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Development and Management of a Bio-Energy Supply Chain Through Contract Farming

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Abstract

This paper discusses how to develop and manage integration, coordination and cooperation in bio-energy supply chains. Farmers decisions on whether or not to participate in a contract farming scheme have been investigated, particularly assessing the trade-offs between the contract attributes and their impact on the likelihood to participate. A stated preference model was implemented where respondents were asked to choose between alternative contracts with varying attribute levels to start biomass cultivation. Results show that participation is mainly influenced by minimum price guaranteed, contract length, and re-negotiation before the end of a contract.

Keywords: agricultural biomass, cooperation, Choice Modeling, Italy

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Introduction

This paper considers the specific case study of contract determinants individual farmers have when engaging in a contract for promoting a bio-energy (biomass production) chain. In particular, it focuses on the issues related to farmer's decision-making process on whether to participate or not in the contract farming scheme. By assessing the likelihood of farmers' participation, the likelihood that a large number of farmers participate in a simultaneous contract is investigated as well. Such sort of cooperation is necessary in order to make the investment profitable for the bio-energy producer company, which requires specific biomass quantities throughout the year. Consequently, a group of farmers needs to agree to be part of the contract farming scheme and set up the bio-energy chain. Using a choice experiment, the farmer's decision making process is explained in terms of trade-offs between the different attributes of the contract farming scheme the farmer is willing to commit or not to it.

Contract farming literature suggests that several attributes may be involved in such decision making process, like: i) base price formula (i.e. the prevailing market price for agro-biomass); ii) a minimum quantity of biomass to be produced each year (measured in hectares invested in biomass); iii) minimum guaranteed price; iv) contract length; v) re-negotiation before the end of a contract; vi) mandatory participation to training and extension programs (Masakure and Henson 2005; Abebe et al. 2013).

Our empirical study has been conducted in the province of Avellino (Southern Italy), in an area characterized by extensive cereal production, such as wheat and barley, where marginal lands are mostly uncultivated, thus potentially available for conversion to bio-mass production and energy cropping. The characteristics and issues in the area are common to many Mediterranean internal regions, which supports the generalizability of the methodology used in this study. In particular, in the study area a public-private-partnership is already taking place to further explore the opportunity to set-up a pilot bio-energy supply chain[1]. Two hundreds face-to-face questionnaires have been administered to local farmers in September-November 2013. More specifically, we implemented a stated preference model to investigate farmers' preferences about contract farming. The choice of a stated preference method was necessary because no actual contracting behaviour was available to be observed (Roe et al. 2004). In a choice experiment, based on an efficient experimental design, farmers were asked to choose between alternative contract farming schemes with varying attribute levels in order to start a biomass production. The biomass crop suggested was *Arundo Donax* (also known as *Giant Cane*). The *Arundo* was chosen because of its high biomass productive efficiency, its ability to significantly mitigate soil erosion risk (it is a multi-year crop) and its capacity to yield an income comparable to wheat. To the best of our knowledge, this is one of the few applications of this methodology to farmers' preferences towards contract farming in bio-energy supply chain (Lajili et al. 1997; Abebe et al. 2013).

[1] Promotion and Development of an bio-energy supply chain in partnership with industrial actors funded by European Regional Development Fund (PON): "Integrated agro-industrial chains with energy efficiency for the development of eco-compatible processes of energy and bio-chemical production for renewable sources for the land valorization (ENERBIOCHEM)".

Facilitating Participation in Contract Farming

Farmers' participation in bio-energy supply chains has been widely discussed (Pellerin and Taylor 2008; Altman et al. 2013). Another important aspect widely debated both in the academic and in the managerial and political context is the conflict between bio-energy production and food security (Seuring and Muller 2008; Negash and Swinnen 2013). Bio-fuels production often requires use of the most fertile and productive areas, thus creating direct competition between energy and food/feed crops (Cicia et al. 2012; Negash and Swinnen 2013). However, if energy crops, especially for bio-mass production, are located on marginal land, they can integrate and complement conventional food/feed crop production rather than conflicting with it (Caracciolo and Lombardi 2012).

Energy crop cultivation always requires the set up and management of integrated and coordinated supply chains, in order to secure the energy company the critical mass for the plant to operate efficiently. It is in the energy company's interest to design supply chain arrangements such that a large group of suppliers (farmers) has convenience to deliver their production. This is a crucial point as, while the process of designing such arrangements is complex and costly, the increasing general interest in sustainable sources of energy is an incentive for energy producers to address the issue of how to foster and manage integration and coordination along the chain (Seuring and Muller 2008).

By chain integration and coordination we mean a process of progressive dependence among different actors, that involves common investments, coordination of activities, and processes of learning and innovation (Handfield and Nichols 1999; Hugos 2003). While all chains are based on agreements between two or more actors, the bio-energy supply chain shows the peculiar feature of the simultaneous focus on integrating and coordinating the bio-energy producer (buying company) and the farmers (suppliers), and stimulating cooperation among farmers. Contract farming is often used to manage integration, coordination and cooperation because it provides flexibility in the way incentives can be set for different typologies of suppliers, thus increasing the chances of large participation (Abebe et al. 2013).

Integration through cooperation is not a new topic in the studies of sustainable use of the natural resources in bio-energy supply chain (van Dam et al. 2010; Scarlat and Dallemand 2011). However how to combine contractual aspects between the buying company and the group of suppliers remains difficult to address (Meinzen-Dick et al. 2004). The role of inter-firm collaboration and contract design results to be a priority in this respect. In particular, it is relevant to further investigate how a contract farming approach can support the development and management of bio-energy supply chains in which a group of farmers needs to (simultaneously) collaborate with an energy-producer company.

To address these issues, a contract design to foster the participation in bio-energy supply chain can move from the following principles: (i) the characteristics of the cooperation problem (i.e. property rights on resources) are well-defined; (ii) the characteristics of the group (i.e. size and heterogeneity) are controlled; (iii) the level of institutional formalization (e.g. type of participation contract) is kept as limited as possible in order to gain benefits from the flexibility ensured by the informal component of the collaborative behavior; (iv) know-how and technology is shared and finally (v) actions of national governments and other external actors should be supportive of the cooperative process, not corrupting the mechanism towards a too individualized or formalized (bureaucratic) process (Ostrom at al. 1999). Subsequently, to successfully organize a bio-energy supply chain, it is a key element to design a participation contract that takes those principles into account but through individual farmer-based decisions.

In designing the contract, the first element to consider is the price mechanism introduced by the contract and whether a minimum price is guaranteed or not (Roe et al. 2004; Schlecht and Spiller 2012). Also, because participation in the contract farming creates mutual dependency, defining the length of the contract and whether renegotiation is an option is another important element (Roe et al. 2004; Schlecht and Spiller 2012; Abebe et al. 2013). To ensure know-how and technology sharing it is often needed to provide an extension service attached to participation decision (Abebe et al. 2013). Finally, seeking economies of scale requires the definition of a minimum volume of product to be delivered by the farmer (Schlecht and Spiller 2012).

Data and the Study Area

Moving from these considerations, we designed a choice experiment for a sample of farmers in a rural area of South Italy to assess their preferences for contract farming and predict their likelihood to participate in a bio-energy supply chain. Data were collected through the administration of a questionnaire with face-to-face interviews. The study area covered several municipalities of the Avellino province, Campania region, some 150 km east of Naples. This area well represents the typical conditions of Southern Italian internal regions. It is characterized by mild continental weather and cultivation of cereals and forage crops, sometimes associated with dairy or animal raring activities. Bio-energy producers are increasingly interested in investing in such areas, where conditions are naturally optimal for bio-energy crops while conventional crops often bring low productivity and high risk of soil erosion.

The aim of the investigation was to investigate farmers (stated) preferences for participation in contract farming. Following established practice in choice experiment literature (Louviere et al. 2000; Hensher et al. 2005), we designed the survey questionnaire through an iterative process, taking indications from different stages of the study and taking into account the specific objectives of our research. The questionnaire was organized in three sections.

In order to collect all the information we needed, while keeping the questionnaire short, we introduced the socio-demographic questions in the first section of the questionnaire, adding some more questions on the farm structure and organization and using these questions to “warm up” the interviewee and introduce him/her to the topic of our research. The objective was to outline the type or types of entrepreneur and farm in our sample and collect information on their behavior to better interpret and understand their choices in the questionnaire choice scenarios.

In the central section of the questionnaire respondents made their choice for contract attributes which were determined through an experimental design approach. We opted for four choice sets each with two alternatives (see Table 1). Each alternative represented a contract, constructed as a combination of different levels of the selected attributes. For each choice scenario, the interviewee was asked to choose the most preferred contract or to choose none of them. The scenarios were introduced with a detailed description of biomass cultivation, specifically the *Giant Cane*, the set-up of the bio-energy chain in the study area, the need of a contract with several farmers in order to provide the bio-energy plant with sufficient and constant raw materials. The selected attributes, that in different level combinations formed the different contract types offered in the choice tasks, were carefully described so that respondents could make an informed choice. The choice scenarios were finally introduced and the cards with the alternative contracts showed to the respondents, highlighting that they represented realistic contract types a bio-energy producer company could propose to the local farmers.

Table 1. Selected attributes and levels of proposed contracts

Attributes	Levels definition	Range
Base Price	Current market price plus or minus a flat amount for marketing premium or fees: values are randomly generated from a normal distribution	from 38€ to 51€ per tons.
Minimum guaranteed price	Presence (1) or absence (0) of a minimum price: values are randomly generated from a binomial distribution.	0 or 1.
Length	Discrete values are randomly generated from an uniform distribution in the 3-10 years interval	from 3 to 10 years
Renegotiation option	Presence (1) or absence (0) of an option to renegotiate the contract terms: values are randomly generated from a binomial distribution.	0 or 1.
Training meeting	Presence (1) or absence (0) of mandatory participation to training meetings: values are randomly generated from a binomial distribution.	0 or 1.
Minimum volume of product	Presence (1) or absence (0) of minimum volume of product to be guaranteed: values are randomly generated from a binomial distribution	0 or 1.

The face-to-face survey administration in the study case area provided 200 complete questionnaires[2]. Based on the data collected by the first section of the questionnaire (summarized in Table 2), in our sample farm managers are mostly male (61%), aged in average 43, full time farmers and owner of the land they cultivate. The sample farms cover an area of 4,092 ha, of which 3,706 ha are cultivated. Farm size is quite variable in the sample, as it goes from a minimum of 1.5 ha to a maximum of 340 ha, however the most frequent size (sample mode) is 20 ha.

Farms are generally fragmented in parcels, varying from a minimum of 1 up to 30 parcels, with an average number of parcels per farm of six. Arable crops, mostly wheat, are clearly predominant in the sample farms (93% of the total cultivated land). Only a very small share of the land is left for olive trees, industrial crops and grapevine. Due to erosion and landslides, along with steep slope, in 30% of the sampled farms part of the arable land is now abandoned,

[2] Two professional interviewers with agro-technological background and a long experience of the study area have been recruited for the field survey. Interviewees have been selected from a list of farm managers who have expressed interest to local extension services to be involved in the bio-energy pilot project.

some 4% of the overall farm land under investigation. This area represents the most suitable part of the farms to be converted into energy crops.

Table 2. Farmers and farms characteristics

Description		Mean	Std.dev	Min	Max
Gender	1 if male; 0 female	61%	N.A.	0	1
Age	(year)	43.2	11.76	18	80
Farm size	Total area of sample farms (ha)	20.5	26.66	1.5	340
Total cultivated area	Total cultivated area of sample farms (ha)	18.6	23.52	1	300
Full time farmer	1 if full time; 0 otherwise	77%	N.A.	0	1
Individual farmers	1 if individual; 0 otherwise	96%	N.A.	0	1
Number of land parcels		6		1	30
Land ownership	*Property*	72%	N.A.	0	1
	Rent	26%	N.A.	0	1
	Other	2%	N.A.	0	1
Crops	*Arable crops (ha)*	16.7	21.91	0.5	280
	Permanent crops (ha)	0.6	1.14	0	9

Note. N.A: not applicable

Part of the survey was orientated to investigate the propensity of farm managers to change and their openness to innovation and investment. This is a crucial aspect to be considered in the assessment of the preference and propensity of those farm managers to adopt energy crops and to participate in contract farming with an energy producer company. Table 3 summarizes main results. About 70% of farm managers have invested in new equipment or new processing systems or have bought more land during the past five years. Much less (46%) have introduced some innovation in the cropping systems, techniques and organization of the farm.

Table 3. Investments and innovation in the past five years* (number of farmers and their %)

		Value	Percentage
Investments in the last 5 years:		139	70%
	Machines	119	60%
	New constructions	66	33%
	Processing and packaging	6	3%
	Marketing	11	6%
	Land acquisition	83	42%
	Other	1	1%
Innovations in the last 5 years:		91	46%
	Cropping system changes	35	18%
	Cropping techniques changes	9	5%
	Organization changes	64	32%

Note. *The number of investments and innovations is greater than the number of the farms as some farms have adopted more than one.

Moreover we have investigated farm managers experience and propensity to cooperate. As showed in Table 4, cooperation is not particularly common in the sample. Although more than half of the sample (56%) is aware of the presence of some forms of cooperation in the area, only 32% of the farmer managers declared to have participated already in one of them. Cooperation is mainly experienced in marketing activities, to control production uncertainty, to secure a minimum price and the access to markets (Table 4). Farmers that participate to different forms of cooperation are generally younger (40 years-old) than the average age of the sample (43) and the size of the farm is bigger (25.58 ha) than the average size of the sample (20.46 ha). The most common form of contract they are involved with (68%) is informal and one-year long.

Table 4. Presence of forms of cooperation in the area and participation

		Value	Percentage
Forms of cooperation in the area:		111	56%
	Informal contracts	66	33%
	Cooperatives and trademarks	40	20%
	Supply chain contracts and guaranteed minimum price	2	1%
Participation in cooperation activities:		64	32%
	Cooperation on the production side *	16	8%
	Cooperation on the marketing side **	48	24%

Note. * Technical assistance, supply of production inputs and raw materials, transfer of technological innovations
** Product marketing, minimum price guarantee, less uncertainty in product allocation, access to markets

Empirical Strategy

The empirical strategy we used has roots in the random utility framework (McFadden 2001) that is widely used in economics studies for analyzing consumer preferences (Cembalo et al. 2008; Verneau et al. 2014). It has been proposed for the first time by Roe et al. (2004) for contract attributes analysis.

The model assumes that when a number C of contract alternatives is showed to the *h-th* farmer, the utility assigned by the farmer to each *c* contract alternative is a linear, additive and separable function of all the *t* attributes that constitutes the contract:

$$(1) \qquad U^h_c = f(\mathbf{z}_c) + \varepsilon^h_c$$

where $\mathbf{z}_c$ is a *T*-vector of observed attributes. The chosen alternative *c* represents the outcome of an "expected utility" maximization exercise of the farmer. To put it differently, the choice of the contract *c* will provide the farmer with the highest utility; in analytical terms, $U^h_c \geq U^h_k$, with the alternative $k \in C$ and $k \neq c$.

Thus, in order to maximize his/her utility, the farmer is assumed to choose the contract alternative with the most desired set of attributes $\mathbf{z}_c$. The probability of the farmer choosing contract *c* across the set of all possible alternatives C is defined by the probability that the utility of alternative *c* is greater than, or equal to, the utility related to each other alternative within the set of contracts:

(2) $\Pr(U^h_c) = \Pr\{U^h_c > \max(U^h_k,...,U^h_C)\}$

The random utility model considers utility U_c equal to the sum of an observable component Ωz_c, where **Ω** is a *T*-vector of unknown parameters, and a stochastic component $\boldsymbol{\varepsilon}_c$:

(3) $U^h_c = \boldsymbol{\Omega}\mathbf{z}_c + \varepsilon^h_c$.

The **Ω** parameters can be distributed in the sample according to a distribution function defined by a location (μ) and a scale (σ) parameter:

(4) $U^h_c = \boldsymbol{\Omega}^h\mathbf{z}_c + \varepsilon^h_c$

where $\boldsymbol{\Omega}^h = \boldsymbol{\Omega} + v^h$, $v^h \sim N(0, \sum_{\boldsymbol{\Omega}})$[3].

If the random term is assumed to have a type I extreme value distribution, then a logistic regression can be adopted to estimate **Ω** or $\boldsymbol{\Omega}^h$ parameters and their weight in affecting the choice of one contract over another (McFadden 2001). Thus, estimated coefficients (**Ω** or $\boldsymbol{\Omega}^h$) provide an explicit indication of overall farmers preferences toward each level of the proposed contract attributes.

In our experiment, four choice tasks, each with two randomly selected alternatives, were presented to respondents. Each contract alternative represents a different combination of levels for the *T* attributes (Table. 5). Six attributes were selected based on a preliminary focus group with key stakeholders and include: base price, minimum guaranteed price, contract length, renegotiation option, extension service, minimum volume of product requirement.

The base price (45€) was defined reflecting current market conditions for biomass resources from agricultural residues plus or minus a fixed amount randomly generated from a normal distribution with mean €0 and standard deviation 2€ (approximated to the closest integer). The final price was reported in the card. Given the length of the economic life of the *Arundo*, the duration of the contract was established to vary between 3 and 10 years, with each value randomly chosen from a uniform distribution.

Contracts could include the presence or absence of the minimum guaranteed price for farmers (guaranteed price at which given quantities are to be purchased by the buyer) and the presence or absence of the renegotiation option (all parties could discuss future contract adjustments to changing market conditions). Contract alternatives could also differ for the presence or absence of mandatory participation to training meetings (four hours per year), provided by the buyer to keep farmers up-do-date on cultivation practices, and for the presence or absence of a minimum guaranteed product quantity by farmers for the buyer.

[3] The combined error term ($v^h\mathbf{z}_c + \varepsilon^h_c$) is correlated across alternatives, relaxing the IIA assumption.

The random nature of combining levels values populate the matrix $\mathbf{z}_c$ characterizing the *c-th* contract. Matrix $\mathbf{z}_c$ thus includes 1600 profiles of contracts (789 of them unique), submitted in 4 choice tasks to the 200 farmers. The $\mathbf{\Omega}$ parameters can be estimated with the maximum likelihood estimator for logit model (Amemiya 1985), using maximum simulated likelihood methods (Train 2009).

Table 5. Attributes and levels of contracts

Attributes	Levels Definition	Average	Std.dev	Min	Max
Base Price	Current market price plus or minus a flat amount for marketing premium or fees: values are randomly generated from a normal distribution	44.55	1.97	38	51
Minimum guaranteed price	Presence (1) or absence (0) of a minimum price: values are randomly generated from a binomial distribution.	0.50	N.A	0	1
Length	Discrete values are randomly generated from an uniform distribution in the 3-10 years interval	6.45	2.32	3	10
Renegotiatio n option	Presence (1) or absence (0) of an option to renegotiate the contract terms: values are randomly generated from a binomial distribution.	0.50	N.A	0	1
Training meeting	Presence (1) or absence (0) of mandatory participation to training meetings: values are randomly generated from a binomial distribution.	0.50	N.A	0	1
Minimum volume of product	Presence (1) or absence (0) of minimum volume of product to be guaranteed: values are randomly generated from a binomial distribution	0.50	N.A	0	1

Note. N.A: not applicable

Results and Discussion

Data on farmers' responses to the choice tasks have been analyzed with fixed parameters ($v^h = 0$) and random parameters logit models. Results are reported in Table 6.

According to the fixed parameters logit (upper part of the Table), the only contract attribute farmers have not considered in their choices is the mandatory requirements for a minimum guaranteed product volume. The coefficient is indeed not statistically significant (coefficient estimate 0.11, z-value 1.18). We interpret this outcome as a tendency to avoid "locked-in" position, in which famers are obliged to deliver to the buying company even in case of insufficient production. The model also provides statistical evidence that farmers clearly prefer higher base price but also a shorter contract length, the presence of a minimum guaranteed price and both the presence of the renegotiation option and the training meetings.

From these results, some indications, in monetary terms, can be obtained on the trade-off farmers have made between the *t-th* contract attribute and the base price ($\Omega_t/\Omega_{baseprice}$, in the fifth column of Table 6). The minimum guaranteed price gains the highest price premium, estimated equal to €10.3 per ton of production. Price premium for the training meetings is valued equal to €3.2 per ton of production, while the price premium for the presence of renegotiation option is €9.3 per ton of production. Adding an extra year to the contract length is considered by farmers a price loss of €1.3 per ton of production.

The influence of the contract characteristics on the farmer's likelihood to join the contracts can be assessed calculating the cumulative distribution function of $\Pr(U_c)= \Pr\{U_c>\max(U_k,...,U_C)\}$ by varying the level values of matrix $\mathbf{z}_c$.

Farmer's likelihood to join is positively related with the base price and negatively with the contract length; the two patterns differ greatly in overall appearance (Fgure 1). The presence or the absence in the contract of the minimum guaranteed price shifts the overall pattern of the previously examined relations. For example, Figure 2 shows how the curve linking base price with the probability of choosing the *c-th* contract is much higher when the minimum guaranteed price term is present in the contract.

Table 6. Fixed parameter and Random parameter results

Fixed parameter	**Coef.**	**Std. Err.**	**z**	**P>z**	**Euros equivalent (€/tonn.)**
Base Price	0.08	0.03	2.27	0.023	
Minimum guaranteed price	0.81	0.10	8.36	0.000	10.3
Contract Length	-0.10	0.03	-3.21	0.001	-1.3
Renegotiation option	0.73	0.10	7.49	0.000	9.3
Training meetings	0.25	0.10	2.65	0.008	3.2
Minimum volume of product	0.11	0.09	1.18	0.239	
Random parameter	**μ**	**Std. Err.**	**z**	**P>z**	
Base Price	0.09	1.03	-3.08	0.002	
Minimum guaranteed price	1.27	0.22	5.73	0.000	
Contract Length	-0.15	0.06	-2.73	0.006	
Renegotiation option	1.14	0.21	5.31	0.000	
Training meetings	0.42	0.15	2.83	0.005	
Minimum volume of product	0.12	0.14	0.84	0.402	
	σ	**Std. Err.**	**z**	**P>z**	
Base Price	1.20	0.58	-2.07	0.039	
Minimum guaranteed price	1.06	0.29	3.62	0.000	
Contract Length	0.26	0.10	2.6	0.009	
Training meetings	1.26	0.31	4.08	0.000	

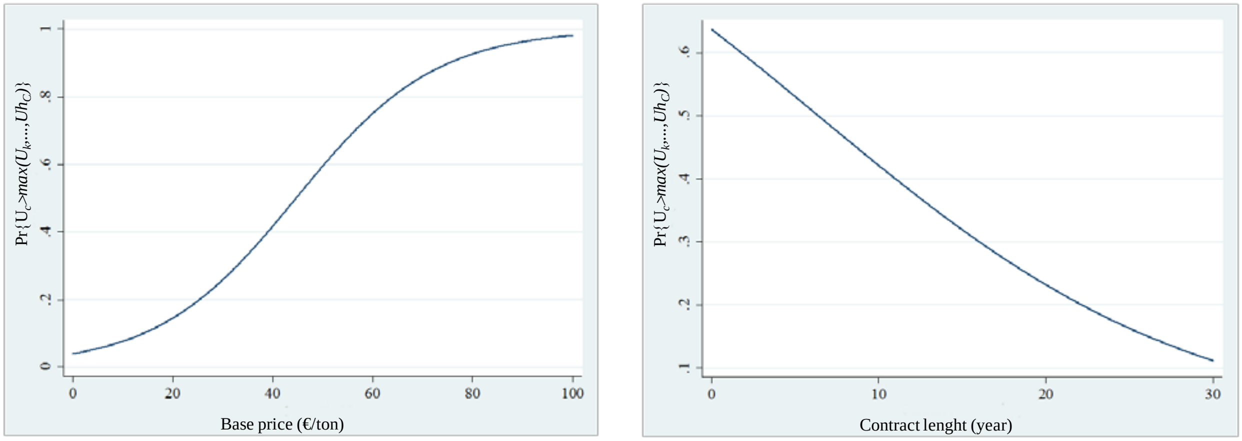

Figure 1. The influence of base price and contract length on the probability of choosing the *c-th* contract.

Note. c.d.f are calculated by maintaining constant (at the sample mean) the values of the other contract characteristics.

The data analysis with a random parameter model reveals that some of the considered attributes vary stochastically in the sample. We assume that they follow a Gaussian distribution, except the base price, which is assumed to follow a log-normal distribution that assures only strictly positive values (Figure 3). Thus, the distribution function for each of these attributes can be estimated using the position (μ) and scale (σ) parameter.

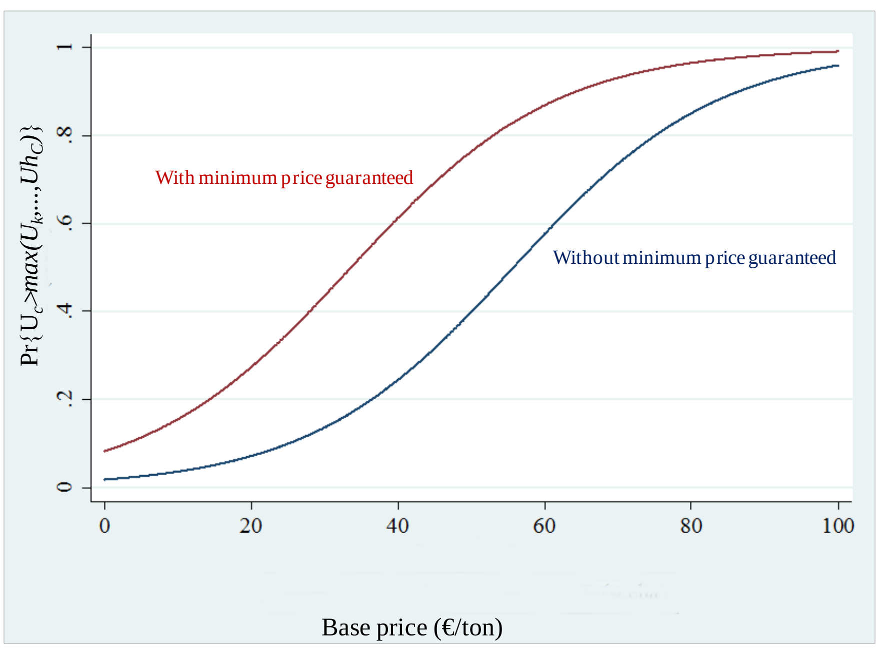

Figure 2. The influence of presence or absence of minimum guaranteed price on the probability of choosing the *c-th* contract

Note. c.d.f are calculated by maintaining constant (at the sample mean) the values of the other contract characteristics.

From Figure 3 it is evident that preference heterogeneity toward each attribute is a major characteristic in our farmers' sample. The higher be the heterogeneity of preferences, the greater will be the difficulties in establishing a consensus among farmers on a specific contract farming scheme, suggesting that "personalized" contract schemes are likely to be needed. Nevertheless, estimating the cumulative function at 0, it results that the whole sample, at varying intensity, prefers the presence of the training meetings; shorter contracts are appreciated by the 96.7 per cent of the sample, while only a negligible fraction of the population (1.1 per cent) do not like the presence of the minimum guaranteed price.

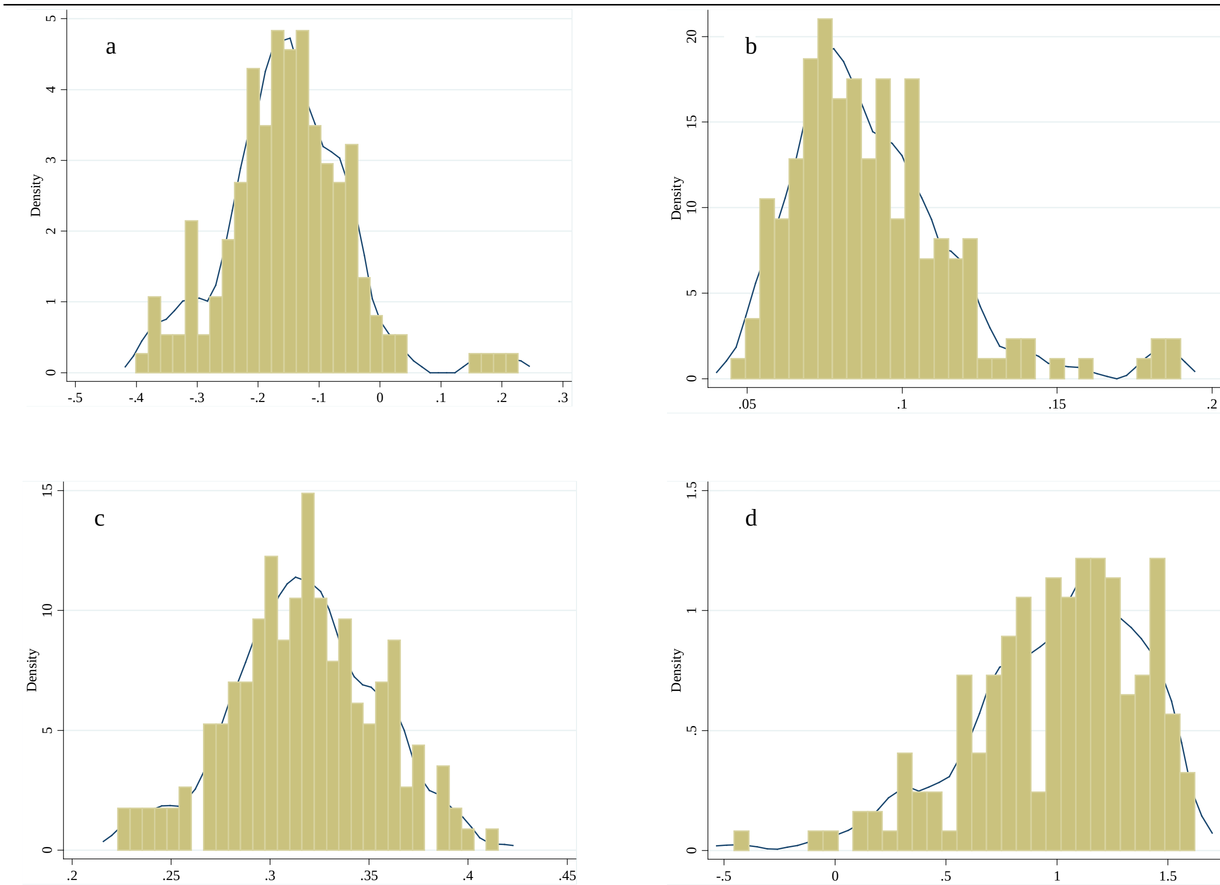

Figure 3. Heterogeneity of parameters concerning contract length (a), base price (b), training meeting (c), and minimum price guaranteed (d).

The correlation matrix of estimated parameters shows an inverse correlation between the base price and both the training meeting and minimum guaranteed price, and a positive correlation between the minimum guaranteed price and the contract length (Table 7).

Table 7. Correlation matrix of estimated parameters

	Renegotiation option	Contract length	Minimum guaranteed price	Training meetings	Base price
Renegotiation option	1.000				
Contract Length	0.041	1.000			
Minimum guaranteed price	-0.036	0.086***	1.000		
Training meetings	-0.005	-0.026	0.003	1.000	
Base Price	0.013	0.037	- 0.140***	-0.093***	1.000

After the respondents went through the contract choice scenarios, stating their choice for each of them, in the debriefing section of the questionnaire they were questioned about the motivations of such choices. Three different sets of debriefing questions were designed, depending on the respondent's choices: a) choice of no contract for all the four choice tasks; b) choice of one contract for each of the four choice tasks; c) choice of at least one contract over the four choice tasks. A 5 score-based Likert scale was used to help the respondent express the level of agreement between the provided statement and their own motivations.

Depending on the choices stated in the four choice tasks they were presented with, respondents can be grouped in three groups. 47% of respondents have chosen at least a contract over all the shown contracts. Slightly less respondents (46%) have chosen a contract alternative for each of the four choice tasks. Finally, only 8% of the sample has not chosen any of the proposed contracts over the four choice sets. The first two groups, where respondents have expressed their choice for some contract alternatives, gather most farmers that have made investments in their farm in the last five years. In particular, the group of respondents that have chosen at least a contract shows a higher propensity to investments (82%) than the sample average (70%) and more openness to participate in multiple or single contracts (43% compared to 32% sample average). Responses to the debriefing questions shed a light on the motivations of their choice in terms of contracts.

Table 8 focuses on the responses of the first group. For each statement, respondents were asked to assign a score to state the intensity of the agreement between their real motivations and the statement, from 1 ("Does not reflect at all") to 5 (Does reflect perfectly"). In the Table, the percentages are reported from the scores of respondents for each statement.

Adding up the percentage of respondents that assigned scores 4 and 5 (agreement with the statement), the most important motivation for choosing to join a bioenergy supply chain contract is the opportunity it represents to create and foster a new cooperation and collaborative environment in the area, among the local farmers (statement (d) 88% of group respondents).

Much importance in affecting the choice is assigned to the positive environmental effects of the introduction of biomass cultivation, in particular in terms of soil quality (statement (f) 79% or group respondents). Respondents trust the local farmers and their potential to make the bio-energy supply chain successful (statement (e) 47%). The motivation for not choosing some contracts is their duration, considered to be too long (statement (b) 64% of group respondents). Consistently with their responses, they are willing to convert some of their cultivated land to biomass. This amounts to 20% of their land, corresponding to 3.97 ha in average per farmer.

Table 8. Motivations for respondents that have chosen at least one contract

Statement		Does not reflect at all → Reflects perfectly				
		1	**2**	**3**	**4**	**5**
Some contracts are in favor of the bioenergy company	a	0.09	0.25	0.4	0.18	0.07
Some contracts last too long	b	0.07	0.06	0.22	0.43	0.21
Some contracts do not provide enough incentive to change cropping system	c	0.08	0.21	0.42	0.16	0.13
Support to supply chain contracts to foster cooperation among fellow farmers	d	0.01	0.05	0.05	0.28	0.6
Trust in fellow farmers to abide by contract terms	e	0.05	0.18	0.29	0.29	0.18
Environmental benefits of *Arundo* on soil	f	0.02	0.04	0.15	0.27	0.52

The second group of respondents (46%) has chosen a contract for each of the four proposed scenarios. Also for respondents of this group (Table 9) the most important reason to accept and join contracts are the benefits in terms of collaboration and cooperation they would promote in the area among the local farmers (statement (d) 80%), as well as the environmental benefits the *Giant Cane* would provide to the soil of the area (statement (e) 74%). Their choice is supported by the perception that the contracts look favorable and pose no major problem (statement (c) 61%) and by the trust in the local farmers (statement (b) 56%). Then, they consider the *Arundo* a valid alternative for the area and their farm (statement (a) 51%). However, they are likely to convert less to the biomass cultivations, 16% of their cultivated land, in average 3.3 ha per farmer.

Table 9. Motivations for respondents that have chosen one contract for each choice set

Statement		Does not reflect at all → Reflects perfectly				
		1	**2**	**3**	**4**	**5**
Arundo is a valid alternative for the area and the farm	a	0.04	0.07	0.36	0.29	0.22
Trust in fellow farmers to abide by contract terms	b	0.04	0.15	0.25	0.33	0.24
Favorable contracts that can be fulfilled	c	0.01	0.08	0.30	0.34	0.27
Support to supply chain contracts to foster cooperation among fellow farmers	d	0.03	0.02	0.15	0.24	0.56
Environmental benefits of *Arundo* on soil	e	0.03	0.03	0.19	0.27	0.47

The last and smallest group comprises respondents that have not chosen any of the proposed contracts from the 4 choice set. They represent only the 8% of the whole sample. It is interesting to note that farmers in this group are older (53 years-old) than the sample average and the previous two groups (42 and 43) and are less full time farmers. They own generally smaller farms (mean 11.91 ha) and have invested or innovated less than the average sample in the last five years. They show a low level of participation to any cooperation with other farmers, limited to mainly informal relationships.

The motivations for their refusal towards all the proposed contracts is mainly economic (Table 10). No contract is chosen as none is sufficiently convenient to be considered (statement (a) 75% of the group respondents). The biomass cultivation, then, the way it is proposed in the contracts, does not represent an interesting option for their farm (statement (b) 63%): they do not feel to have enough skills to start it (60% of the group respondents) and it seems too risky (60%), subsequently they would not replace with biomass any of the existing crops in their farms (50%). No proposed price is convenient enough to promote the change (statement (g), 56%) and the local farmers are not reliable to create a successful supply chain (statement (f) 56%).

Table 10. Motivations for respondents that have chosen no contract in any choice set

Statement		Does not reflect at all		→	Reflects perfectly	
		1	**2**	**3**	**4**	**5**
No contract is convenient	a	0.13	0.00	0.13	0.31	0.44
Biomass not a valid option for the farm	b	0.13	0.06	0.19	0.06	0.56
Contracts last too long	c	0.19	0.00	0.56	0.19	0.06
Contracts favor the bioenergy company	d	0.06	0.13	0.63	0.00	0.19
Bioenergy company could get too much power	e	0.06	0.00	0.50	0.19	0.25
Distrust in local farmers to abide by contract terms	f	0.06	0.00	0.38	0.25	0.31
No price is convenient enough for changing	g	0.13	0.00	0.31	0.06	0.50

Conclusions

Energy producer companies are increasingly focusing on bio-mass production to diversify their activities and move into the sustainable energy sector. In Italy as well as in many other countries these companies need often to deal with many small bio-mass producers and to engineer bio-energy supply chains almost from scratch. In this respect, it becomes relevant to understand the key elements that can help design effective supply chain mechanisms, in particular how to develop and manage integration, coordination and cooperation along the chain.

This is the focus of this paper. It concerns the analysis of farmers' preferences towards different contract attributes, with the aim of identifying those attributes that would promote farmers' participation in a bio-energy supply chain through cooperation. In our study area, engineering novel supply chain is particularly needed for farmers in order to support their income, diversify their production from cereals and convert marginal areas, often affected by soil erosion hazard, into productive areas.

We propose the adoption of biomass crop such as the *Arundo Donax* (also known as *Giant Cane*). It ensures high biomass productive efficiency, shows a significant ability to mitigate soil erosion risk and, based on the prominent biomass market price, can provide revenue comparable to wheat.

The analysis considers the attributes of a contract farming scheme and investigates the monetary trade-offs farmers are likely to make. In particular, six contract attributes are considered on the

base of focus group indications: base price, minimum guaranteed price, contract length, renegotiation option, extension service, minimum volume of product requirement.
Our results seem to highlight that cooperation among farmers can be enhanced by contract farming if effective contract attributes are proposed to them. Indeed, the decision of a farmer to participate in a supply chain is based on considerations regarding his/her own economic pay-off, but also on the characteristics (attributes) of the contract proposed by the buyer (i.e. the bio-energy producer company). Moreover it is needed to identify contract attributes that maximize the likelihood to cooperate. In other words, a cooperation in a bio-energy supply chain context implies that one farmer decision is not independent from what other farmers do.

Of all the considered contract attributes, only "mandatory requirements of product volume to be guaranteed to buyers" does not contribute to the choice of whether to accept the proposed contract farming scheme or not. If we consider the trade-off, in monetary terms, of the other four attributes with the base price, minimum guaranteed price and renegotiation option are valued significantly higher than contract length and training meetings. In particular, the analysis of trade-offs between contract attributes suggests that using a "minimum price guarantee" approach is an effective solution: on one hand it reduces the "cost of the contract" for the energy company and on the other hand it reduces the negative effect of a long-term contract duration. Thus by proposing a minimum price guarantee energy producer company can at the same time reduce the price offered for the bio-mass, offer longer contracts and get higher rate of farmers participation. Farmers can benefit from a less risky contractual scheme and operate investments in bio-mass production in a long-term perspective. Also the possibility to re-negotiate contract terms works in the same direction.

From a managerial point of view, our results indicate that conditions for a contract farming approach, aiming at building a bio-energy supply chain in the study area, do exist. This is not a trivial outcome since introducing contract farming schemes in this area arises complex issues, related to the combination of the individual and social dimension of the decision-making process. For instance, our results point out that it is key to take into account individual differences for contract attributes. While company managers may prefer more standardized contracts, empirical evidence seems to indicate that more "profiled" and "personalized" contract schemes need to be introduced. However, very personalized contract conditions may be risky for the buying company and costly to manage. Different conditions may lead farmers to make comparison and induce them to complain for potentially unfair treatments. Eventually, this may lead farmers to dis-trust the buying company, thus hampering motivations to act collectively.

Further research is needed in this field of inquiry. First, our study does not explore contract attributes in detail. The way the proposed attributes take form in a formal contract could make the difference. Second, we need to explore farmers' preferences for the same attributes but in alternative arrangements, for example when a contract is offered via a producers' organization instead of individual farmers. Third, we investigated an area in many ways representative of marginal rural areas where the opportunity costs of capitals are quite low. External validity of this study in areas with higher opportunity costs is poor. Finally, continued improvements in the experimental approaches used to gauge contract choice is warranted.

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