Sustainable Collective Innovation in the Agri-Food Value Chain: The Case of the “Aureo” Wheat Supply Chain

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Abstract: This paper contributes to the theoretical debate in agri-food economics on sustainable innovations. Specifically, it aims to define an interpretative model of sustainable innovation processes conceived at the supply chain level, and the determinants promoting these processes. The paper also proposes a best practice of sustainable collective innovation, namely the “Aureo” wheat supply chain. Sustainable collective innovation requires the commitment and involvement of all actors of the agri-food supply chain, while its effectiveness depends on the governance models adopted. The study findings validate the proposed theoretical framework, highlighting several economic, social, and environmental benefits that the process can provide. The results contribute to the debate on the topic, providing useful insights for practitioners and policy-makers.

Keywords: sustainable innovations; sustainability; governance; contracts; shared value

1. Introduction

The economic and political-institutional environment and the deep social changes which took place at the end of the last century, encouraged companies to implement sustainable innovations [1] as a strategy of product differentiation [2–5]. This process also affected the agri-food sector, which was struggling with issues related to: (i) the rising competitive pressure due to market globalization and liberalization; (ii) environmental pollution and climate change; (iii) the rising societal awareness of the link between food, health, and environment [6]. The current attitudes of consumers towards environmental, social, and public health issues have prompted them to evaluate the social costs associated with the production of goods and services purchased. The latter are widely considered by citizen-consumers in their purchasing decisions. They in fact assess both tangible and intangible food attributes such as the ethical, social, and environmental impact related to food production [6–8]. To this extent, along with food products’ organoleptic characteristics (e.g., appearance, taste, etc.), the citizen-consumer is more and more interested in knowing the environmental and social impacts of the products (i.e., production, transformation, and commercialization). Specifically, the citizen-consumer favors safe and sustainable food products and is willing to reward socially responsible companies and supply chains in her/his choices [8–10]. As for the intangible attributes, food embeds heritage, tradition, and local knowledge, which play a crucial role for the citizen-consumer. Further, they define the uniqueness of a product as well as those of its production area.

In light of these societal demands, innovation in the agri-food sector is mainly oriented towards the production of more sustainable, healthier, and safer products, able to express uniqueness and typicality [11]. Innovation has become a complex process that, rethinking the governance models, involves all actors of the agri-food supply chain. The effectiveness of this process depends on the
behavior and choices of the different actors operating at the various stages of the agri-food supply chain. As a consequence, a potential risk is the emergence of opportunistic behaviors that may undermine the innovation process and cause the failure of the product on the market.

Most of the literature on innovation in the agri-food sector investigated companies rather than the whole supply chain. In particular, it unveiled the determinants encouraging the innovation processes [3,12–14].

This paper aims to fill the gap related to the lack of studies on sustainable collective innovation processes. To the best of our knowledge this is the first study that investigates sustainable innovation through a collective approach. The latter is a competitive collective strategy that implements sustainable innovations (either product or process innovations) at each stage of the value chain to create a new or reformulated product characterized by tangible and intangible attributes. The study explores innovation according to a collective model, posing the following research questions:

- RQ1: What are the factors determining a sustainable collective innovation process?
- RQ2: Which tools can make a collective innovation process effective?

Addressing the above-mentioned research questions will offer useful insights for companies in the agri-food supply chain to design sustainable collective innovation processes in an effective way. The study has implications for policy makers as well. Indeed, the findings suggest policy tools to foster sustainable collective innovation processes.

The paper is organized into three sections: Section 2 outlines the main literature on innovation in the agri-food sector and describes a conceptual framework of sustainable collective innovation. Section 3 introduces a case study that enables the validation of the theoretical framework, highlighting advantages and positive externalities of the sustainable collective innovation model. Lastly, the final section summarizes the main conclusions and the study’s implications.

2. Theoretical Background

2.1. Innovation in Agri-Food Sector

In the agri-food sector, innovation is crucial in strengthening companies’ competitiveness and their position in the market [2–7,15–17]. Considering the relevance of the sector both in terms of production and employment, innovation is indispensable. [18–20]. Further, agri-food is also responsible for the development of other sectors closely related to it [21].

Most of the literature on innovation in agri-food focuses on the determinants favoring its implementation. Grunert et al. [3] deeply contribute to this literature, identifying two main drivers of innovation: research and development (R&D) activities and market orientation. Other drivers of innovation identified in the literature are linked to both internal and external factors of the company such as: size [16,22], location [5,23–25], the market power of dealers [26,27], the quantity, quality and organization of the human capital employed in the company [5,13,16,28], membership in networks of enterprises [29–31], as well as the role of the entrepreneur, especially for SMEs [13,20].

A recent stream of research focuses on the analysis of the relationship between innovation and cooperation, drawing insights from the Open Innovation model proposed by Chesbrough [32,33]. In the agri-food sector, cooperation is considered particularly advantageous, enabling the company to easily internalize externally developed knowledge and technologies. Specifically, collaborating with individuals belonging to the same sector allows the sharing of similar or additional knowledge that contributes to speeding up innovation processes [34]. Conversely, collaboration with companies from other sectors and universities would offer the possibility of transferring knowledge useful for improving product quality and, more generally, increase in the added value [35–40].

Companies’ increasing orientation towards the implementation of environmentally friendly innovations, also known as eco-innovations [1], led some authors to investigate their determinants. The debate on eco-innovations has developed only recently [41] and studies on the agri-food
sector are still limited. Triguero et al. [14] conceptualized a theoretical framework considering the main determinants of eco-innovations identified in the literature, namely: the market pulls, the regulatory push/pull, and the technology push. Specifically, the increase in consumer demand for sustainable products and the greater willingness to pay were identified as a market pull towards eco-innovations [42,43]. Other scholars investigated tax rules and incentives as possible drivers of eco-innovations. Indeed, companies would benefit more from adopting sustainable technologies rather than incurring costs for failure to comply with the rules [41,44]. Lastly, technology push can be developed on the basis of internal company resources or through cooperation and/or strategic alliances with different stakeholders (customers, suppliers, universities, and research centers), representing a stimulus to eco-innovation [45–47].

In addition to the studies on the determinants of eco-innovations, some research has instead focused attention on specific sectors, such as pasta, investigating how sustainable innovations of product [48,49] or process [50] can contribute to reducing the ecological footprint of the sector. Furthermore, some of these studies also revealed consumer preferences for pasta produced with local raw materials and with a low environmental impact [51].

Finally, innovation has also been analyzed in relation to the governance mechanisms. According to Karantininis et al. [52], the ability to introduce innovations improves when the control of the supply chain is exercised by the downstream companies, which tend to implement vertical integration processes. This relationship is more effective when it comes to product innovations. The tendency to vertical integration in these cases could be linked to the need for investments in specific assets, completely eliminating the hold-up problem [53]. In contrast, when the control of the supply chain is entrusted to the upstream manufacturers, the rate of innovations would seem to be very low. By contrast, Zilberman et al. [54] proposed a theoretical framework describing the main problems and the related governance strategies that a company can adopt when it decides to introduce an innovation (product, process, or organization). They identified contract farming as a tool to support companies that want to control quality and retain greater added value.

Although some authors have highlighted how agri-food supply chain governance can influence innovation processes, the extent of this relationship is still unknown [52]. In particular, this positive relationship is clear when the governance mechanisms enable distribution of the value created by innovation (governance value chain) along the supply chain, identifying the form of governance as a determinant of the innovation and value creation process [55,56]. In addition, governance models based on shared value help to create a good climate of mutual trust that allows agents to manage contractual relations with a certain flexibility, making contracts simpler and less expensive [57,58].

Although some studies clearly show that innovative processes cannot be limited to company boundaries [14,38,59–61], there is still no analytical approach in the literature interpreting innovation as a collective process.

2.2. “Sustainable Collective Innovation” in Agri-Food Value Chains: A Conceptual Framework

In recent years, empirical evidence shows that the innovation processes implemented in the agri-food supply chains have undergone a significant evolution. This is due to the need to face up to new challenges, and to address the current citizen-consumers’ requirements regarding food quality, safety, and environmental sustainability of production processes [6,51,62]. These attributes, together with the ethical aspects of the production processes (i.e., respect for workers’ rights, fair wages, etc.), have been internalized in the systemic agri-food supply chains’ perspective, considering all the choices and operations that take place within the value chain, starting from the raw materials adopted to the transformation process that leads to the creation of the final product [48,50,63]. The current citizen-consumers’ needs are among the main drivers of the agri-food supply chains’ innovation process. The agri-food companies, introducing sustainable innovations in different stages of the value chain, can reposition themselves on the market and meet the rising demands of society. In order to be
effective, innovation processes require a collective approach based on integration strategies (i.e., vertical and horizontal) and on coherent and synergistic behaviors of all economic actors involved.

By adapting the theoretical framework of Triguero et al. [14], in this study we proposed an interpretative model in which the sustainable collective innovation processes are driven by citizen-consumers’ demand (i.e., new citizen-consumers’ demand pull) while their effectiveness relies on: (i) the structural characteristics and internal resources of the supply chain; (ii) the degree of integration between the various stages of the supply chain and the cooperation between the subjects of the same supply chain, companies from other sectors, universities, research centers, and other local stakeholders; (iii) the supply chain governance; (iv) the policies (Figure 1).

**Figure 1.** The determinants of sustainable collective innovations in agri-food supply chains. Source: Our elaboration.

Some agri-food supply chains have leader companies with adequate financial and human resources enabling development independently of sustainable knowledge and innovations to transfer to the supply chain. However, the agri-food sector is mainly represented by supply chains with fragmented structures characterized by many SMEs without R&D departments. Thus, the resources needed to start processes of sustainable collective innovation depend on the degree of integration, both between the actors operating in the different segments of agri-food supply chains, and between the agri-food supply chain and the territory, through the consolidation of cooperative relationships and strategic alliances. Cooperation with companies from other sectors and with research institutions (universities and/or research centers) favors access to knowledge and technologies for the development of sustainable innovation. In addition, when cooperation extends to other local stakeholders such as institutions, local bodies, and trade associations, it stimulates the resolution of issues related to the context and improves the level of fixed social capital. The latter facilitates the development of the territory and the relations among the different actors operating in the agri-food supply chain [64]. However, these integration and cooperation processes mostly do not take place autonomously but are favored and supported by policies. In fact, several policies (e.g., Horizon 2020, Rural Development Programs, etc.) aim to encourage aggregation and cooperation between companies, research bodies, and other local stakeholders, to convey knowledge and innovation in the supply chains, in order to improve environmental sustainability and to reduce the costs of production processes. A further factor is represented by the governance mechanisms established between the players in the food supply chain. The more these mechanisms tend to distribute and share the value created by sustainable innovations, the easier it will be to involve them in the supply chain.
Asymmetrical distribution of value along the agri-food supply chain is common, with consequential benefits for companies holding the leadership in the market [65]. In sustainable collective innovation processes, where the agri-food industry maximizes the profit, for instance centralizing the value created by the innovation, the companies upstream of the supply chain (e.g., farms) may show little interest in making specific commitments to implement sustainable innovations, adopting opportunistic behaviors. The latter would negatively affect the quality of the final product, eliminating the benefits of innovation. A possible solution may come from the vertical integration of some phases of the value chain [66]. However, the vertical integration process is convenient mainly for the downstream production phases. This would be not very efficient for the upstream phases (production of raw materials), due to the severe fragmentation of the farms, or for the close link between the quality of the raw material and local traditions/knowledge that the vertical integration process would break. In addition, vertical integration of the upstream phases would entail excessive financial costs that the agri-food industry may not be able to sustain, as well as a useless tightening of the organizational structure [54]. To overcome these limitations and ensure the effectiveness of sustainable collective innovation, the agri-food industry has to adopt flexible, fair, and inclusive governance models, able to ensure the adequate sharing of the value created by the innovations implemented, and encourage all actors in the supply chain to adhere to their commitments.

To sum up, as shown in Figure 1, the new citizen-consumers’ needs (tangible and intangible) are vital to bring out the latent demand for innovation, while the other elements and their interaction are crucial to determine the effective adoption. Therefore, adopting a sustainable collective innovation requires implementation within the framework of a competitive (collective) strategy. The latter requires the leadership of a leading company, which operates downstream of the value chain. As the economic actor closest to the market and able to meet citizen-consumers’ needs, it is also the one that can promote governance mechanisms based on a fairer distribution of the value created [55,58]. Such governance mechanisms designed will encourage coherent and correct behavior by all the intermediate operators (PTi) and farms (Fi) of the supply chain (Figure 2).

As for the activation and management of collective innovation strategies, governance not only represents a set of rules useful for regulating trade along the supply chain and minimizing transaction costs [66,67], but it also takes on a completely new role becoming the driver of effective adoption of sustainable collective innovation within the value chain.

2.3. Methodology and Study Design

To validate the proposed interpretative model, we used the case study methodology. This methodology is particularly suitable in this exploratory phase, because—as demonstrated in the literature [68]—it is suitable to validate a new interpretative model. This methodology enables
the analysis of a unique case [69,70], highlighting its peculiarities and uniqueness, within the particular economic and social context of reference [71].

The case study investigated explores the wheat supply chain and an innovative project concerning the “Aureo” varietal implemented by Barilla. The latter is one of the most important pasta factories in the world, deeply focused on sustainability, and with a business model that has attracted the interest of several scholars [64,72–74].

The choice of the “Aureo” project, as a case of successful sustainable collective innovation, enables validation of the proposed theoretical framework and highlights the positive impacts generated at economic, environmental, social, and reputational level.

The study relies on both primary and secondary data. The latter were acquired from the websites of Barilla and the company brand Voiello, their annual sustainability reports, and press releases. The primary data were collected from the “Aureo” wheat supply chain of Campania Region by administering a semi-structured questionnaire to the main intermediary agent in the area. The intermediary agent supplied most of the wheat to the Barilla pasta factory for the production of Voiello pasta. The questionnaire aimed to investigate the different aspects defined by the framework, and data were collected through a face-to-face interview in which the main topics were addressed, and a few telephone interviews to investigate in depth some topics not mentioned in the questionnaire. The main topics addressed in the questionnaire were: (i) the sustainable innovations (product and process) introduced by the project in the different stages of the value chain; (ii) the degree of involvement of the actors involved; (iii) the incentives established by the governance model to guarantee fair behaviors between the actors operating in the primary stage of the agri-food supply chain. The telephone interviews enabled the collection of further information about the agricultural phase.

3. The Case of “Aureo” Wheat Supply Chain

3.1. The Company

The Barilla pasta factory, founded in Parma in 1877, is one of the foremost Italian companies in the food sector, as well as a global leader in the pasta market, producing more than one million tons each year. The company has 28 production plants (14 in Italy and 14 abroad), with a turnover of 3483 million euros in 2018 and a total production of about two million tons, exporting to more than 100 countries. In addition to pasta, the company also produces sauces and bakery products; while along with the Barilla brand, the company holds 10 other brands, including Mulino Bianco, Voiello, and Wasa.

The company’s recent strategy, summed up by the slogan “Good for You, Good for the Planet”, is oriented to the production of healthier food from sustainable and inclusive supply chains. Specifically, the company encourages responsible behavior at all stages of the supply chain in order to improve the efficiency of the production processes, reduce greenhouse gas emissions and water consumption, and promote more sustainable farming [64].

3.2. The “Aureo” Wheat Supply Chain Project

The current citizen-consumers’ needs have prompted the Barilla pasta factory to produce a reformulated healthier pasta, obtained exclusively from local sustainable supply chains. This innovation also met the desire of Barilla to relaunch the brand Voiello, the old Neapolitan brand acquired by the company in 1973.

The first step taken by Barilla was to identify a variety of durum wheat able to ensure high technological parameters (i.e., protein and strength of gluten), and to face climate differences of the Italian territory.

Since Barilla did not have in-house expertise to identify a wheat variety with these characteristics, it started a research and collaboration project with the seed company Produttori Sementi Bologna (PSB). This collaboration led, in 2009, to the selection of the “Aureo” wheat varietal. It is a varietal
obtained through traditional means that, along with the main characteristics for the production of high-quality pasta, is also less water-demanding and does not require irrigation.

Furthermore, in 2009, Barilla established a collaboration with Horta, a University of Piacenza spin-off, to identify sustainable innovation processes aimed at reducing environmental impacts at the primary stage accounting for more than 60% of the pasta ecological footprint.

Since Barilla did not directly monitor the primary phase, it transferred the innovation to the top intermediary agent in Campania. The latter was asked to identify farms available to start the trial. As emerged during the focus groups, the intermediary had difficulties involving farms in the experimental project, due to the investments needed and the lack of incentives.

The involvement of farms to create a local supply chain was achieved through the Integrated Projects for the Food Chain (IPFs), co-financed by Campania Region’s Rural Development Programme (RDP) 2007–2013, Measure 124. The IPFs were designed to: (i) encourage the integration and development of local agri-food chains to increase the overall competitiveness of the agri-food sector; (ii) encourage cooperation between companies and research institutions to convey sustainable innovation technology and increase the quality of agri-food production; (iii) create and/or strengthen relationships among several actors of the supply chain.

The IPFs called “Innovare con Aureo” were financed in July 2010, for a total amount of more than 15 million euros. Apart from the Barilla pasta factory, the project included 440 farms grouped in a consortium located in the provinces of Benevento and Avellino, four intermediary agents, two university departments [75], some professional associations, and local public authorities.

The project tested the cultivation of the “Aureo” wheat variety, along with sustainable process innovations for the primary stage, and paved the way for further innovations to implement in other stages of the value chain. Universities verified the chemical-nutritional characteristics of the “Aureo” wheat variety to improve its genetics and maximize the production potential in the different cultivation areas. The analysis of sustainable impact highlighted the socio-economic and environmental benefits derived from the introduction of the “Aureo” wheat variety, attracting the interest of other farms located in the territory. To create the basis for the establishment of a dense network of relations between Barilla and other economic operators in the supply chain in Campania, the project involved professional associations and some local public authorities.

As the theoretical framework pointed out, the “Aureo” project confirmed that the Campania Region’s RDP played a key role in the process of integration and cooperation of the supply chain. However, the overall effectiveness of the sustainable collective innovation process has been ensured by the governance mechanisms tested during the implementation of the project. These governance mechanisms, based on a fairer and shared distribution of the value created by innovation, encouraged the actors of the supply chain to adopt sustainable innovations at the different stages of the value chain.

Currently, the “Aureo” wheat supply chain has been extended to other Italian regions such as Lazio, Abruzzo, Molise, Puglia, Basilicata, Calabria, and Sicily, as well as all of Campania. Several stockpiles and thousands of farms are part of the supply chain and provide the pasta factory with a total of 100,000 tons of wheat per year. Moreover, in order to limit the ecological costs related to the procurement of raw materials, the “Aureo” certified seeds are provided by farms within the same supply chain. The first and second processing phases are managed directly by Barilla through the mill of Altamura (Bari, Apulia Region) acquired in 1974, and through the production plant of Marcianise (Caserta, Campania Region) dedicated to the production of Voïello pasta.

3.2.1. The Sustainable Innovations in the “Aureo” Wheat Supply Chain

The agricultural phase. Sustainable innovations for the agricultural phase consist of the adoption of a “Cultivation Decalogue” and a Decision Support System for the cultivation of “Aureo” variety certified seed that was defined with Horta. The “Cultivation Decalogue” provided basic rules in order to preserve wheat quality; while the Decision Support System, called “granoduro.net”, supported farmers’ decisions from sowing to harvesting, by the collection, organization, and processing of soil and
weather data. “Granoduro.net” is powered by a dataset coming from automated agro-meteorological station networks located in the production areas.

To preserve the sustainability of the production, the Decision Support System provides input to farmers about nitrogen fertilization in order to reduce runoff. As for the plant protection treatments, the System suggests carrying them out only if meteorological conditions may cause the onset of plant diseases.

Therefore, “Granoduro.net” enabled farms of the “Aureo” supply chain to move from a model that does not consider cultural needs to a sustainable and precision agriculture able to maximize grain yield, rationalize the use of chemicals (i.e., fertilizers and plant protection), and minimize the consumption of natural resources (i.e., water, soil, and energy).

Despite its apparent complexity, the Decision Support System did not require specific technical knowledge and was easily accessible to everyone. This characteristic is crucial especially in Southern Italy where farmers are older and less educated. These factors, along with farm fragmentation, low financial resources, and inadequate access to credit, often hinder the spread of innovation [76].

All the investments made by the farms for the implementation of the project, were co-financed by the policies (i.e., RDP), highlighting their role in encouraging the adoption of innovations in the agri-food value chain.

The storage phase. Once the wheat reaches the storage center, it is subjected to checks, defined by law, and a “Storage Protocol” with clear rules for all processing phases. When all checks are positive, the wheat is pre-cleaned and then weighed and stored in homogeneous batches according to its quality characteristics. Since the protocol prohibits the use of chemical products during the storage phase, companies adopted innovative silos with forced air circulation systems and natural refrigeration. This process avoids molds or parasites, which can produce mycotoxins, while ensuring the healthiness of the raw material without using disinfection treatments. All the investments made by the intermediary agent for the implementation of the project were co-financed by the policy (RDP).

The transformation phases. Barilla directly manages the first and second processing phases. The processing of the wheat into flour takes place in the Altamura mill while the pasta is produced in the Marcianise plant. In the milling and pasta production phases the company undertakes several prevention and control activities of raw materials. Indeed, every year several tests are carried out to test the quality of the wheat used for pasta production. In addition, between 2010 and 2018, Barilla invested more than 11 million euros in sustainable technologies in the Marcianise plant to improve production processes, and reduce environmental CO$_2$ emissions and waste [77].

As for the marketing phase, Barilla undertook a rebranding of Voiello pasta and marketed the reformulated product with a recyclable packaging. In addition, a communication campaign was launched involving farmers in the “Aureo” wheat supply chain and with claims conveying the new brand’s values and the pasta’s distinctive characteristics.

3.2.2. The Governance of “Aureo” Supply Chain

The “Aureo” wheat supply chain is based on two governance structures: hierarchical and hybrid. Barilla manages not only the pasta production phase but also the first transformation phase. The primary and storage phases are managed through supply chain contracts which ensure a fair distribution of the value created and encourage all actors in the supply chain to share a common competitive strategy. Thus, the supply chain contract is the main strength of the “Aureo” project. In the experimental phase, in order to test their usefulness, one-year supply chain contracts were signed. Starting from the 2016/2017 cereal season, the first three-year contracts have been signed. This reflects the trusting environment created among the economic agents involved [57,58].

The empirical investigation focused exclusively on the cultivation contracts between Barilla and farms. The price and content were discussed with the main intermediary agent in Campania involved in the “Aureo” supply chain. Further, the prices stipulated in the contract of the 2016/2017 cereal season were also published by the company [78].
Farmers are often skeptical about implementing sustainable innovations especially when they require new skills or create interdependence with external entities [79]. To encourage farms to maintain specified commitments, Barilla’s wheat cultivation contracts ensure the purchase of all the wheat produced. The price depends on the protein content of the wheat delivered. If the wheat has a protein content of less than 14.00%, farmers are granted the market price, while for grain with a protein content of 14.01% or more, the contract establishes the recognition of a fixed price, calculated as the sum of: (i) all hypothetical production costs incurring in a hectare of cereals (from cultivation operations such as the purchase of seeds, to fertilizers and plant health); (ii) the transportation costs to deliver the wheat to the storage center indicated in the contract; (iii) a premium price variable according to the protein content of the grain produced. The components of the fixed price are annually redefined by Barilla according to the rise in the prices of fertilizers, plant protection products and agricultural fuels. Accordingly, the contract on the one hand guaranteed a secure income for all farmers, and on the other encouraged farmers to constantly improve wheat quality to access the highest fixed price.

In the last cereal season 2018/2019 (i.e., the period between the month of July of year t and the month of May of year t + 1) the fixed price (including the premium price), stated by the intermediary agent, started from a minimum of 22.22 euros per quintal for wheat with a protein content between 14.01% and 14.20%, up to a maximum of 28.50 euros per quintal for wheat with a protein content equal to or greater than 15.50%. In addition, if during the cereal season the fixed prices were equal to the average market price recorded on the Foggia commodities exchange, they were increased by an additional premium of 1.50 euros per quintal. Due to the innovations implemented in the agricultural phase, farmers received the highest guaranteed fixed price of 28.50 euros per quintal. This price was significantly higher than the market price recorded for fine durum wheat on the Foggia Commodities Exchange (maximum price € 24.85). Further, all farms of “Aureo” wheat supply chain were able to benefit from funding from the Ministry of Agricultural, Food and Forestry Policies (MiPAAF) for an amount of up to 100.00 euros per hectare. It is a funding under the “Durum Wheat Fund” designed to promote: (i) the aggregation of the supply chain in the pasta sector; (ii) the use of good cultivation practices to improve the quality of production; (iii) the promotion of sustainability in the cereal production chain.

3.3. Project Results

The main result of the sustainable collective innovation process developed with the “Aureo” project was the launch on the market of the new Voiello pasta, reformulated and produced with 100% Italian wheat of the “Aureo” varietal. Initially marketed only in the Italian market, currently the 100% “Aureo” Voiello pasta is also delivered to foreign markets. This pasta has a protein content of 14.5% per 100 g of product which is higher than the protein content of traditional Barilla pasta (11.5–13% of protein for every 100 g). The market price of the 100% “Aureo” Voiello pasta is about 2.60 euros per kilo, much higher than Barilla pasta, which is sold at an average price of about 1.30 euros per kilo. The price difference of approximately 1.30 euros per kilo is a proxy of the value created by the sustainable collective innovation process and shared—through the contract—with all actors of the “Aureo” wheat supply chain.

The collective innovation process enabled the creation of a pasta with unique qualitative and nutritional characteristics as well as higher social and environmental sustainability. The contract contributed to the stabilization, in the medium term, of farm incomes that in turn enabled multifunctional farms to stay in business, with an important role in overseeing marginal territories [8]. Without the “Aureo” project, the risk of land abandonment would have been very high with negative repercussions on the economic, social, and territorial balances.

The “granoduro.net” Decision Support System stemmed the variability of wheat yields and quality due to increasingly adverse and unpredictable climatic conditions. By combining the data related to weather conditions with the information collected on the characteristics of the soil, the system guided the farmers in carrying out targeted treatments. The production yield was increased by up to 20%...
compared to conventional yields, while the costs for cultivation operations and for the purchase of fertilizers and plant protection products were lower by roughly 30% [80].

As for environmental sustainability, the “Aureo” project, based on the adoption of different sustainable supply chain innovations, has allowed responsible management of natural resources. The cultivation of “Aureo” wheat, which performs well in arid areas without requiring the use of irrigation, allowed a saving of about 20 million m\(^3\) of water per year. The targeted use of chemical treatments, the reduction of operations due to the cultivation protocol and the use of the Decision Support System, as well as the decline in import of wheat from foreign countries, reduced CO\(_2\) emissions by about 3500 tons per year [80].

Further positive externalities consider the sustainable innovations implemented at the storage facilities and the Voiello production facility. In particular, between 2010 and 2018, in the Marcianise plant there was a reduction per ton of product of 36% of water, a 23% reduction of CO\(_2\) emissions, and a reduction in waste due to a 90% increase in recycled material [77].

4. Discussion

The “Aureo” project represents an emblematic case of sustainable collective innovation process that supports the proposed theoretical framework. The “Aureo” case study showed that the production of an innovative product such as a reformulated pasta, with sustainable characteristics, implies a new way of organizing innovation processes. Since the process involved the whole agri-food supply chain, it is considered a process of sustainable collective innovation.

The study revealed that one of the main drivers of sustainable collective innovation processes is the current citizen-consumers’ needs as well as the willingness of companies to meet them (i.e., RQ1). Further drivers—for companies of the supply chain—reside in the possibility to make production processes more efficient and sustainable, or to improve companies’ economic performance and market positioning. However, the implementation and the effectiveness of the sustainable collective innovation process was possible with the interaction of several tools: cooperative relationships, access to policy, and supply chain governance (i.e., RQ2). In fact, the case study shows that the cooperation between Barilla and the companies Produttori Sementi Bologna (PSB) and Horta was a decisive element in overcoming some company limitations. Access to the Integrated Projects for the Food Chain (IPFs) “Innovare con Aureo” policy facilitated the development of the supply chain in the area, and by the creation of relational networks it encouraged the aggregation between different economic operators operating in the cereal sector with the Barilla pasta factory. Lastly, the governance mechanisms (i.e., supply chain contracts) contributed to the overall effectiveness of the sustainable collective innovation process by encouraging farms and storage facilities to adopt sustainable innovations (of product and process).

The case study showed that the governance has on the one hand made the collective innovation process sustainable, while on the other it generated benefits in terms of economic value. The strategy adopted for the “Aureo” chain produced an increase in the income of all the actors involved, including the farmers who are often not fairly remunerated. The results showed that the supply chain contracts contributed to stabilizing the income of farmers who have also managed to maximize profits due to the sustainable innovations adopted. The “Aureo” wheat variety, which suits the extreme soil and climate conditions, offers an excellent opportunity for the conversion of farms cultivating low-income crops (e.g., tobacco or traditional cereals). As a result, this innovation contributed to both the economic and employment recovery of some internal areas, avoiding the phenomena of land abandonment and environmental degradation. These results are in line with the study of Pancino and colleagues [64], which showed the role of contractual formulas in involving farmers in the introduction of sustainable agricultural practices.

Considering that the value generated by an innovation does not end in its economic return but affects the environment and society in general, the collective competitive strategy proposed with the “Aureo” project has generated significant positive impacts on the environment and landscape, contributing to environmental sustainability and a greater safeguard of biodiversity.
The output of the sustainable collective innovation process (i.e., a pasta characterized by ethical and environmental sustainable attributes) was positively accepted by the citizen-consumer, who shows an increasing attention to the quality, the healthiness and origin of the raw material, and the environmental impact of pasta production [50,51]. Consequently, the success of this new pasta has produced significant effects for the company in terms of sales, turnover, and reputation.

5. Study Implications and Limitations

The study findings provide useful implications for both decision makers and practitioners, as they contribute to the debate on the role of sectoral policies in supporting innovation in the agri-food supply chain. The study shows that collective planning tools play a crucial role in creating synergies both horizontally and vertically, positively affecting the creation of social capital, understood as the complex of social and relational networks. This type of capital favors the creation of bonds that go beyond the purely economic aspect and increase the level of trust and reciprocity. These elements, along with the quality of governance, are able to influence the outcome of sustainable collective innovation processes.

The analysis certainly has some limitations relating to the use of the case study methodology, which do not allow the generalization of the results observed. However, it is in line with the main aim of the study, which was the validation of the theoretical model proposed regarding the determinants of the sustainable collective innovation processes. Therefore, future research could be conducted on different supply chains and territories, in order to confirm the role of the determinants of collective innovation processes proposed in this paper, and above all the role of the value chain governance model for their effectiveness.

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