato campaign, such as origin, quantity and quality of tomato. These functions ensure relevant impacts on the stability and sustainability of the LAFS over time: this strengthens the sense of belonging, ownership, and equality of treatment among members [17,18].

3. Results: Environmental and Social Benefits (ESBs) in the Processed Tomato LAFS

Outdoor tomato production requires highly intensive soil and water management since tomato quality and yield depend both on the soil structure and on nutrients and water supply. However, the supply chain is located in one of the most important industrial and agricultural areas in Italy (the Po Valley) whose population density is among the highest in Europe, and it is hard to assess the contribution of the tomato sector to local concentration of pollutants since soil and water are under increasing pressure by a large number of other human activities, such as industry and urban development. Nitrogen pollution and water footprint of animal husbandry is also considerable (mostly

in Parma area). This makes it hard to discriminate impacts from tomato production and processing and other human activities.

Main environmental and social benefits (ESBs) investigated are healthy functioning soil and water quality and quantity, whose provision is driven mainly by increasing market demand for sustainable food products, but also supported by policies with indirect and direct focus. Soil protection and functionality and water quality and availability cannot be dealt with and understood separately, since soil structure and conditions are fundamental for decisions concerning water management, water saving, and irrigation infrastructures.

Soil functionality is essential for product quality and integrated production methods adopted to ensure food safety while allowing environment protection by means of reduced chemical inputs, as well as improved water quality. Producers, consumers, and the environment benefit from farming and pest management systems limiting the use of pesticides and reducing related risks of exposures, thus safeguarding also public health. Water consumption is concentrated in the stages of tomato cultivation (irrigation) and of manufacturing process (not only for processing but also for cooling or cleaning) and poses relevant problems of competition over the allocation of water resources (agriculture, energy generation, industry and transport, households, natural ecosystems) also in an area rich in water as the Po Valley. However, the use of water within the tomato chain is nowadays reduced by means of practices aimed at reducing water demand, such as water-saving irrigation systems. Water quantity needed is affected not only by agricultural production but also by soil quality and climate. Therefore, in order to save water and maximise both yield and quality, micro-irrigation (including fertirrigation) is the practice for effective and sustainable water management. Micro-irrigation grants uniform distribution of water and allow relevant water saving since water can be precisely regulated and tailored to the soil and plants' needs and to production and quality targets. The development of optimal water management strategies is, in fact, one of the main concerns of the tomato supply chain. First of all, yield and quality of tomato (brix level) depends on water (and nutrients) inputs. Secondly, only appropriate irrigation management can preserve soil and water quality by avoiding nitrate leaching and groundwater pollution. Furthermore, water management is fundamental also for soil and water quantity, since groundwater extraction higher than natural reload is causing depressurisation of the aquifer and a consequent serious and irreversible land subsidence problem.

The provision of ESBs related to water and soil is, therefore, delivered through productive and investment choices of the supply chain actors. Producers and processors have to guarantee production and processing viability by dealing with severe emergencies related to soil and water (mainly nitrate pollution, drought, floods, competition for natural resources) and to gain competitive advantage by meeting new consumers' demand (certified quality food, environmentally-friendly productions). Widespread use of innovation initially depended primarily on economic decisions of private actors, lured by the savings that could be made by reducing pesticides, water and energy consumption, rather than on a general focus on environmental concerns. However, fortunately, private needs coincided with increasing attention to reducing pressure on natural resources and environmental impact. Furthermore, the increasing national and international demand for high environmental performance products entailed a willingness to reward farmers and processing firms for their role in safeguarding the environment by paying higher prices for foods produced/processed under stringent rules: among other recommendations, the Statute of the Inter-branch Organisation commits all producers to follow, promote, and guarantee regional integrated or organic production specifications and all processors to reduce the impact on the environment and to reuse by-products and waste water, also for energy purposes.

Major turning points in the provision of beneficial outcomes on soil and water coincided with the adoption of major technical innovations: integrated production in the 90s and micro-irrigation in the years 2000. Further, it was public policy to foster and support the change of attitude already begun.

The European framework directive on the sustainable use of pesticides and the mandatory application of integrated pest management came into force in Italy only in 2014. Nevertheless, in Emilia

Romagna Region, the transition from conventional agriculture to sustainable agriculture had already started in the 1980s with pest management provisions, and went through successive steps that resulted in integrated crop management schemes aimed not only to reduce the use of chemicals, but also to minimise water and energy consumption. In the 1990s, regional technical standards for integrated production in industrial tomato cultivation were defined in cooperation with research centres and producers' organisations and from then on updated every year. As a result of this policy, in 2006, already 60% of the tomato was produced according integrated production rules; in 2016, it was 96% (and 4% organic).

The second innovation was the diffusion of micro-irrigation since the year 2000, when farmers started to adopt high-efficiency irrigation systems better suited to new environmental conditions. Data from the 2010 Agricultural Census show that intensification of tomato farms favours major sustainability of agricultural activities, since large farms invest more in environmentally-friendly agronomical practices and in innovative water-saving technologies and methods (Figure 3), in response to market and policy changes. By percentage, most of the irrigation of tomato farms came from groundwater and in much smaller part from water consortium (on turn or demand basis), whereas other sources, such as farm reservoirs and surface water, were of minor relevance. It is worth noticing that the percentage of farms irrigating with groundwater was equal in larger and smaller size tomato farms, as equal but to a lesser extent was the use of collective water sources. However, not necessarily high use of groundwater meant higher water consumption, since this depended from irrigations systems adopted. At 2010, the use of sprinklers was almost evenly widespread among all tomato farm size, but it was used more in smaller farms than in larger farms, whereas micro-irrigation was much less adopted by small farms and remained reserved to bigger size farms. Therefore, intensification of tomato production has been linked to the adoption of more sustainable agronomic practices and precision technology techniques which reduce the need for plant protection products and for irrigation and consequently reduce costs. Moreover, it emerges that, in the two provinces, half or more of the arable land in the tomato farms followed a crop rotation plan, showing great attention given to maintain the soil clean and fertile, to reduce the risk of pests and diseases, to improve soil mineralisation, and to enhance yield quality and quantity. Once again, the larger farms had the higher percentage of arable land under rotation plan (almost 60%). As for soil management, arable land was mainly conventionally sowed: an average of 80% of tomato farms arable land, ranging from 74% in smaller farms to 86% in farms with more than 40 hectares, and this reflected the widespread utilisation of Integrated Production schemes that require conventional sowing at 40-50 cm and then a second soil working (grubbing, vibration). Finally, it has also to be noticed that bigger tomato farms paid more attention than smaller ones to conserve and/or restore the non-productive features of local rural landscapes, such as hedges and rows, which are also important for wild flora and fauna; and even in this case, it was the largest firms that mostly improved biodiversity in agricultural land.

Anyhow, in recent years, it has become increasingly clear that water and soil issues are hard to manage at farm level, because they are influenced not only by the plant physiology but also by geological characteristics, atmospheric conditions, anthropic activities. For example, irrigation water needs grew by 20–30% due to higher temperature and heatwaves that extended irrigation season and increased evapotranspiration, whereas effective rainfalls and water level in rivers, lakes, and reservoirs decreased, and consequently, water saving has become a fundamental issue.

The issue of environmental impact and utilization of resources began to be approached not at the farm/firm scale but from a supply chain perspective. This followed the path set by several recent studies within two different lines of research focused, on the one hand, on the concept of Water Footprint (WF) assessing pressure exerted by humans on the environment, and, on the other, on the concept of "Life Cycle Assessment" (LCA) based on indicators of impact on the environment. Aldaya e Hoekstra [19] provided evidence that the processed tomato system in Emilia Romagna had a WF 30% lower than Puglia owing to an inferior consumptive and degradative freshwater use (referred, respectively, to blue and green water, that is surface/ground water and rainwater, and to grey water,

that is freshwater needed to dilute pollutants). The LCA study of Manfredi and Vignali [20], instead, showed that in order to obtain a functional unit of end product (a glass jar containing 700 grams of tomato puree), when considering only the WF, it is cultivation that contributes the most (99% cultivation, 1% processing). However, when considering the supply chain throughout four different phases (cultivation, processing, packaging and transport), it emerges cultivation contributed the most to eutrophication potential (71%) and much less to the other impacts (7–27%). It is packaging instead that contributes the most to all impact categories except eutrophication potential (41–69%), whereas processing contributed much less (6–20%) to all impact categories except eutrophication potential and ionizing radiation (2%), and finally transport contributed only 14–25% to all impact categories and 6% to eutrophication potential.

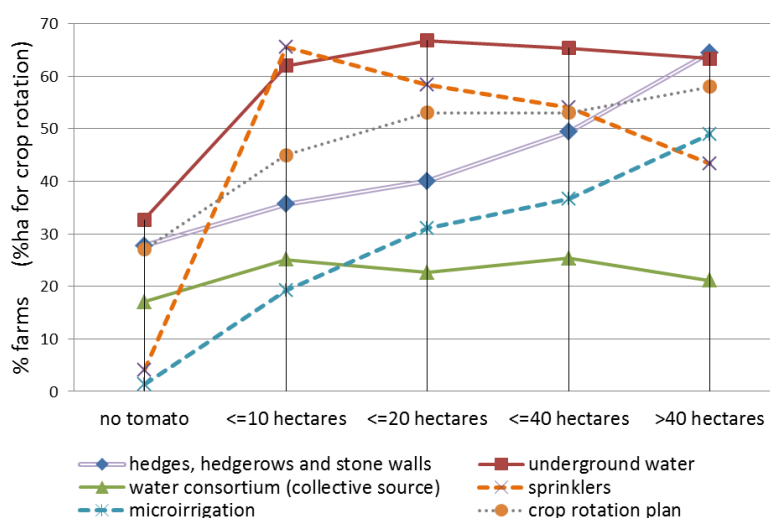


Figure 3. Key indicators of beneficial outcomes by tomato farm size in hectares. Source: our elaborations from Agricultural Census data (2010).

Further evidence of how such approaches can foster purposeful collective action of producers and processing firms and contribute greatly in terms of beneficial environmental outcomes emerged from a research project carried out as of 2010 by the University of Tuscia in collaboration with WWF. This research focused on analysis of the direct and indirect water consumption in the processed tomato supply chain, from production to packaging, of one of the most well-known private tomato industry in the area, the Mutti company. Santini and Valentini [21] adopted a fine-tuned version of the WF applied to two production stages (supply chain and operative phase) that led to assess “the contribution to water consumption of each component (. . .) in order to distinguish the causes and define potential improvement or corrective action” and to envisage “the possibility to achieve tangible progress on water resources use”. Main water withdrawal is attributed (Table 3) to the production of raw materials to obtain the end product (mostly to tomato cultivation, accounting for 82% of the overall WF, and to packaging, 11%).

Table 3. The water footprint of Mutti processed tomato (m³/ton).

Water Use	Green WF	Blue WF	Grey WF	TOTAL
Water for tomato cultivation	49.03 (15%)	114.53 (35%)	161.67 (50%)	325.23
Water for packing and packaging material production	6.43 (15%)	6.61 (15%)	30.39 (70%)	43.43
Water for transport, energy, etc.	0	0.03 (0.2%)	16.36 (99.8%)	16.39
Annual water-use for processing	0	7.87 (100%)	0	7.87
TOTAL	55.46 (14%)	129.03 (33%)	208.42 (53%)	392.92

Source: adapted from Santini, Valentini, 2015 [21].

However, even if not directly managed by Mutti, the study suggested that WF reduction potential of Mutti's products could be carried out by both stimulating and supporting the producers to adopt practices (pesticide/fertiliser use and irrigation techniques) with lower water consumption impact and improving the choice of the products used for the packaging/packing phases.

Experiments conducted in 2011 by two tomato suppliers confirmed the hypothesis: innovative irrigation methods (reduction of number of irrigations and lower quantity of water provided for each irrigation turn) resulted in an overall water saving of at least 10% and adoption of fertirrigation (average 25% reduction in fertilisers per hectare) resulted in a yield increase of more than 8.5%. The authors recognise the lack of WF literature "*individuating benchmarks regarding reduction objectives to be pursued and strategies to be adopted for successful objective achievement*" but are confident on the fact that "*the pioneering work done allows (. . .) to make general and preliminary evaluations, which can be verified and reviewed, and can pave the way for a commitment to a WF reduction*" [21].

Certainly, the Mutti company has played a forceful role in the supply chain WF reduction by providing part of its tomato suppliers with training on the use of innovative techniques and with soil moisture/fertility detectors and smart irrigation controllers and by setting up weather tracking systems and managed to reach a reduction of 4.6% of the WF (−1,000,000,000 litres of water in the period 2012–2016 compared to 2010 baseline levels, notwithstanding the increase in production and processing), far beyond the initial target of −3%. Innovation and quality are the core of Mutti's strategy, together with sustainability. Mutti was the first firm to obtain in 1999 the regional certification of Integrated Production. In 2001, it obtained the GMO-free certification. In 2010, it started to collaborate with the WWF and carried on two projects, one on water footprint (already discussed above) and one on carbon footprint (aimed at reducing CO₂ emissions). In 2012, it engaged in a project on traceability of raw materials and, in order to reduce CO₂ emissions, installed a solar plant and also a concentration plant. And, in 2016, it completed the certification process for the International standards.

4. Discussion: The Role of Main Drivers

4.1. The Role of Collective Action

The strength of the LAFS is to be found in the collective action of producers and processor that ensures cohesion and programming and in the inter-branch agreements/contracts that ensure profitability by lowering transactions costs. The IO monitors the trading by gathering all the contracts signed and all the delivery certificates, by verifying production and quality, and by checking the management of eventual contracts for processing, etc. Agreed rules and contracts underpin the cohesion of the IO partners. Processed tomato is produced on a contractual basis and tomato trading between Producers' Organisations and processing firms is totally transparent. In particular, commercial relationships within the IO are regulated by general rules contained in a Framework Contract and by specific contractual conditions set in detailed Supply/Delivery Contracts between producers and processors, and between producers and self-processing cooperatives. All the trading takes place between the members of the IO, except for the limit of 10% of the tomato under contract (in order not to hamper risk differentiation). Moreover, non-compliance with the agreed rules in force on quantity and quality is penalised in different ways, ranging from fines to exclusion from the IO.

The definition and respect of contracts and of agreed rules, in fact, bind together producers and processors. The respect of quantities and quality agreed in contracts (no pesticide residues or chemical ingredients, brix level, consistency, flaws, etc.) guarantees prices and incomes and a premium/penalty on price is used as an incentive/deterrent against misconduct (Table 4). Single producers are not allowed to contract directly with the processing industries outside the POs and processing firms interact with producers and all negotiations are channelled through the Producers' Organisations.

Nevertheless, the collective action and the inter-branch agreements/contracts proved to be also vulnerable. Lately, in fact, the stability of the supply chain linked to timing and respect of contracts began to waver. During the 2016 campaign, the two crucial elements of programming failed: time limit

for contracts and time limit for payments have not been respected. Producers found themselves in weaker negotiating positions, since, due to unsold surplus of previous years, processing firms required to reduce tomato cultivations in order to avoid overproduction crisis and keep the price level high. Producers and processors could not reach a timely agreement and contracts were only signed in June, when the tomato was almost ready for harvest. Therefore, since tomato production exceeded tomato under contract, a programming penalty of 2.25 Euros per ton was applied to every producer on the reference price agreed (Table 4). Moreover, one of the biggest producing and processing cooperatives set in Parma (Consorzio Padano Ortofrutticolo-CO.PAD.OR., 4000 hectares cultivated under tomato, 300,000 tons of tomato processed yearly) incurred in severe financial setbacks and paid to member farms only 35% of the sums due for the tomato of 2015 and has not paid for the tomato of 2016 at all.

Table 4. Tomato produced, under contract and delivered within the Inter-branch organisation (IO) (tons, Euros).

Industrial Tomato	2011	2012	2013	2014	2015	2016
Tomato production in northern Italy (t)	2,562,828	2,370,917	1,889,374	2,322,065	2,623,514	2,773,146
Yield (t/ha)	71.24	70.85	64.76	65.08	67.36	71.85
Reference price * (€/t)	88.00	84.00	85.00	92.00	92.00	85.20
Weighted average payment rate (€/t)	96.36	90.52	96.95	89.95	94.68	92.96
Weighted average final price (€/t)	84.80	76.04	82.41	82.75	87.11	79.20
Programming bonus/penalty* (€/t)	0	0	0	1.00	0	-2.25
Total final price to producer (€/t)	84.80	76.04	82.41	83.75	87.11	76.95

* CREA survey. Source: our elaboration on data from IO and from own survey.

These recent events witness that, despite the strong effort in the governance by the IO and all stakeholders, the LAFS can still be vulnerable under the pressures of the global competition. However, thanks to the mediating role of the IO, the tomato stakeholders managed to balance the different negotiating position and to match demand and supply on actual needs of processing firms.

4.2. The Role of Public Policies

Farmers and processing firms use a broad spectrum of policy instruments to support organisational and technical innovation and to switch to more sustainable production and processing practices and means. Public support was firstly regulatory through the agricultural policy of the region; secondly, it was of financial type through the different measures of Common Market Organisation (CMO) and RDP (direct and indirect focus on ESB provision); and thirdly, it was conveyed also through research and technical advice of specific research programmes and the technical regional advisory structures. Agro-environment-climatic measures are mainly financed through the CMO (CAP 1st Pillar) and the Rural Development Plans (CAP 2nd Pillar). Further, integrated production had broad-based support from both CMO and RDP (Regional Development Plans).

It was not possible to single out all of the financial resources allocated to the tomato sector, however, from the analysis of some of the payments made to representative CMO and RDP beneficiaries (Producers Organisations, cooperatives and Associations of Producers Organisations), it shows that the great majority of resources (97%) come from the CMO (Table 5). Furthermore, even if it is a tiny amount in comparison with CMO and RDP, it is important to mention the resources made indirectly available to the tomato supply chain from the regional law for promotion of development services to the agri-food system (Law 28/1998), that financed research projects strategically important for environment and economic sustainability of the LAFS (concerning mainly technological and nutritional characteristics of industrial tomato, varietal experimentation, sustainable system, tomato traceability management, reuse of processing firms waste).

Crucial impulse has been given by the reform of the Common Market Organisation of the Fruit and Vegetables sector (at the European level), which forced tomato farmers organisations and processing firms to set up the Inter-branch Organisation [17]. The CMO reform involved, in fact, the transition

from a top-down spending policy coordinated and managed from the EU to a bottom-up governance model where the decision-making is transferred to a local coordination mechanism (the IO).

Table 5. Main resources * for the processing tomato sector (payments 2002–2015, €).

Policy Instruments	Total
Processed fruit and vegetables coupled subsidies	206,342,432
Fruit and Vegetables Operational Programmes	80,207,559
Total CMO	286,549,991
Processing and commercialisation of agricultural products	5,677,040
Value added of agricultural production	6,674,012
Information and promotion activities	30,800
Development of new products, processes, technologies	613,590
Total RDP	12,964,643
Research Projects financed by Regional Law n, 28/1998	1,957,311
	301,471,945

* Resources referred to some of the payments made to representative Common Market Organisation (CMO) and Regional Development Plans (RDP) beneficiaries (Producers Organisations, Cooperatives and Associations of Producers Organisations). Source: our elaboration on data of the regional Payment Agency AGREA.

From 2000 onwards, more than three quarters of the CMO concern coupled subsidies to tomato producers (72%), and another relevant share (28%) is allocated to Operational programmes of Producers Organisations and their Associations for production programming (mainly through Integrated Production), supply and marketing concentration, cost optimization, and farm gate prices stabilisation (Table 5). As for coupled subsidies, with the reform of 2007, aid was decoupled from tomato cultivation and linked to effective sales of tomato from recognised POs to processing firms. From January 2014, the new CMO came into effect and from 2015 tomato could benefit again of coupled aid, but much lower in comparison with the previous one, since direct payments had to converge to a national unitary value.

In conclusion, during the first decade of 2000s, CAP subsidies under the 1st Pillar were substantially reduced for the tomato sector, and they have not been compensated by any other form of CAP or regional support. This forced the tomato sector to adapt through a pro-active strategy, more oriented to cost-reduction, sustainability and quality, aggregation, and cooperation of actors operating in the sector.

Further, the agricultural policy of Emilia-Romagna played an important role in supporting the adoption, adaptation, and promotion of integrated production by compensating consequent reduction in yield and increase in production costs, even if resources available were far below CMO ones. Emilia Romagna Region encouraged tomato producers to adopt the regional guidelines on integrated crop management by providing over time full compliance with environmental aid envisaged by the CMO Regulation, with specific measures of the Regional Development Plans (RDP), with Regional Act n.29/1998 financing research, experimentation, supervision, and technical support, with Regional Act n.28/1999 introducing the promotion of agricultural and food products obtained with methods and practices respectful of the environment and of human health, and by the establishment of the regional eco-label named *Qualità Controllata—QC* (Controlled Quality), which foresees also mandatory control operations carried out by accredited certification bodies in accordance with standard EN 45011.

Again, the effect on ESBO provision is indirect, but contributed significantly to the widespread diffusion of environmentally-friendly attitude of farmers and processing firms. Emilia Romagna Region adopted supervised pest control in the early 1970s (national guidelines were only adopted in 1987), formalised integrated production schedules, and designed Nitrate Vulnerable Zones (NVZs) in 1997 (even before national transposition into national law of Nitrate Directive). Moreover, in water use regulation, Emilia Romagna has been particularly pro-active: it financed from 1998 onwards research on water saving systems and varieties, cultivation techniques, and provided technical assistance,

information, dissemination of results, adopted regional implementation acts on water, soil and mines in 1999, and on Strategic Environmental Assessment in 2008.

In general, policies played a very relevant role in promoting and supporting collective actions among producers and between producers and processing firms (creation of Producers' Organisations and of the Inter-branch Organisation), and in complementing private schemes (integrated production schemes), in supporting individual actions (cross-compliance guidelines, regional measures supporting improvements in agricultural production, investment in technological innovation), ultimately fostering the adoption of more environmentally-friendly practices and innovations.

The effect on the provision of environmental and social beneficial outcomes in the CMO case is indirect, but it is as relevant as direct outcomes since aggregation of producers in Producers' Organisations (initially) and aggregation of producers and processors in the IO (later on), consolidated the adoption of Integrated production and fostered quality certifications of producers and processing firms. In the RDP case, instead, the effect on ESBO is both direct and indirect. Agro-environment-climatic measures spurred widespread use of integrated production and measures for investment in tomato food processing promoted the introduction of new products, processes, and technologies (including water saving technologies).

4.3. The Role of Private Schemes

Together with governance arrangements and policies, private schemes form an integral part of the competitive strategy of the LAFS. Acknowledged reputation and quality are the distinctive feature of the processing tomato supply chain of northern Italy, since everyone involved in the production chain complies with these requirements and maintains high moral standards and business ethics. Labelling and certifications are the means chosen to derive maximum benefit from attention to quality and to environmental issues. The tomato sector is highly certified to meet different needs: to comply with regulations/laws, raise market profile, differentiate from competitors, grant certified quality, and reduce consumers' uncertainty. However, respect of ethical standard of production and attention to consumer and environment protection does not mean necessarily higher competitiveness, since they result in higher costs and prices.

All producers/POs and processing firms of the tomato supply chain use certifications as a means of promoting the high value of their products on the national and international market. Few certifications focus directly on the product and are referred to intrinsic qualities and to conformity to certain verifiable requirements (100% Italian, organic, Genetically Modified Organism-GMO free). Some others are referred to entire production processes. The respect of codified production schemes proves the use of environmentally-friendly methods throughout the production phase.

System certifications are more numerous and focus on the entire supply chain and demonstrate enhancement in management, environmental, ethical, and food security performance. For example, ISO 22005 gives evidence of the existence of traceability system that allows to trace back, not only the product, but also the interventions to which it was subjected and its single components, and enables determination of the history or origin of the product and identification of all responsible organisations in the feed and food chain. Some certifications are required to processing firms and retailers from large organised distribution networks for exports in certain countries and are mainly referred to hygiene and food safety requirements (HACCP methodology, Good Manufacturing Practice, Good Laboratory Practice, Good Hygiene Practice, and others), etc.

There is evidence that a virtuous circle occurred. Private economic rationale and public policies together favoured the adoption of European, national, and regional protection measures, the respect of legislative and quality standard requirements, the adoption of innovative resource-saving farming and irrigation practices, the setting of additional voluntary environmentally-friendly contractual rules, the accession to standards and certifications guaranteeing quality sustainability, as well as complete traceability. However, at the same time, great attention to quality, traceability, innovation, and environmental factors determined strong product differentiation that provided added value for

consumers and competitive advantage over other competitors, notwithstanding higher production and processing costs and prices. Moreover, in turn, supply chain integration allowed reducing transaction costs, lowering the threshold for product and process innovation costs, facilitating access to expertise and technology.

5. Conclusions and Policy Implications

In this work, we examined the provision of environmental and social benefits in a specific LAFS characterised by densely cultivated, industrialised, and populated areas and identified with the core of the processing tomato supply chain of northern Italy (Parma and Piacenza). The methodological frame is based, on the one hand, on the concept of socio-ecological system introduced by Ostrom, and on the other hand, on the literature focusing the so-called localised agri-food systems.

The effects of the local system on the provision of environmental and social benefits depend on the interplay of three major drivers: market mechanisms, collective action and public policies.

A fundamental impulse to the provision of ESBs was given by market mechanisms. Driven by input reduction (cost saving practices/techniques) and increasing demand for social and environmental sustainable food products, private initiative led to continuous innovation in production and processing practices and techniques and to generalised voluntary participation in recognised and independently certified quality and traceability schemes. Private schemes form an integral part of the competitive strategy of the supply chain. Promotion and implementation of private schemes has been handled by producers' and processing organisations in order to enhance quality and foreign market penetration. Integrated production and precision farming practices have been widely adopted primarily due to economic reasons (lower need for agricultural inputs means lower input costs). Labelling and certifications are the means chosen to derive maximum benefit from attention to quality and to environmental issues. The tomato sector is highly organised to meet different needs: to comply with regulations/laws, raise market profile, differentiate from competitors, grant certified quality, and reduce consumers' uncertainty.

In this context, policies played two different functions. The first was to stimulate new adapting strategies in the tomato sector, by reforming the system of support in 2014–2020 and adopting the contract systems, based on POs and IO. The second function was supportive of changes. The CAP funded initially the formation of POs and, through their operational programmes, quality certification, food safety guarantees, and environment-related measures, and then fostered the expansion of the tomato sector and the attention to environmental and social sustainability. The CAP and the regional agricultural policy incentivised private schemes and fostered the adoption of more environmentally-friendly practices and innovations and influenced beneficial outcomes on soil and water resources both in a direct and indirect way.

However, the fundamental role has essentially been played by collective actions, coordinated and supervised within Producers Organisation at first and within the District and the Inter-branch Organisation at a later stage. Cooperation/collaboration climate is a cultural feature in this agri-food system and favoured collective actions aiming at the creation of POs and District/IO and the maintenance of such complex governance over time. This climate is strongly rooted in the tradition of cooperatives in the Emilia-Romagna agriculture since the last decades of 1800. These socio-political features are highly-specific to this area, and this can explain why the creation of IO has met so many difficulties in those southern regions (Campania and Apulia) highly specialised in tomato, where a scarce level of cooperation and trust between producers and tomato industry still exists. Collective actions in Emilia-Romagna areas allowed tapping the full potential of market drivers and policies. Local producers and processing firms, through the IO, defined a system of shared rules that directly strengthened mutual trust and market (price/income) stability and indirectly favoured stronger emphasis on the quality and sustainability of products (crucial elements for the price-setting mechanism).

These findings have strong implications for the CAP reform post-2020, on which some proposals have been recently launched by the European Commission in the Communication on the Common Agricultural Policy post-2020. First, these findings highlight the need to carefully consider the value chain and its organisation as one of the main tool to convey public policies consistent with the provision of public goods. Second, they stress the importance of positive interplays between public policies and private mechanisms, that can work efficiently and in a complementary way when well-targeted at the appropriate territorial scale. Third, they suggest the need to design a proper policy mix, taking into account both first and second pillar measures. It seems particularly interesting, in this regard, the proposal to introduce at national level a CAP strategic plan, where both pillars are coordinated and finalised towards common goals in operational terms. From this perspective, the measures linked to common market organisations, since they have been so decisive in the tomato localised system, will require closer coordination with the direct payments and the rural development measures.

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