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Making Virtue Out of Necessity: Managing the Citrus Waste Supply Chain for Bioeconomy Applications

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Abstract: The efficient use of agricultural wastes and by-products, which essentially transforms waste materials into value-added products, is considered as pivotal for an effective bioeconomy strategy for the rural development. Within this scope, citrus waste management represents a major issue for citrus processors. However, it also represents a potentially unexploited resource for rural sustainable development. This study focuses on analyzing the current management of citrus waste in South Italy, and on identifying the determinants and barriers that may affect an entrepreneur's choice in the destination of citrus waste. This study investigates the preferences of citrus processors regarding the contract characteristics necessary to take part in a co-investment scheme. Both analyses are preliminary steps in designing an innovative and sustainable citrus by-product supply chain. Results show that the distance between the citrus processors and the citrus by-products plant is one of the main criteria for choosing alternative valorization pathways. Moreover, guaranteed capital, a short duration of the contract, and reduced risk are contract scheme characteristics that improve entrepreneurs' willingness to co-invest in the development of a citrus waste multifunctional plant. The overall applied approach can be extended to other contexts for designing new and innovative by-product supply chains, thereby enhancing the implementation of bioeconomy strategies.

Keywords: bio-economy; agricultural by-product; horizontal coordination; contract mechanism; choice model; waste valorization

1. Introduction

The increasing awareness concerning more sustainable uses of natural resources and the shift to a resource-efficient economy [1–5] are stimulating policy initiatives and institutional processes towards the development of bioeconomy strategies [6]. Bioeconomy is aimed at "making virtue out of necessity" [7]. More formally, a recent definition of bioeconomy refers to it as economic, environmental, and social activities combined with the production, yield, transport, pre-processing, conversion, and use of biomass to produce bioenergy, bioproducts, and biofuels [8]. Moreover, bioeconomy has been identified as a strategic lever, both at the European and international level [9,10], for job creation in rural and urban areas and for the reduction of dependence on energy from fossil fuels, thereby simultaneously promoting environmental and economic sustainability [9]. The bioeconomy concept is strictly linked to the circular economy. Indeed, closing the material loop by recycling and reusing products—thus reducing raw material use—is the main aim of the Circular Economy Policy

Package [11], while The Circular Economy Action Plan [12] recognizes bioeconomy as the main pillar of the circular economy. Despite the existence of differences and overlaps between the two concepts, worldwide, both notions are considered key principles for promoting the societal transition towards a more sustainable economy through the adoption of innovations. As a synthesis of the two ideas, the circular bioeconomy concept [13] is gaining momentum in different research fields among policy makers and stakeholders [14,15] for using and producing bio-based products more circularly [16,17].

In this context, agricultural wastes and by-products are gaining a renewed importance since they could be considered part of an effective bioeconomy strategy by transforming waste materials into value-added products [18–20]. Indeed, new sources of economic value for the participants in the supply chain—as well as social benefits for society [21]—can be unlocked by using waste materials for producing valuable novel products [22]. This study focuses on the valorization of citrus waste (known in Italy as *pastazzo*) as a useful example for generating new market and non-market values [23,24].

Pastazzo management represents a major issue for citrus processors due to the high costs incurred for pre-treatments before its disposal [25,26]. At the same time, *pastazzo* embodies a potentially unexploited resource for the rural economy. Some technical background is needed to illustrate this. Citrus fruits, specifically oranges, lemons, limes, grapefruits, and tangerines, are among the most cultivated fruits globally [27]. The global volume of citrus processed every year is about 31.2 million tons [28], 50–60% of which is waste; that is, *pastazzo* [26,29]. *Pastazzo* is mainly composed of water (75–85%), mono- and disaccharides (6–8%), and a limited level of oils in the peel waste [30]. However, the essential oils also represent a potential risk to the environment if they are not appropriately disposed of [26,31,32].

To date, several technological innovations have been developed to valorize *pastazzo*, and these are mainly aimed at converting potential environmental hazards and economic issues [29] into a valuable resource. Some of these approaches consist of pectin extraction [33], dietary fiber extraction [34,35], biogas production [36], ruminant feeding [37], and essential oil (particularly D-limonene) extraction [27]. For instance, several improvements in citrus waste valorization in the context of bioeconomy development are coming from Brazil, the world's largest orange juice producer [38]. For instance, one recent study from Brazil showed the possibility to reduce fat in ice cream without significant changes in flavor and color by using citrus by-products [35]. At the same time, investments in orange waste biorefinery are gaining attention, not only in the main producer country [39], but also in the Mediterranean area [40]. To transfer the technology from the lab to the real market, it is necessary for governments to support strategies and mechanisms that bridge research and industry, thereby fostering collaborative R&D schemes between the involved stakeholders [41,42]. For example, systemic problems hold up the adoption of renewable energy technologies [43,44]. Moreover, massive financial investments are required by the involved stakeholders to foster the industrial adoption of innovations [40], but this cannot be performed without first understanding and then removing the barriers to the adoption and diffusion of the technological innovations [40,45,46]. The adoption of disruptive innovations often needs a structural reorganization of the supply chain. During the last decade, several studies analyzed factors that affect green and sustainable supply chain implementation [47–50]. One of the main barriers to technology adoption is the lack of cooperation and coordination among the stakeholders within the new supply chain [51,52].

A contracts mechanism can be considered as an effective way to achieve supply chain cooperation and coordination because it delivers flexibility by promoting participation [52–54]. A preliminary investigation of some relevant contract attributes is crucial to fostering cooperation among the stakeholders and to sharing the risk of the investment among the participants involved in a new and eco-innovative supply chain [52], thereby decreasing the risk and uncertainty of the adoption of the innovation [55].

With this in mind, the first aim of the present study was to focus on analyzing the current (status quo) waste management of *pastazzo* in the Sicily region. By means of the statistical analysis of data acquired in Sicilian citrus plants in 2015, the determinants and barriers that influence an entrepreneur's choice of how to dispose of *pastazzo* were investigated. Secondly, we analyzed the preferences of citrus processors with regard to the contract attributes needed to promote cooperation within an investment opportunity. At the same time, we identified the potential barriers to the implementation of a multifunctional plant to enable full valorization of *pastazzo* into valuable by-products.

Sicily is the regional leader in Italy for citrus cultivation [56]. Processing citrus by-products in Sicily via a multifunctional plant could provide the solution to two main issues: (1) low returns from citrus cultivation and consequently its abandonment, and (2) the environmental problem associated with *pastazzo* management [57]. Nevertheless, an innovative multifunctional plant is costly and risky since the adoption of technological innovations is strongly required. It is worth pointing out that the choice of a specific bioproduct technical solution has to be made on a case-specific base. A multifunctional plant, which is illustrated later, may represent one of the most effective solutions available in Sicily.

The current study's innovation resides in the knowledge presented of the contract attributes required to manage the coordination and cooperation of the stakeholders involved in *pastazzo* management in Sicily. This is relevant because although most chains are based on agreements between two or more of the participants, the case in hand shows the peculiar features of coordinating the citrus producers (suppliers) and stimulating the coordination and cooperation among them.

2. Background of the Study

2.1. Literature Overview

Promoting a novel value chain is challenging in several ways. One of the most crucial concerns is that the structural changes that occur in the food system add value through innovation. The adoption of a bioeconomy strategy—transforming waste and/or by-products into value-added products—falls into this challenge, as it requires a complex process of organization among stakeholders. Recent studies have analyzed the development of novel value chains for promoting biomass valorization, highlighting several implementation challenges [58–63]. To illustrate this, Ekman and colleagues [64] pointed out the high risk perception of investors that is associated with the implementation of technological innovations needed for processing waste and by-products. Carraresi and colleagues [58] highlighted that to create value through by-products valorization, companies should re-design their business models by enhancing the adoption of technological innovations. In the same vein, the establishment of stable relationships among stakeholders is a critical step for overcoming supply chain fragmentation. Indeed, the cross-industry collaboration represents one of the key elements for the development of value chains adopting bioeconomy strategies [65]. New business models need to be based on networking among actors. This is based on the principle that coordination along a value chain is deemed to reduce the uncertainty about economic investments.

Improving horizontal coordination among agri-food companies helps the value chain to reach efficient and effective goals [66]. To this end, considerable efforts have been undertaken by researchers to investigate what forms of coordination are more effective for fostering the development of novel value chains [67–69]. Chain integration and coordination are at the root of a process of progressive dependence among different actors [52]. Several coordination mechanisms have been selected to manage interdependencies that aim at improving supply chain performances. Handayati and colleagues [54] identified four different chain coordination mechanisms: (1) supply chain contract, (2) information sharing, (3) joint decision-making, and (4) collective learning, although all relevant and current papers focus on the first one. Contracting is the most diffused mechanism of coordination in the agri-food supply chain for managing tactical and operational decisions [70,71]. Contract models in the agri-food sector have been specifically discussed to investigate vertical and horizontal chain integration, as they highlight the pros and cons of investing in a cooperative setting [5,66,71,72]. Furthermore, a growing number of studies have specifically investigated the biomass supply chains with the lenses of contract mechanisms as a mean to foster coordination [52,55,73,74]. To illustrate, WamishoHossiso and colleagues [55] analyzed a contract design on the farmers' willingness to grow biomass according to different price-based and quantity-based mechanisms. The willingness of local farmers to convert wheat cultivations into bio-energy crops in a rural marginal area of the South of Italy was also investigated by Cembalo and colleagues [75]. According to Karantininis and colleagues [76], integration might increase the level of innovation in agricultural supply chains.

Based on this background, the current study investigated the stated preferences of citrus processors with regard to the contract attributes needed to foster horizontal coordination in the Sicilian citrus supply chain. Specifically, we identified potential constraints for the implementation of a multifunctional plant to enable full valorization of *pastazzo* into valuable by-products.

2.2. The Hidden Value of Citrus By-Products

The dry portion of *pastazzo* (about 15–20%) includes mono- and disaccharides (glucose, fructose, and sucrose; about 6–8%) and polysaccharides (pectin, cellulose, and hemicellulose; about 1.5–3%), and it is characterized by a significant presence of essential oils that are composed, in particular, of D-limonene (about 83–97%) [77]. The relative composition may vary according to several factors, including the growing conditions, variety, and climatic situation [78]. *Pastazzo* also contains functional nutrients, such as flavonoids, bitter principles (limonin, isolimonin), carotenes, vitamins (ascorbic acid, Vitamin B complex, carotenoids), and important minerals such as calcium and potassium [30,79].

Recently, citrus peel residues have attracted the attention of scholars and industry in light of their potential uses. Indeed, several studies have highlighted the importance of citrus waste valorization, both for enhancing economic competitiveness (e.g., by reducing disposal costs) and for addressing potential environmental hazards [26,40,80]. The oils contained in citrus peel waste inhibit bacterial and yeast activities, thereby decreasing the rate of decomposition [26]. Hence, the direct disposal of citrus waste may generate several environmental problems if the waste is not initially treated to extract the oil component.

Several innovations have been developed during the past few years for the valorization of the *pastazzo* market [29,81], and the extraction of pectin has been one of the most promising. Pectin is a polysaccharide that is commonly contained in fruits, and it is widely used by the food and chemical industries [33,82]. Recently, a novel method was developed to increase the pectin yield from citrus peels. By using this method, about 39 kg of pectin can be produced per ton of wet citrus waste [33]. Many components of citrus by-products that are made up of polysaccharides and lignin could be used to create functional foods, especially dietary fiber [83,84]. Indeed, dietary fiber from citrus by-products has a high content of cellulose and minor concentrations of lignins, pectins, and hemicellulose [34]. This provides a higher portion of soluble dietary fibers than wheat bran [85]. Moreover, the fibers from citrus waste include bioactive compounds such as flavonoids and C-vitamin, which have antioxidant power [34]. Because of the above-mentioned characteristics, a dietary intake of fibers from citrus by-products may help to prevent fiber deficit in the human diet [34]. Furthermore, food scientists suggest that orange fiber could be considered a good alternative to fat in ice cream since its functional properties reduce about 70% of ice cream's fat [35].

As well as human nutrition, citrus by-products can also be used as feedstuff [86], thereby reducing the competition for land use between food and feed production [37]. The possibility of introducing citrus by-products for ruminant nutrition is due to both the availability of soluble fibers and the ability of ruminants to ferment a large quantity of fibers [86]. Citrus pulp can be given to ruminants as a fresh product or as silage, even if the citrus pulp is usually fed in its dehydrated form [37]. Citrus molasses and citrus sludge are also used as part of a livestock diet. The former can be a source of feed energy for cattle [87], while the latter could be considered to be feedstuff since it has abundant amino acid components [88].

Citrus waste shows a great potential for biofuel and biogas production [89]. The biogas yield for each ton of citrus by-products is currently about 89.3 Nm^3 [90] depending on different factors, such as the citrus variety, temperature, pH, and microbiological characteristics of the biomass [91].

In this regard, several orange producing countries, including oil producers such as Iran, are strongly committed to using citrus as a bioenergy source and for producing biogas [32,92,93].

Finally, citrus waste has other minor uses. Citrus waste is a source of D-limonene, an essential oil that can be used to build chemical structures such as biosolvent, a renewable alternative to the halocarbon solvent [94]. D-limonene can also be used as a fragrance compound to produce adhesive terpene resins [95]. The high sorption capacity of citrus waste can be exploited for remediating wastewater from heavy metals contamination [96].

Even though the potential use of citrus by-products has been shown in the literature, to the best of our knowledge, only one Spanish company has developed a pilot multifunctional plant based on a cascade-type valorization approach, converting citrus waste into cattle feed pellets, essential oils, biofuels, and finally purifying the water used for the process by applying a pervaporation/condensation approach [27]. The scant adoption and diffusion of this alternative are mainly due to the radical nature of the innovation needed for its implementation, which requires the development of new organizational models and structural changes to the pre-existing supply chains [26].

3. The Empirical Analysis

3.1. Citrus By-Product Supply Chain

The study was conducted in Sicily, a citrus production region in southern Italy that accounts for about 60% of the citrus cultivated areas in Italy [56]. More in detail, around 80,000 hectares are entirely devoted to citrus cultivation in Sicily. Most of them—about 54,000 hectares—are dedicated to orange cultivation [56]. In terms of citrus production, Sicily produces around 1,500,000 tons of fresh fruits [56]. The Sicilian coastal areas have the greatest share of production, with 40% of the total orange trees being in Catania, Syracuse, Enna, and Agrigento provinces [90].

The Sicilian citrus processing industry can be categorized into micro firms, generally family-run properties with one or two employees (that generally use old process systems), and small to medium companies with more than 20 employees [57]. Citrus processing is usually organized in two steps. The first consists of a basic transformation to obtain citrus concentrates, which is the business model of the small firms, whereas successively larger firms complete the transformation and sell processed citrus products on the market [97,98].

As previously discussed, once the fruit is pressed, a large quantity of fresh citrus (about 65%) waste is produced. Citrus by-products are considered a serious issue because the high costs for disposing of citrus wastes induce opportunistic and illegal behaviors by the citrus processing industry. For instance, in 2014, a police investigation named “Last Orange Operation” reported an illegal disposal of *pastazzo* in different Sicilian areas with citrus wastes being thrown into streams and onto private or public plots of land (without pre-treatment), thereby causing several environmental problems [99].

The citrus sector in Sicily is also marked by decreasing profit margins, which have caused a persistent reduction in areas under cultivation and have made overall farming activities unviable. In Sicily, about 33,000 hectares of the citrus production area were lost from 1992 to 2014 [57]. In this context, the valorization of citrus by-products could result in extremely relevant environmental and economic benefits for the whole citrus supply chain and the farming sector in particular. Economic value for the firm and social benefits for the citizens can be generated by a multifunctional plant able to process *pastazzo* [40] through a cascade-type approach that achieves, at the same time, both environmental and economic efficiency [27]. Following this route, *pastazzo* valorization may also reduce companies’ costs for waste disposal, thereby creating economic value for the involved stakeholders and indirectly decreasing the risk of environmental problems.

However, the steps required to develop a multifunctional plant are fraught with barriers and challenges. These relate mainly to poor awareness among potential investors, small capitalization, lack of liquidity for participating firms, and the risk perception of the investment [46,100,101].

The direct involvement of supply chain participants in the development and management of an innovation through coordination and integration may represent a way of solving the above-mentioned problems [102]. Contract design has been mainly explored in the development of new bioenergy supply chains [103] in which different conditions have been considered, such as the price of the agricultural biomass, the length of contract, options for renegotiation, and the definition of a minimum product volume to be provided by the farmers [52]. Thus, flexible contracts could be designed to facilitate stakeholders' cooperation within the shared investment, thereby increasing the probability that a large number of stakeholders may take part in the development of the multifunctional plant [101].

3.2. Empirical Framework and Methodology

Two different empirical models were used in this study. The first model analyzes the current destination of *pastazzo* in the Sicily region (status-quo analysis) and identifies the determinants and barriers of the different possible uses (biogas, pectin, or feedstuff). This analysis provides a picture of the ways by which stakeholders manage citrus by-products. Subsequently, a second analysis was conducted to investigate the propensity of citrus processors to cooperate within an investment opportunity. In the second analysis, entrepreneurs were asked to take part in the development of a hypothetical multifunctional plant for citrus by-product valorization through a choice experiment. Entrepreneurs' preferences for the contract attributes were assessed by using a contingent valuation approach. More precisely, the contingent evaluation investigates how features of a contract may influence the propensities of entrepreneurs to participate in a hypothetical plant that produces several by-products of *pastazzo*. Both analyses can be considered preliminary steps to the design of an effective citrus by-product supply chain.

The status-quo analysis uses a discrete choice model to identify the entrepreneur's motivations for actual *pastazzo* management. Let $\pi_{i,j}$ be the probability that the i-th entrepreneur, faced with J-alternatives (such as biogas, pectin, and feedstuff), would have chosen the j-th alternative $(Y_{ij} = 1)$. According to the conditional logit model [104], the probability can be expressed as:

$$\pi_{i,j}(Y_{ij} = 1) = \frac{e^{\beta' z_{ij}}}{\sum_j \; e^{\beta' z_{ij}}} \tag{1}$$

where z_{ij} comprises the entrepreneur characteristics (such as age, gender, and educational level) as well as alternative specific attributes (e.g., distance from the firm), whereas β is the parameter vector that can be obtained by using the maximum likelihood estimate (MLE).

For the second aim of the present study, a choice experiment approach was used to examine the stated preferences of the citrus processors for different contract attributes to facilitate and coordinate the finalization of their participation in the investment while simultaneously identifying the entrepreneurs' preferences toward the existence and the attributes of any trade-offs between them.

Previous studies followed similar approaches [52,101,105]. Two different alternative contracts were shown to the entrepreneurs. The contract alternatives were characterized by a different composition of attributes and levels.

Each contract typology consisted of four different attributes that were compatible with the specific investment. Attributes were directly adapted from Schifani and coauthors [101], and they were in line with those suggested by other studies [52,55]. Specific levels have been validated through three focus groups carried out during the research. Therefore, the differences between each contract's typology are based on the following factors (Table 1).

Table 1. Attributes and levels of contracts.

Attributes	Level Definition	Mean	Std.dev	Min	Max
Risk and remuneration of investment	Random extraction from uniform distribution, from 9% to 20%	14.77	3.84	9	20
Capital warranted	Presence (1) or absence	0.50	N.A	0	1
Length of investment	Random extraction from uniform distribution, from 15 to 20	17.54	1.69	15	20
Management decisions	Presence (1) or absence (0)	0.50	N.A	0	1

N.A: not applicable.

The above table displays (1) the length of the investment (from 15 to 20 years); (2) the degree of risk and profitability of the investment (annual rate from 9% to 20%); (3) the presence or absence of capital invested and the amount that is warranted; (4) whether there is an ability to take part in the management decisions of the multifunctional plant (Table 1).

Analytically, considering the c-th different contract's alternatives shown to the i-th entrepreneur, the utility associated with each alternative is assumed to be a linear function composed of all the attributes $\mathbf{x}_j$ that identify the c-th contract:

$$U^i{}_c = f\ (\mathbf{x}_j) + \varepsilon^i{}_j \tag{2}$$

According to the random utility theory [104], the utility $U^i{}_j$ can be decomposed to an observable component $\boldsymbol{B}\mathbf{x}_j$ and an unobservable component $\varepsilon^i{}_j$. $\boldsymbol{B}$ is a vector of parameters to be estimated by a conditional logit model and MLE [106].

$$U^i{}_j = \boldsymbol{B}\mathbf{x}_j + \varepsilon^i{}_j \tag{3}$$

$\boldsymbol{B}$ parameters could be assessed by applying a logit model and maximum likelihood estimation [106].

3.3. Data

The data populating both the models are observational and are gathered from a sample of Sicilian small and medium citrus processing firms that produce *pastazzo* as waste. Data were collected in 2015 by submitting a vis-à-vis questionnaire to the entrepreneurs of the surveyed firms. The questionnaire was administered by two professional interviewers with agro-technological knowledge and experience. The Sicilian Chamber of Commerce Industry Handicraft and Agriculture identified 42 citrus processor companies in Sicily [57]. Since the limited capitalization of micro companies represents an insurmountable barrier for the investment, micro citrus processors were excluded from the analysis. Thus, a total of 21 enterprises constituted the population of interest, while a sample of 11 enterprises successfully completed the survey (Figure 1).

Figure 1. Spatial localization of the 11 surveyed firms.

The survey tool was comprehensive and included information regarding: (a) the socio-demographic aspects about the entrepreneur and the main company's structural characteristics; (b) the current waste management system; and (c) the choice-based contingent valuation about the potential contract's typologies between the firm and the other private (or public) companies.

Based on the collected data, about half of the plants are located in Messina (54%), and they are frequently conducted by a male (81%) with an average age of 54 years (42 years being the youngest entrepreneur and 74 years being the oldest entrepreneur). The average company has been running for 22 years with the youngest being eight years old and the oldest being 47 years old. With regard to the specific citrus transformed, all of the firms transform oranges, but with some differences—54% of the companies transform only oranges and lemons, whereas the remaining 46% also transform other citrus fruits. In 2015, each firm processed (on average) 21,909 tons of oranges to produce 8,891 tons of orange juice and 12,791 tons of *pastazzo*. In most cases, the orange by-products were used to produce biogas (45%) or were converted into pectin (36%), while two plants transformed their *pastazzo* to produce animal feed. In the cases where the orange by-products were not processed in situ, an average of about 82 km of *pastazzo* was dispatched to the processing firm (Table 2).

Table 2. Sample characteristics.

PLANT	PROVINCE	AGE	GENDER	YEARS	CITRUS TRANSF [a]	TRANS. ORANGE (t)	PROD. JUICE (t)	ORANGE BY-PRODUCT (t)	DISPOSAL DISTANCE (Km)	BY-PRODUCT END USE
1	Messina	56	M	25	Or-Lem-Others	40,000	18,800	21,200	0	Animal feed
2	Catania	49	M	20	Or-Lem	15,000	6000	9000	116	Biogas
3	Palermo	72	M	47	Or-Lem	10,000	4000	6000	128	Biogas
4	Messina	53	F	20	Or-Lem	40,000	16,000	23,000	20	Pectin
5	Messina	49	M	10	Or-Lem	12,000	4500	7000	3.6	Pectin
6	Catania	54	M	18	Or-Lem-Others	30,000	12,000	18,000	130	Biogas
7	Messina	74	M	35	Or-Lem-Others	23,000	9000	14,000	110	Biogas
8	Messina	59	F	20	Or-Lem	25,000	10,000	14,000	105	Biogas
9	Messina	43	M	15	Or-Lem-Others	8000	3000	5000	67	Pectin
10	Catania	42	M	8	Or-Lem-Others	25,000	9500	15,500	0	Animal feed
11	Palermo	47	M	20	Or-Lem	13,000	5000	8000	222	Pectin
Mean		**54**		**22**		**21,909**	**8890**	**12,790**	**81.96**	

[a] Or: orange; Lem: lemons.

4. Results and Discussions

4.1. Status-Quo Analysis

The first model aimed to analyze the determinants and barriers related to the current entrepreneur's choice on the *pastazzo* way of valorization (such as biogas, pectin, or feedstuff). Variables that were not significant at the chosen level ($p < 0.10$) were not accounted for in the adopted models.

The results in Table 3 clearly show that some aspects significantly influence the entrepreneur's choice on the final destination(s) of the citrus by-products. Estimates that are based on the semi-nonparametric estimator [107] confirm the findings. The distance between the companies and plants to transform the *pastazzo* negatively affects the chosen alternative.

Table 3. Determinants of the current destination of *pastazzo*—conditional logit estimates.

Variable	Coef.	Std. err	t-Stat	*p*-Value
ln (distance)	−1.09	0.39	−2.78	0.005
Biogas × age	0.13	0.03	4.5	0
Pectin × *ln* (return past)	−14.37	3.94	−3.65	0
Feedstuff × *ln* (return past)	−5.80	2.60	−2.23	0.026

Wald $\chi^2(5) = 44.17$; *p*-value < 0.01; $R^2 = 0.51$ (pseudo).

Distance can be considered a proxy of transport cost and represents a critical barrier (as shown in Figure 2) for processing the *pastazzo*. Thus, it directly influences the disposal costs. Accordingly, our results confirm that the transportation costs of citrus waste are among the main constraints for *pastazzo* valorization in the Mediterranean area [40]. Indeed, the study of Negro and coauthors [108] has demonstrated that the distance from the juice production plant to the biogas production plant negatively influences ethanol production from citrus by-products by increasing the transport costs [109]. The current low economic return of citrus by-products increases the quantity of *pastazzo* wasted per year and thereby causes environmental issues [32] that inhibit economic and social value creation. Hence, to reduce costs and increase the economic return, it is critical to minimize the costs of transport [109] by reducing the distance between the site where the fresh fruits are processed and the site where the *pastazzo* is transformed.

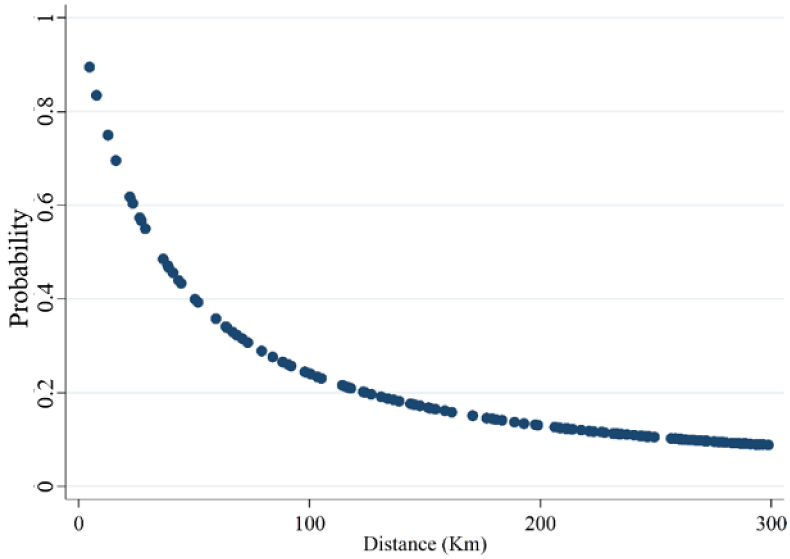

Figure 2. The relationship between the probability of the entrepreneur choosing a specific site and the distance of the site.

The return from *pastazzo* negatively influences the transformation of the orange by-products into pectin and feedstuff (Figure 3), but it positively influences the biogas way of valorization. The return from citrus by-products in pectin is lower than the returns from biogas or feedstuff production. Indeed, one ton of wet citrus waste produces about 38 kg of pectin [33]. The percentage is more than 4% if one deals with the dried citrus waste [110]. Current research has shown a new technical process that increases the pectin yield from ~40% of wet citrus waste to 58% [111]. The return from *pastazzo* in bran production for animal feed is more than it is for pectin production [110]. However, the dehydration of the citrus waste and the pelletizing process to produce animal feed require a lot of energy, which indirectly reduces the profitability of *pastazzo* to feed ruminants [108]. The willingness to transform *pastazzo* is positively influenced by the return from biogas production because the return from the use of the citrus waste in biogas production is higher than it is for other similar agricultural by-products [112]. Furthermore, the transformation of citrus by-products into biogas increases with the age of the entrepreneur. The older entrepreneurs seem to prefer transforming *pastazzo* into biogas rather than pectin or feedstuff products. Pectin production from citrus waste is a relatively new route. During the past decade, several studies have investigated technology innovations to optimize the pectin yield [111,113]. The innovative process and the low return from pectin production could represent a huge barrier, even if there is a large demand for pectin in the market [82].

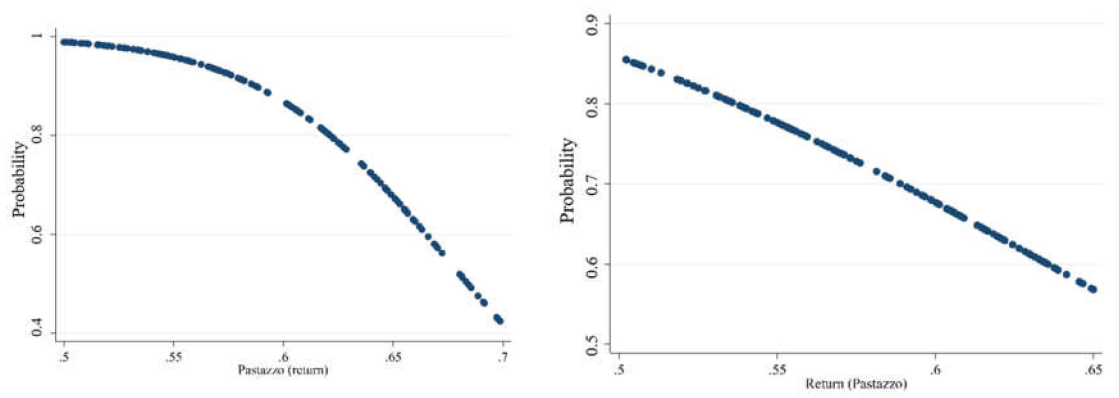

Figure 3. The relationship between the probability of the entrepreneur choosing pectin (left) or feedstuff (right) and the *pastazzo* return.

4.2. Preferences for Different Contract Attributes

With regard to the second aim of the study, Table 4 sets out the entrepreneurs' preferences about the contract attributes, which aim to enhance the propensity of the citrus by-product producers to co-invest in a multifunctional plant for *pastazzo* transformation. Four rounds were carried out with each citrus processor. In each round, two contract alternatives with specific levels for the considered attributes were proposed to each interviewee. The entrepreneurs could choose one of the two proposed contract alternatives or none. Overall, a total of 44 = 11 × 4 choice events were generated within our sample (n = 11).

Table 4. Preferences towards contract attributes—conditional logit estimates.

Fixed Parameters	Coef.	Std. Err.	z-Stat	p-Value	Odds Ratio
Risk and remuneration of the investment	−0.150	0.090	−1.670	0.095	0.861
Guarantee capital	4.037	1.877	2.150	0.031	56.681
Length of investment	−0.207	0.114	−1.820	0.069	0.813
Management decisions	1.209	0.772	1.570	0.117	3.349

The estimates (Table 4) pointed out that "management decisions" was the only contract attribute that was not statistically significant because the estimated coefficient was not significantly different from 0 (p-value > 0.10). Similar results have been obtained using the semi-nonparametric estimator [107]. In other words, according to the interviewed entrepreneurs, to be explicitly involved in managing the decisions at the plant [114] does not constitute a critical aspect of their decision to co-invest. This is probably due to the lack of trust in their management power or to the recent sustainable perspective in agro supply-chain management, in which the decision-making process has become more complicated due to the simultaneously involved economic, environmental, and social aspects [115–117].

Some contract attributes considered in this analysis are significant, such as the risk and the remuneration of the investment, the length of the investment, and the guarantee of the invested capital. Our outcomes emphasize the role of risk aversion [118] in affecting managerial decisions since the interviewees preferred a short investment time frame with low risk and consequently a low remuneration on the invested capital.

In terms of risk perception, the results are in line with previous studies [119,120] that regard the risk perception as one of the most important barriers to the adoption of innovation. Indeed, the financial cost due to a high initial investment increases the risk perception, and it represents "the core barrier" of the pro-environmental innovation adoption [46]. The financial risk perception in co-innovation systems is associated with the direct investment risk and the opportunity cost of the investment [121].

The age of the interviewees (who averaged more than 50 years old) may also explain the low risk propensity because risk aversion increases with the age of the entrepreneur [122]. Past studies have pointed out a delay in the investments due to risk aversion [123–125]. A thorough examination of the available technologies is necessary to valorize agricultural waste and the connected risk for each of them [126], since technological uncertainty may prevent investments from turning into innovation [127].

The preferred short length of the contract underlines the high-risk aversion that is also evident from the required guarantee on the invested capital. This seems to be the attribute that most influences entrepreneurs' choices. Cembalo et al. [52] obtained similar results about the duration of contracts by investigating farmers' preferences in a new bio-energetic supply chain.

Overall, the results from our study are completely in line with those of Schifani et al. [101], who demonstrated that farmers' propensities to join a collective investment (regulated by contract schemes) were positively related to the presence of an option that safeguards the capital invested, and were negatively related to the length of investment and a lower degree of risk (together with a lower long-run return). Figure 4 confirms the existence of the same relationship in our case, and corroborates the negative impact of the risk and the remuneration of the investment on the probability that the entrepreneur would take part in the investment, whereas the guaranteed investment option significantly increases the likelihood of the entrepreneur investing in the multifunctional plant.

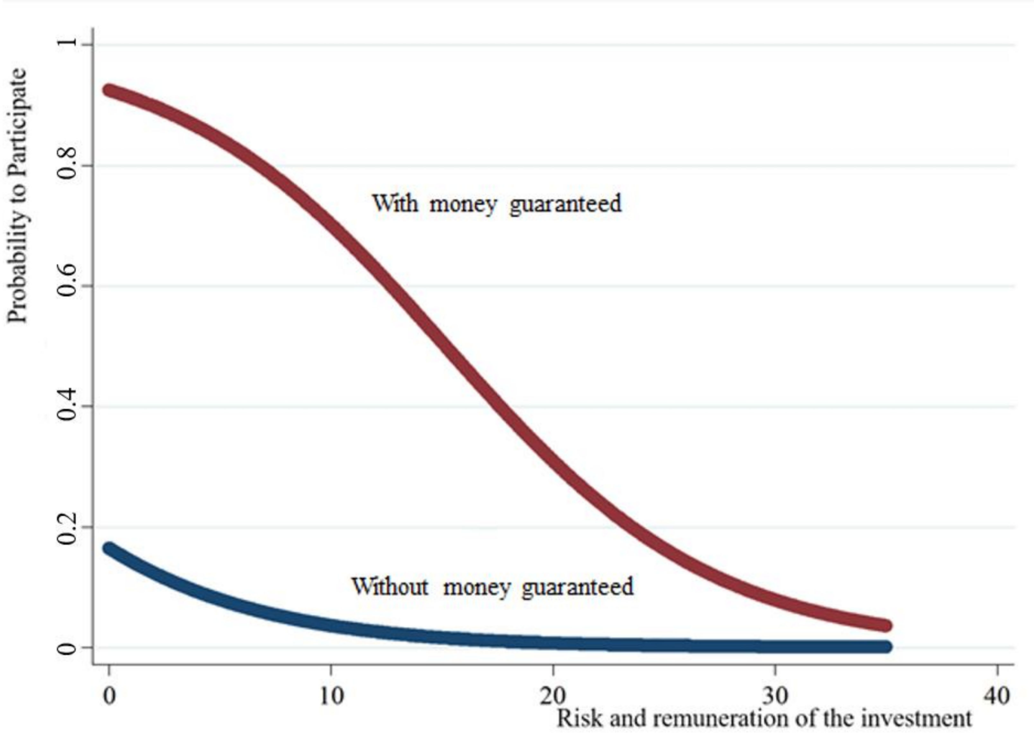

Figure 4. The influence of risk, the remuneration from the investment, and the presence of a guarantee of money on the entrepreneur's probability of investing.

5. Concluding Remarks

Several studies have shown the cost-effectiveness of producing innovative products obtained by processing *pastazzo* [39,40]. The adoption and diffusion of technological innovation for *pastazzo* valorization may be viewed as an effective bioeconomy strategy for solving both economic and environmental issues [29,32]. Even though the technical feasibility of processing *pastazzo* is increasing globally, research about the adoption of technology and implementation in bioeconomy supply chains is still relatively scarce.

It is critical to understand the factors that could influence participation in the implementation of a multifunctional plant to process citrus by-products in order to improve the co-innovation; that is, the common vision and common goals shared by the participants involved in the supply chain [121].

This study firstly investigated the determinants and barriers affecting an entrepreneur's choice on the current *pastazzo* destination (biogas, pectin, or feedstuff). Secondly, we investigated citrus processors' preferences about the contract characteristics needed to take part in a cooperative action for the realization of an industrial plant for *pastazzo* valorization.

This study had some limitations. The small sample of investigated companies was a consequence of the very limited population of medium and large citrus processors. Small citrus processors were excluded from the analysis since their limited capitalization could act as an insurmountable barrier to the entry of investors.

Nevertheless, the outcomes about the first and second aims of the study may be helpful for the implementation of a cascade-type valorization for *pastazzo*. The distance between the citrus companies and plants to transform citrus by-products decreases the current propensity to process them. As a consequence, a multifunctional plant should be as close as possible to the companies to enhance the entrepreneur's willingness to valorize *pastazzo* at an industrial level. Furthermore, the return from citrus by-products negatively affects the orange by-product transformation into pectin and feedstuff. Moreover, the probability that orange *pastazzo* will be transformed into biogas is positively correlated to the age of the entrepreneur. This implies that the return from each alternative encompassed in the cascade-type approach, such as cattle feed pellets, essential oils, and biofuels production, may influence the propensity to invest in the multifunctional plant.

Since the likelihood of committing current *pastazzo* to biogas production increases if the entrepreneur is not young, the age of the citrus transformer could also influence the level of participation in the proposed horizontal coordination. Moreover, the required guaranteed capital, the short duration of the contract, and the low risk are contract scheme characteristics that improve entrepreneurs' willingness to co-invest in the development of a citrus waste multifunctional plant.

One the main advantages of the multifunctional plant resides in the flexibility of its cascade approach in allowing the use of different quantities and qualities of the orange *pastazzo* [110]. However—despite biogas—pectin and feedstuff productions are, to date, economically profitable, although some bottlenecks may reduce their potential benefits. Indeed, the economic convenience may be undermined by the increasing transportation costs of citrus waste. In the same way, a rise in the costs of the energy required for the dehydration process can be seen as a serious obstacle for the overall competitiveness of the innovative supply chain.

Future research may improve the analysis by investigating the personal attitudes to the collective action of the involved stakeholders. This could be important in order to identify other potential determinants and barriers for by-product supply chain creation. The investment in the citrus waste multifunctional plant was only hypothetical, thus results are based on stated preferences. Moreover, since the analysis is focused on Sicily, the study presents a limited external validity. However, the overall approach can be easily adopted in another context for designing novel value chains in bioeconomy scenarios. Indeed, the investigation of citrus producers' propensities to be directly involved in the co-investment represents an important feature to be analyzed. Improvement of the involvement of all the stakeholders could foster the development of a new and innovative by-product supply chain, thereby enhancing the implementation of bioeconomy strategies.

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References

1. Nankya, R.; Mulumba, J.W.; Caracciolo, F.; Raimondo, M.; Schiavello, F.; Gotor, E.; Kikulwe, E.; Jarvis, D.I. Yield Perceptions, Determinants and Adoption Impact of on Farm Varietal Mixtures for Common Bean and Banana in Uganda. *Sustainability* **2017**, *9*, 1321. [CrossRef]
2. Testa, R.; Foderà, M.; Di Trapani, A.M.; Tudisca, S.; Sgroi, F. Giant reed as energy crop for Southern Italy: An economic feasibility study. *Renew. Sustain. Energy Rev.* **2016**, *58*, 558–564. [CrossRef]
3. Kumar, A.; Kumar, N.; Baredar, P.; Shukla, A. A review on biomass energy resources, potential, conversion and policy in India. *Renew. Sustain. Energy Rev.* **2015**, *45*, 530–539. [CrossRef]
4. Tilman, D.; Balzer, C.; Hill, J.; Befort, B.L. Global food demand and the sustainable intensification of agriculture. *Proc. Natl. Acad. Sci. USA* **2011**, *108*, 20260–20264. [CrossRef] [PubMed]
5. Iakovou, E.; Karagiannidis, A.; Vlachos, D.; Toka, A.; Malamakis, A. Waste biomass-to-energy supply chain management: A critical synthesis. *Waste Manag.* **2010**, *30*, 1860–1870. [CrossRef] [PubMed]
6. Hagemann, N.; Gawel, E.; Purkus, A.; Pannicke, N.; Hauck, J. Possible Futures towards a Wood-Based Bio-economy: A Scenario Analysis for Germany. *Sustainability* **2016**, *8*, 98. [CrossRef]

7. Von Braun, J. Bio-economy—Science and technology policy for agricultural development and food security. Presented at Festschrift seminar in honor of Per Pinstrup-Andersen on "New directions in the fight against hunger and malnutrition", Cornell University, Ithaca, NY, USA,, 13 December 2013.
8. Lamers, P.; Searcy, E.; Hess, J.R.; Stichnothe, H. (Eds.) *Developing the Global Bioeconomy: Technical, Market, and Environmental Lessons from Bioenergy*; Academic Press: Cambridge, MA, USA, 2016.
9. European Commission. *Innovating for Sustainable Growth: A Bio-Economy for Europe*; European Commission: Brussels, Belgium, 2012.
10. McCormick, K.; Kautto, N. The bio-economy in Europe: An overview. *Sustainability* **2013**, *5*, 2589–2608. [CrossRef]
11. European Commission. *On the Implementation of the Circular Economy Package: Options to Address the Interface between Chemical, Product and Waste Legislation*; European Commission: Strasbourg, France, 2018.
12. European Commission. *Closing the Loop—An EU Action Plan for the Circular Economy*; European Commission: Brussels, Belgium, 2015.
13. D'Amato, D.; Droste, N.; Allen, B.; Kettunen, M.; Lähtinen, K.; Korhonen, J.; Leskinene, P.; Matthies, B.D.; Toppinen, A. Green, circular, bio economy: A comparative analysis of sustainability avenues. *J. Clean. Prod.* **2017**, *168*, 716–734. [CrossRef]
14. Hetemäki, L.; Hanewinkel, M.; Muys, B.; Ollikainen, M.; Palahí, M.; Trasobares, A. *Leading the Way to a European Circular Bioeconomy Strategy*; European Forest Institute: Joensuu, Finland, 2017.
15. Sheridan, K. Making the Bioeconomy Circular: The Biobased Industries' Next Goal? *Ind. Biotechnol.* **2016**, *12*, 339–340. [CrossRef]
16. Borrello, M.; Caracciolo, F.; Lombardi, A.; Pascucci, S.; Cembalo, L. Consumers' Perspective on Circular Economy Strategy for Reducing Food Waste. *Sustainability* **2017**, *9*, 141. [CrossRef]
17. European Environment Agency (EEA). *Report No 8/2018*; EEA: Copenhagen, Denmark, 2018.
18. Mirabella, N.; Castellani, V.; Sala, S. Current options for the valorization of food manufacturing waste: A review. *J. Clean. Prod.* **2014**, *65*, 28–41. [CrossRef]
19. Scarlat, N.; Dallemand, J.F.; Monforti-Ferrario, F.; Banja, M.; Motola, V. Renewable energy policy framework and bioenergy contribution in the European Union—An overview from National Renewable Energy Action Plans and Progress Reports. *Renew. Sustain. Energy Rev.* **2015**, *51*, 969–985. [CrossRef]
20. Oldfield, T.L.; White, E.; Holden, N.M. An environmental analysis of options for utilising wasted food and food residue. *J. Environ. Manag.* **2016**, *183*, 826–835. [CrossRef] [PubMed]
21. Boehlje, M.; Bröring, S. The increasing multifunctionality of agricultural raw materials: Three dilemmas for innovation and adoption. *Int. Food. Agribus. Manag. Rev.* **2011**, *14*, 1–16.
22. Laufenberg, G.; Kunz, B.; Nystroem, M. Transformation of vegetable waste into value added products: (A) the upgrading concept; (B) practical implementations. *Bioresour. Technol.* **2003**, *87*, 167–198. [CrossRef]
23. Marotta, G.; Nazzaro, C. Value Portfolio in the Multifunctional Farm: New Theoretical-Methodological Approaches. *Riv. Econ. Agrar.* **2012**, *2*, 7–36.
24. Chinnici, G.; Selvaggi, R.; D'Amico, M.; Pecorino, B. Assessment of the potential energy supply and biomethane from the anaerobic digestion of agro-food feedstocks in Sicily. *Renew. Sustain. Energy Rev.* **2018**, *82 Pt 1* , 6–13. [CrossRef]
25. Ledesma-Escobar, C.A.; de Castro, M.D.L. Towards a comprehensive exploitation of citrus. *Trends Food Sci. Technol.* **2014**, *39*, 63–75. [CrossRef]
26. Sharma, K.; Mahato, N.; Cho, M.H.; Lee, Y.R. Converting citrus wastes into value-added products: Economic and environmently friendly approaches. *Nutrition* **2017**, *34*, 29–46. [CrossRef] [PubMed]
27. Lin, C.S.K.; Pfaltzgraff, L.A.; Herrero-Davila, L.; Mubofu, E.B.; Abderrahim, S.; Clark, J.H.; Koutinas, A.A.; Kopsahelis, N.; Stamatelatou, K.; Dickson, F.; et al. Food waste as a valuable resource for the production of chemicals, materials and fuels. Current situation and global perspective. *Energy Environ. Sci.* **2013**, *6*, 426–464. [CrossRef]
28. BP Statistical Review of World Energy. 2012. Available online: http://www.bp.com/assets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2011/STAGING/local_assets/pdf/statistical_review_of_world_energy_full_report_2012.pdf (accessed on 5 September 2012).
29. Wikandari, R.; Nguyen, H.; Millati, R.; Niklasson, C.; Taherzadeh, M.J. Improvement of biogas production from orange peel waste by leaching of limonene. *BioMed Res Int.* **2015**, *2015*, 494182. [CrossRef] [PubMed]

30. Valenti, F.; Porto, S.M.C.; Chinnici, G.; Cascone, G.; Arcidiacono, C. A GIS-based model to estimate citrus pulp availability for biogas production: An application to a region of the Mediterranean Basin. *Biofuels Bioprod. Biorefin.* **2016**, *10*, 710–727. [CrossRef]
31. Mamma, D.; Christakopoulos, P. Biotransformation of citrus by-products into value added products. *Waste Biomass Valoriz.* **2014**, *5*, 529–549. [CrossRef]
32. Taghizadeh-Alisaraei, A.; Hosseini, S.H.; Ghobadian, B.; Motevali, A. Biofuel production from citrus wastes: A feasibility study in Iran. *Renew. Sustain. Energy Rev.* **2017**, *69*, 1100–1112. [CrossRef]
33. Pourbafrani, M.; Forgács, G.; Horváth, I.S.; Niklasson, C.; Taherzadeh, M.J. Production of biofuels, limonene and pectin from citrus wastes. *Bioresour. Technol.* **2010**, *101*, 4246–4250. [CrossRef] [PubMed]
34. Fernández-López, J.; Fernández-Ginés, J.M.; Aleson-Carbonell, L.; Sendra, E.; Sayas-Barberá, E.; Pérez-Alvarez, J.A. Application of functional citrus by-products to meat products. *Trends Food Sci. Technol.* **2004**, *15*, 176–185. [CrossRef]
35. De Moraes Crizel, T.; Jablonski, A.; de Oliveira Rios, A.; Rech, R.; Flôres, S.H. Dietary fiber from orange byproducts as a potential fat replacer. *LWT Food Sci. Technol.* **2013**, *53*, 9–14. [CrossRef]
36. Calabrò, P.S.; Pontoni, L.; Porqueddu, I.; Greco, R.; Pirozzi, F.; Malpei, F. Effect of the concentration of essential oil on orange peel waste biomethanization: Preliminary batch results. *Waste Manag.* **2016**, *48*, 440–447. [CrossRef] [PubMed]
37. Bampidis, V.A.; Robinson, P.H. Citrus by-products as ruminant feeds: A review. *Anim. Feed Sci. Technol.* **2006**, *128*, 175–217. [CrossRef]
38. Scheiterle, L.; Ulmer, A.; Birner, R.; Pyka, A. From commodity-based value chains to biomass-based value webs: The case of sugarcane in Brazil's bioeconomy. *J. Clean. Prod.* **2018**, *172*, 3851–3863. [CrossRef]
39. Matharu, A.S.; de Melo, E.M.; Houghton, J.A. Opportunity for high value-added chemicals from food supply chain wastes. *Bioresour. Technol.* **2016**, *215*, 123–130. [CrossRef] [PubMed]
40. Vergamini, D.; Cuming, D.; Viaggi, D. The Integrated Management of Food Processing Waste: The Use of the Full Cost Method for Planning and Pricing Mediterranean Citrus By-Products. *Int. Food Agribus. Manag. Rev.* **2015**, *18*, 153–172.
41. Roberts, J.J.; Cassula, A.M.; Prado, P.O.; Dias, R.A.; Balestieri, J.A.P. Assessment of dry residual biomass potential for use as alternative energy source in the party of General Pueyrredón, Argentina. *Renew. Sustain. Energy Rev.* **2015**, *41*, 568–583. [CrossRef]
42. Mohan, S.R. Strategy and design of Innovation Policy Road Mapping for a waste biorefinery. *Bioresour. Technol.* **2016**, *215*, 76–83. [CrossRef] [PubMed]
43. Negro, S.O.; Alkemade, F.; Hekkert, M.P. Why does renewable energy diffuse so slowly? A review of innovation system problems. *Renew. Sustain. Energy Rev.* **2012**, *16*, 3836–3846. [CrossRef]
44. Popp, J.; Harangi-Rákos, M.; Gabnai, Z.; Balogh, P.; Antal, G.; Bai, A. Biofuels and their co-products as livestock feed: Global economic and environmental implications. *Molecules* **2016**, *21*, 285. [CrossRef] [PubMed]
45. Surendra, K.C.; Takara, D.; Hashimoto, A.G.; Khanal, S.K. Biogas as a sustainable energy source for developing countries: Opportunities and challenges. *Renew. Sustain. Energy Rev.* **2014**, *31*, 846–859. [CrossRef]
46. Long, T.B.; Blok, V.; Coninx, I. Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: Evidence from the Netherlands, France, Switzerland and Italy. *J. Clean. Prod.* **2016**, *112*, 9–21. [CrossRef]
47. Zhu, Q.; Sarkis, J.; Lai, K.H. Initiatives and outcomes of green supply chain management implementation by Chinese manufacturers. *J. Environ. Manag.* **2007**, *85*, 179–189. [CrossRef] [PubMed]
48. Shang, K.C.; Lu, C.S.; Li, S. A taxonomy of green supply chain management capability among electronics-related manufacturing firms in Taiwan. *J. Environ. Manag.* **2010**, *91*, 1218–1226. [CrossRef] [PubMed]
49. Tseng, S.C.; Hung, S.W. A strategic decision-making model considering the social costs of carbon dioxide emissions for sustainable supply chain management. *J. Environ. Manag.* **2014**, *133*, 315–322. [CrossRef] [PubMed]
50. Agi, M.A.; Nishant, R. Understanding influential factors on implementing green supply chain management practices: An interpretive structural modelling analysis. *J. Environ. Manag.* **2017**, *188*, 351–363. [CrossRef] [PubMed]

51. McCormick, K.; Kåberger, T. Key barriers for bioenergy in Europe: Economic conditions, know-how and institutional capacity, and supply chain co-ordination. *Biomass Bioenergy* **2007**, *31*, 443–452. [CrossRef]
52. Cembalo, L.; Pascucci, S.; Tagliafierro, C.; Caracciolo, F. Development and management of a bio-energy supply chain through contract farming. *Int. Food Agribus. Manag. Rev.* **2014**, *17*, 33–52.
53. Abebe, G.K.; Bijman, J.; Kemp, R.; Omta, O.; Tsegaye, A. Contract farming configuration: Smallholders' preferences for contract design attributes. *Food Policy* **2013**, *40*, 14–24. [CrossRef]
54. Handayati, Y.; Simatupang, T.M.; Perdana, T. Agri-food supply chain coordination: The state-of-the-art and recent developments. *Logist. Res.* **2015**, *8*, 5. [CrossRef]
55. Wamisho Hossiso, K.; De Laporte, A.; Ripplinger, D. The Effects of Contract Mechanism Design and Risk Preferences on Biomass Supply for Ethanol Production. *Agribusiness* **2017**, *33*, 339–357. [CrossRef]
56. Italian National Institute of Statistics (ISTAT). 2017. Available online: http://agri.istat.it/sag_is_pdwout/jsp/dawinci.jsp?q=plC240000030000203200&an=2017&ig=1&ct=506&id=15A|21A|31A (accessed on 13 December 2018).
57. Cerruto, E.; Selvaggi, R.; Papa, R. Potential biogas production from by-product of citrus industry in Sicily. *Qual. Access Success* **2016**, *17*, 251–258.
58. Carraresi, L.; Berg, S.; Bröring, S. Emerging value chains within the bioeconomy: Structural changes in the case of phosphate recovery. *J. Clean. Prod.* **2018**, *183*, 87–101. [CrossRef]
59. Berg, S.; Cloutier, L.M.; Bröring, S. Collective stakeholder representations and perceptions of drivers of novel biomass-based value chains. *J. Clean. Prod.* **2018**, *200*, 231–241. [CrossRef]
60. Golembiewski, B.; Sick, N.; Broring, S. Patterns of convergence within the emerging bioeconomy—The case of the agricultural and energy sector. *Int. J. Innov. Technol. Manag.* **2015**, *12*, 1550012. [CrossRef]
61. Korhonen, J.; Patari, S.; Toppinen, A.; Tuppura, A. The role of environmental regulation in the future competitiveness of the pulp and paper industry: The case of the sulfur emissions directive in Northern Europe. *J. Clean. Prod.* **2015**, *108*, 864–872. [CrossRef]
62. Kircher, M. The emerging bioeconomy: Industrial drivers, global impact, and international strategies. *Ind. Biotechnol.* **2014**, *10*, 11–18. [CrossRef]
63. Correll, D.; Suzuki, Y.; Martens, B.J. Logistical supply chain design for bioeconomy applications. *Biomass Bioenergy* **2014**, *66*, 60–69. [CrossRef]
64. Ekman, A.; Campos, M.; Lindahl, S.; Co, M.; Börjesson, P.; Karlsson, E.N.; Turner, C. Bioresource utilisation by sustainable technologies in new value-added biorefinery concepts e two case studies from food and forest industry. *J. Clean. Prod.* **2013**, *57*, 46–58. [CrossRef]
65. Fischer, C.; Hartmann, M. *Agri-Food Chain Relationships*; CABI: Oxford, UK, 2010.
66. Mancuso, T.; Baldi, L.; Peri, M.; Blandino, M.; Reyneri, A. Exploring a New Form of Horizontal Coordination to Improve Economic Sustainability of the Soft Wheat Chain in the Northwest of Italy. In Proceedings of the International European Forum on System Dynamics and Innovation in Food Networks, Innsbruck-Igls, Austria, 5–9 February 2018; pp. 273–282.
67. Pedrosa, A. Motivating stakeholders for co-created innovation. *Technol. Innov. Manag. Rev.* **2009**, *1*, 35–39.
68. Almeida, C.M.V.B.; Bonilla, S.H.; Giannetti, B.F.; Huisingh, D. Cleaner production initiatives and challenges for a sustainable world: An introduction to this special volume. *J. Clean. Prod.* **2013**, *47*, 1–10. [CrossRef]
69. De Besi, M.; McCormick, K. Towards a bioeconomy in Europe: National, regional and industrial strategies. *Sustainability* **2015**, *7*, 10461–10478. [CrossRef]
70. Tan, B.; Çömden, N. Agricultural planning of annual plants under demand, maturation, harvest, and yield risk. *Eur. J. Oper. Res.* **2012**, *220*, 539–549. [CrossRef]
71. Carillo, F.; Caracciolo, F.; Cembalo, L. Do durum wheat producers benefit of vertical coordination? *Agric. Food Econ.* **2017**, *5*, 19. [CrossRef]
72. Jang, J.; Olson, F. The role of product differentiation for contract choice in the agro-food sector. *Eur. Rev. Agric. Econ.* **2010**, *37*, 251–273. [CrossRef]
73. Yang, X.; Paulson, N.D.; Khanna, M. Optimal mix of vertical integration and contracting for energy crops: Effect of risk preferences and land quality. *Appl. Econ. Perspect. Policy* **2015**, *38*, 632–654. [CrossRef]
74. Okwo, A.; Thomas, V.M. Biomass feedstock contracts: Role of land quality and yield variability in near term feasibility. *Energy Econ.* **2014**, *42*, 67–80. [CrossRef]
75. Cembalo, L.; Caracciolo, F.; Migliore, G.; Lombardi, A.; Schifani, G. Bioenergy chain building: A collective action perspective. *Agric. Food Econ.* **2014**, *2*, 18. [CrossRef]

76. Karantininis, K.; Sauer, J.; Furtan, W.H. Innovation and integration in the agri-food industry. *Food Policy* **2010**, *35*, 112–120. [CrossRef]
77. Bicas, J.L.; Fontanille, P.; Pastore, G.M.; Larroche, C. Characterization of monoterpene biotransformation in two pseudomonads. *J. Appl. Microbiol.* **2008**, *105*, 1991–2001. [CrossRef] [PubMed]
78. Salunkhe, D.K.; Kadam, S.S. *Handbook of Fruit Science and Technology: Production, Composition, Storage, and Processing*; Marcl Dekker, Inc.: New York, NY, USA, 1995; pp. 62–116.
79. Ammerman, C.B.; Henry, P.R. Citrus and vegetable products for ruminant animals. In Proceedings of the Alternative Feeds for Dairy and Beef Cattle, St. Louis, MO, USA, 22–24 September 1991; pp. 103–110.
80. Tripodo, M.M.; Lanuzza, F.; Micali, G.; Coppolino, R.; Nucita, F. Citrus waste recovery: A new environmentally friendly procedure to obtain animal feed. *Bioresour. Technol.* **2004**, *91*, 111–115. [CrossRef]
81. Demirbas, M.F.; Balat, M.; Balat, H. Biowastes-to-biofuels. *Energy Convers. Manag.* **2011**, *52*, 1815–1828. [CrossRef]
82. Bae, I.Y.; Rha, H.J.; Lee, S.; Lee, H.G. Preparation and characterization of pectin hydroxamates from citrus unshiu peels. *J. Excip. Food Chem.* **2016**, *2*, 1123.
83. Marın, F.R.; Martinez, M.; Uribesalgo, T.; Castillo, S.; Frutos, M.J. Changes in nutraceutical composition of lemon juices according to different industrial extraction systems. *Food Chem.* **2002**, *78*, 319–324. [CrossRef]
84. Asp, N.G. Dietary fibre-definition, chemistry and analytical determination. *Mol. Asp. Med.* **1987**, *9*, 17–29. [CrossRef]
85. Gorinstein, S.; Martìn-Belloso, O.; Park, Y.S.; Haruenkit, R.; Lojek, A.; Ĉìž, M.; Caspi, A.; Libman, I.; Trakhtenberg, S. Comparison of some biochemical characteristics of different citrus fruits. *Food Chem.* **2001**, *74*, 309–315. [CrossRef]
86. Grasser, L.A.; Fadel, J.G.; Garnett, I.; DePeters, E.J. Quantity and economic importance of nine selected by-products used in California dairy rations. *J. Dairy Sci.* **1995**, *78*, 962–971. [CrossRef]
87. Wing, J.M.; Van Horn, H.H.; Sklare, S.D.; Harris, B., Jr. Effects of citrus molasses, distillers solubles and molasses on rumen parameters and lactation. *J. Dairy Sci.* **1988**, *71*, 414–420. [CrossRef]
88. Coleman, R.L.; Shaw, P.E. Amino acid composition of dried citrus sludge and its potential as a poultry feedstuff. *J. Agric. Food Chem.* **1977**, *25*, 971–973. [CrossRef]
89. Martín, M.A.; Fernández, R.; Serrano, A.; Siles, J.A. Semi-continuous anaerobic co-digestion of orange peel waste and residual glycerol derived from biodiesel manufacturing. *Waste Manag.* **2013**, *33*, 1633–1639. [CrossRef] [PubMed]
90. Valenti, F.; Porto, S.M.C.; Chinnici, G.; Selvaggi, R.; Cascone, G.; Arcidiacono, C.; Pecorino, B. Use of citrus pulp for biogas production. A GIS analysis of citrus-growing areas and processing industries in South Italy. *Land Use Policy* **2017**, *66*, 151–161. [CrossRef]
91. Patinvoh, R.J.; Osadolor, O.A.; Chandolias, K.; Horváth, I.S.; Taherzadeh, M.J. Innovative pretreatment strategies for biogas production. *Bioresour. Technol.* **2017**, *224*, 13–24. [CrossRef] [PubMed]
92. Torquato, L.D.; Pachiega, R.; Crespi, M.S.; Nespeca, M.G.; de Oliveira, J.E.; Maintinguer, S.I. Potential of biohydrogen production from effluents of citrus processing industry using anaerobic bacteria from sewage sludge. *Waste Manag.* **2017**, *59*, 181–193. [CrossRef] [PubMed]
93. Aboagye, D.; Banadda, N.; Kiggundu, N.; Kabenge, I. Assessment of orange peel waste availability in ghana and potential bio-oil yield using fast pyrolysis. *Renew. Sustain. Energy Rev.* **2017**, *70*, 814–821. [CrossRef]
94. Kerton, F.M.; Marriott, R. *Alternative Solvents for Green Chemistry (No. 20)*; Royal Society of Chemistry: London, UK, 2013.
95. Braddock, R.J. *Handbook of Citrus By-Products and Processing Technology*; John & Wiley Sons: Hoboken, NJ, USA, 1999.
96. Kausar, A.; Bhatti, H.N.; MacKinnon, G. Equilibrium, kinetic and thermodynamic studies on the removal of U (VI) by low cost agricultural waste. *Colloids Surf. B Biointerfaces* **2013**, *111*, 124–133. [CrossRef] [PubMed]
97. Aguglia, L.; Carillo, F.; Madau, F.A.; Perito, M.A. *La Commercializzazione Degli Agrumi Freschi e Trasformati*; Report No. 3; INEA (National Institut of Agrary Economy): Rome, Italy, 2008; pp. 3–50.
98. Chinnici, G.; D'Amico, M.; Rizzo, M.; Pecorino, B. Analysis of biomass availability for energy use in Sicily. *Renew. Sustain. Energy Rev.* **2015**, *52*, 1025–1030. [CrossRef]
99. Operazione Last Orange: Sigilli alla Canditfrucht. Ai domiciliari Nunzio Calabrò. *24live.it: Barcellona News*, 17 April 2014. Available online: http://www.24live.it/69631-operazione-last-orange-traffico-illecito-di-rifiuti-sigilli-alla-canditfrucht-ai-domiciliari-nunzio-calabro (accessed on 13 December 2018).

100. Freeman, R.E. *Strategic Management: A Stakeholder Approach*; CUP: New York, NY, USA, 2010.
101. Schifani, G.; Migliore, G.; Caracciolo, F.; Romeo, P.; Cembalo, L.; Cicia, G. Triggering Collective Action for Bio-Energy Supply Chain Through Contract Schemes. *New Medit.* **2016**, *15*, 56–63.
102. Handfield, R.B.; Nichols, E.L. *Supply Chain Redesign: Transforming Supply Chains into Integrated Value Systems*; FT Press: Upper Saddle River, NJ, USA, 2002.
103. Cembalo, L.; Caracciolo, F.; D'Amico, M. Managing a venture in bio-energy supply chain: An operational approach. *Qual. Access Success* **2016**, *17*, 118–123.
104. McFadden, D. Economic choices. *Am. Econ. Rev.* **2001**, *91*, 351–378. [CrossRef]
105. Roe, B.; Sporleder, T.L.; Belleville, B. Hog producer preferences for marketing contract attributes. *Am. J. Agric. Econ.* **2004**, *86*, 115–123. [CrossRef]
106. Amemiya, T. *Advanced Econometrics*; HUP: Cambridge, MA, USA, 1985.
107. Gallant, A.R.; Nychka, D.W. Semi-nonparametric maximum likelihood estimation. *Econometrica* **1987**, *55*, 363–390. [CrossRef]
108. Negro, V.; Mancini, G.; Ruggeri, B.; Fino, D. Citrus waste as feedstock for bio-based products recovery: Review on limonene case study and energy valorization. *Bioresour. Technol.* **2016**, *214*, 806–815. [CrossRef] [PubMed]
109. Zema, D.A. Planning the optimal site, size, and feed of biogas plants in agricultural districts. *Biofuels Bioprod. Biorefin.* **2017**, *11*, 454–471. [CrossRef]
110. Rezzadori, K.; Benedetti, S.; Amante, E.R. Proposals for the residues recovery: Orange waste as raw material for new products. *Food Bioprod. Process.* **2012**, *90*, 606–614. [CrossRef]
111. Satari, B.; Palhed, J.; Karimi, K.; Lundin, M.; Taherzadeh, M.J.; Zamani, A. Process Optimization for Citrus Waste Biorefinery via Simultaneous Pectin Extraction and Pretreatment. *BioResources* **2017**, *12*, 1706–1722. [CrossRef]
112. Su, H.; Tan, F.; Xu, Y. Enhancement of biogas and methanization of citrus waste via biodegradation pretreatment and subsequent optimized fermentation. *Fuel* **2016**, *181*, 843–851. [CrossRef]
113. Kim, W.C.; Lee, D.Y.; Lee, C.H.; Kim, C.W. Optimization of narirutin extraction during washing step of the pectin production from citrus peels. *J. Food Eng.* **2004**, *63*, 191–197. [CrossRef]
114. Kopecka, J.A.; Santema, S.C.; Buijs, J.A. Designerly ways of muddling through. *J. Bus. Res.* **2012**, *65*, 729–739. [CrossRef]
115. Borodin, V.; Bourtembourg, J.; Hnaien, F.; Labadie, N. Handling uncertainty in agricultural supply chain management: A state of the art. *Eur. J. Oper. Res.* **2016**, *254*, 348–359. [CrossRef]
116. Lerro, M.; Raimondo, M.; Freda, R. Determinants of corporate social responsibility support: A consumers' perspective. *Qual. Access Success* **2016**, *17*, 172–180.
117. Hall, J.; Matos, S.; Silvestre, B. Understanding why firms should invest in sustainable supply chains: A complexity approach. *Int J. Prod. Res.* **2012**, *50*, 1332–1348. [CrossRef]
118. Barham, B.L.; Chavas, J.P.; Fitz, D.; Salas, V.R.; Schechter, L. The roles of risk and ambiguity in technology adoption. *J. Econ. Behav. Organ.* **2014**, *97*, 204–218. [CrossRef]
119. Del Río González, P. Analysing the factors influencing clean technology adoption: A study of the Spanish pulp and paper industry. *Bus. Strateg. Environ.* **2005**, *14*, 20–37. [CrossRef]
120. Johnson, M. Barriers to innovation adoption: A study of e-markets. *Ind. Manag. Data Syst.* **2010**, *110*, 157–174. [CrossRef]
121. Abhari, K.; Davidson, E.; Xiao, B. Perceived Individual Risk of Co-innovation in Collaborative Innovation Networks. In Proceedings of the 50th Hawaii International Conference on System Sciences, Waikoloa, HI, USA, 4–7 January 2017.
122. De Paola, M. The determinants of risk aversion: The role of intergenerational transmission. *Ger. Econ. Rev.* **2013**, *14*, 214–234. [CrossRef]
123. Foster, A.D.; Rosenzweig, M.R. Microeconomics of technology adoption. *Annu. Rev. Econ.* **2010**, *2*, 395–424. [CrossRef] [PubMed]
124. Knight, J.; Weir, S.; Woldehanna, T. The role of education in facilitating risk-taking and innovation in agriculture. *J. Dev. Stud.* **2003**, *39*, 1–22. [CrossRef]
125. Chronopoulos, M.; Lumbreras, S. Optimal regime switching under risk aversion and uncertainty. *Eur. J. Oper. Res.* **2017**, *256*, 543–555. [CrossRef]

126. Broitman, D.; Raviv, O.; Ayalon, O.; Kan, I. Designing an agricultural vegetative waste-management system under uncertain prices of treatment-technology output products. *Waste Manag.* **2018**, *75*, 37–43. [CrossRef] [PubMed]
127. Chronopoulos, M.; Siddiqui, A. When is it better to wait for a new version? Optimal replacement of an emerging technology under uncertainty. *Ann. Oper. Res.* **2015**, *235*, 177–201. [CrossRef]