Managing integration in bio-energy chains by promoting a collective action

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Abstract
This paper discusses how to develop and manage integration, coordination and cooperation (collective action) in bio-energy supply chains. Farmers decision 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 has been 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: Bio-energy supply chain, , Contract farming, Choice modelling, Italy

Introduction

Farmers' participation in bio-energy supply chains has been widely discussed among scholars and practitioners (Pellerin and Taylor 2008; Altman et al., 2013). Particularly the issue of trade-off between bio-energy production and food security has gained attention in the academic as well as in the managerial and political debate (Seuring and Muller 2008; Negash and Swinnen, 2013). Often production of bio-fuels requires usage of the most fertile and productive areas, thus creating direct competition between energy and food/feed crops (Negash and Swinnen, 2013). In other cases, especially for bio-mass production, more marginal land can be devoted to energy crop production, thus integrating and complementing conventional food/feed crop production more than substituting them. However, while energy crops cultivated in marginal areas are less competing with food or feed production, they are still calling for the development and management of integrated and coordinated supply chains. The production of energy from bio-mass, in fact, requires specific investment from the energy production company, and the achievement of a given critical mass to let the energy production plant operate efficiently. In other words in case of bio-mass the energy producer company needs to design supply chain arrangements with all its suppliers (farmers), eventually leading a (large) group of them to deliver their production. While designing such arrangements might be complex and costly, the interest for sustainable sources of energy is increasing the attention of energy producers to better understand how to tackle these issues, and in particular in terms 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 brings to 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, bio-energy supply chain shows a peculiar feature which consists in the simultaneous focus on integrating and coordinating the bio-energy producer (buying company) and the farmers (suppliers), and stimulating cooperation and collective action among farmers at the same time. To manage integration, coordination and cooperation (collective action) contract farming is an often used arrangement because providing flexibility in the way incentives can be set for different typologies of suppliers, thus creating higher likelihood to participate in the supply chain than other arrangements (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 (McCarthy et al. 2004; 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 still difficult to address (Meinzen-Dick et al. 2004). Thus the role of inter-firm collaboration and contract design results to be a priority in this respect. Particularly 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. This paper tackles these issues considering the specific case study of a contract farming scheme that aims at promoting a collective action among farmers in order to set up a bio-energy (biomass production) chain. In particular, it considers the issues related to farmers decision-making process on whether to participate or not in the contract farming scheme. By assessing the likelihood of farmers to participate this paper also aims at understanding the likelihood of a large number of farmers to participate and thus create, de facto, a collective action. This collective action is necessary in order to make the investment profitable, as the bio-energy producer company needs specific biomass quantities throughout the year. To this end, a group of farmers needs to agree to be part of the contract farming scheme and set up the bio-energy chain. Finally in this paper we also aim at better understanding the trade-offs farmers are facing when it comes to decide about different attributes of the contract farming scheme. As already pointed out in literature, contract farming may be characterised by several attributes (Masakure and Henson, 2005; Abebe et al., 2013). Examples of main attributes used in contract farming are: 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). The empirical study has been conducted in the province of Avellino (Southern Italy), in an area characterised by extensive cereal production, such as wheat and barley, in which marginal lands are mostly uncultivated, thus being suitable to conversion to bio-mass production and energy cropping. This area resembles the same characteristics of many Mediterranean internal regions, thus calling for generalizability of both the methodology and the results of this study. Particularly in the study area a public-private-partnership is taking place to further explore the opportunity to set-up a pilot bio-energy supply chain[1]. 200 face-to-face questionnaires have been administered to 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 is *Arundo Donax* (also known as *Giant Cane*). The *Arundo* is 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 application of this methodology to analyse farmers' preferences towards contract farming in bio-energy supply chain (Lajili et al. 1997; Abebe et al., 2013).

Facilitating participation in collective action through contract farming

Promoting participation of farmers in a bio-energy supply chain requires a rather complex contractual design (Markelova et al. 2009). The reason of this complexity lies in the combination of individual and collective decision making issues: on one hand, farmers still participate as individual entities, engaging in a decision making process which has direct consequences for each farming system. On the other hand, to achieve a level of biomass production allowing for an efficient investment in terms of energy conversion requires that a group of farmers will participate in the contract simultaneously. While farmers may have

[1] Promotion and Development of an bio-energy supply chain in partnership with industrial actors (Novamont and Chemtex) 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)".

different preferences for contract features (Abebe et al. 2013) and would like to personalise participation conditions, the bio-energy producer company would like to standardise contracts and pool as many participants as possible while cost-minimising. In many contexts, where supply chains need to be engineered, such as in developing countries, contract farming and participation in producer organizations are often proposed as an effective design to organize collective action for pooling and marketing agricultural commodities (Rasmussen and Meinzen-Dick 1995; Baland and Platteau 1996; Agrawal 2001). Pooling bio-energy crops to seek economies of scale through a cooperation and collective action shares similar features. Thus, by setting up a contract, a bio-energy producer company is supporting/facilitating farmers participation in a formalised collective action to produce and market bio-mass. However, while formalization reduces transaction costs of individual renegotiation, as well as uncertainty, the more formalized the collective action is, the less flexible and adaptable it becomes (high specificity/mutual dependency) (Meinzen-Dick et al. 2004). The presence of and dependency on a group-based decision making are, therefore, apt to creating tension between the contract provider (the bio-energy producer) and biomass producer (the farmer), making the individual and collective participation potentially conflicting. Moreover, collective actions are often sensitive to issues like crowding effect (too many participants would lower the benefits of being part of the collective action) and free-riding (efforts and costs might not be equally distributed or difficult to monitor) (Poteete and Orstom 2004).
To overcome these issues, the following principles are for the participation contract design: (i) the characteristics of the collective 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 collective action; (iv) know-how and technology is shared and finally (v) actions of national governments and other external actors should be supportive of the collective process, not corrupting the mechanism towards a too individualised or formalised (bureaucratic) process (Ostrom at al. 1999; Poteete and Ostrom 2004). Subsequently, to successfully organize a collective action for 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. 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 collective action 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

We used the conceptual elements highlighted in literature to design a choice experiment among farmers in South Italy in order to assess their preferences for contract farming, and to predict their likelihood to participate in a bio-energy supply chain. Particularly data were collected through the administration of a questionnaire with face-to-face interviews. We draw our sample selecting farmers operating in a study area composed by several municipalities located in the Avellino province, Campania region, some 150 km east of Naples (Italy). The study area reflects the typical conditions of internal Southern Italian regions. It is characterised by mild continental weather, and interested by extensive cultivation of cereals and forage crops, sometimes associated with dairy or animal raring activities. Several bio-energy producers are increasingly interested in investing in this type of areas where conditions are naturally optimal for establishing bio-energy crops, often characterized by too low productivity for conventional crops, and by high risk of soil erosion. As said the aim of the investigation has been to analyse farmers (stated) preferences concerning participation in a collective action through 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 behaviour 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 have been 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. 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 collective action enforced by contracts 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, remarking 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
Base Price	Current market price plus or minus a flat amount for marketing premium or fees: values are randomly generated
Minimum guaranteed price	Presence (1) or absence (0) of a minimum price: values are randomly generated from a binomial distribution.
Length	Discrete values are randomly generated from an uniform distribution in the 3-10 years interval
Renegotiation option	Presence (1) or absence (0) of an option to renegotiate the contract terms: values are randomly generated from a
Training meeting	Presence (1) or absence (0) of mandatory participation to training meetings: values are randomly generated from a
Minimum volume of product	Presence (1) or absence (0) of minimum volume of product to be guaranteed: values are randomly generated from a

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 mangers are mostly male (63%), 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 3706 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.

Table 2. Farmers and farms characteristics

	Description	Mean	Std.dev	Min	Max
Gender	1 if male; 0 female	0.61	N.A.	0	1
Age	(year)	43.17	11.76	18	80
Farm size	Total area of sample farms (ha)	20.46	26.66	1.5	340
Total cultivated area	Total cultivated area of sample farms (ha)	18.59	23.52	1	300
Full time farmer	1 if full time; 0 otherwise	0.77	N.A.	0	1
Individual farmers	1 if individual; 0 otherwise	0.96	N.A.	0	1
Number of land parcels		6		1	30
Land ownership					
	Property	0.72	N.A.	0	1
	Rent	0.26	N.A.	0	1
	Other	0.02	N.A.	0	1
Crops					
	Arable crops (ha)	16.70	21.91	0.5	280
	Permanent crops (ha)	0.5955	1.14	0	9

N.A: not applicable
Source: our elaboration on field survey data

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

[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.

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 3. Investments and innovation in the past five years*

	Absolute freq.	Relative freq.
Investments in the last 5 years:	139	0.70
Machines	119	0.60
New constructions	66	0.33
Processing and packaging	6	0.03
Marketing	11	0.06
Land acquisition	83	0.42
Other	1	0.01
Innovations in the last 5 years:	91	0.46
Cropping system changes	35	0.18
Cropping techniques changes	9	0.05
Organization changes	64	0.32

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

Source: our elaboration on field survey data

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

	Absolute freq.	Relative freq.
Forms of cooperation in the area:	111	0.56
Informal contracts	66	0.33
Cooperatives and trademarks	40	0.20
Supply chain contracts and guaranteed minimum price	2	0.01
Participation in cooperation activities:	64	0.32
Cooperation on the production side *	16	0.08
Cooperation on the marketing side **	48	0.24

** 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*

Source: our elaboration on field survey data

Empirical strategy

The empirical strategy we used has roots in the random utility theory (McFadden 2001), and 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) $$U^h_c = f(\mathbf{z}_c) + \varepsilon^h_c$$

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

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

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

The $\mathbf{\Omega}$ parameters can be distributed in the sample according to a distribution function defined by a location (μ) and a scale (σ) parameter:

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

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

Table 5. Attributes and levels of contracts

Attributes	Levels definition	mean	s.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
Renegotiati on option	Presence (1) or absence (0) of an option to renegotiate the contract terms: values are randomly generated from a binomial	0.50	N.A	0	1
Training meeting	Presence (1)/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

N.A: not applicable
Source: our elaboration on field survey data

Using empirical data, collected generally through stated preference surveys (so-called choice experiments), the model estimates the marginal utility of each contract attribute. If the random term is assumed to have a type I extreme value distribution, then a logistic regression can be adopted to estimate $\mathbf{\Omega}$ or $\mathbf{\Omega}^h$ parameters and their weight in affecting the choice of one contract over another (McFadden 2001). In our experiment, four choice tasks, each with two

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

randomly selected alternatives, were presented to respondents. Each contract alternative represent a different combination of levels for the T attributes. 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. 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 $\boldsymbol{\Omega}$ parameters can be estimated with the maximum likelihood estimator for logit model (Amemiya 1985), using maximum simulated likelihood methods (Train 2009).

Results and Discussion

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

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				
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	

Source: our elaboration on field survey data

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, on the trade-off farmers have made between the *t-th* contract attribute and the base price ($\Omega_t/\Omega_{baseprice}$). 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 collective contracts can be assessed calculating the cumulative distribution function of $Pr(U_c) = Pr\{U_c > max(U_k,...,Uh_C)\}$ 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 (figure 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*-contract is much higher when the minimum guaranteed price term is present in the contract.

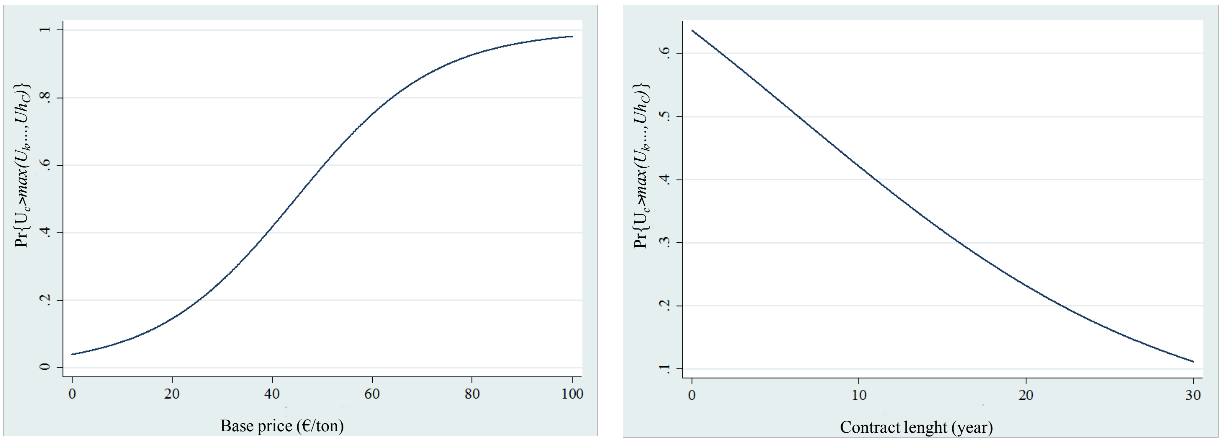

Figure 1. The influence of base price and contract length on the probability of choosing the *c-th* contract. - *Note: c.d.f are calculated by maintaining constant (at the sample mean) the values of the other contract characteristics.*
Source: our elaboration on field survey data

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.*
Source: our elaboration on field survey data

From figure 3 it is evident that preference heterogeneity is a major characteristic in our farmers' sample In particular, 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. 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 collective 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.

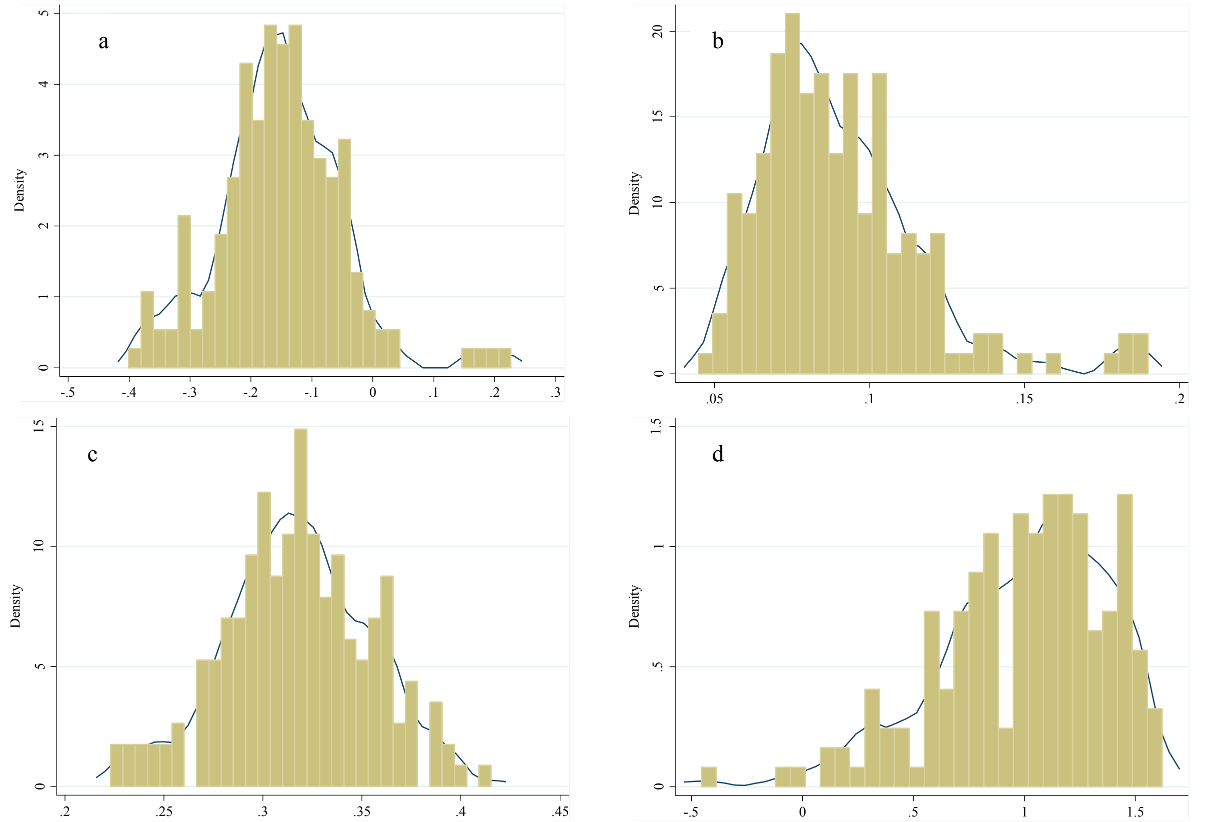

Figure 3. Heterogeneity of parameters concerning contract length (a), base price (b), training meeting (c) and minimum price guaranteed (d) - *Source: our elaboration on field survey data*

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	Min. guaranteed price	Training meetings	Base Price
Renegotiation option	1.000				
Contract Length	0.041	1.000			
Min. 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

Source: our elaboration on field survey data

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, percentage of respondents assigning the score for each statement is reported. Adding up the percentage of respondents that assigned score 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).

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

Source: our elaboration on field survey data

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). They 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.

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 collective 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 favourable and pose no major problem (statement c, 61%) and by the trust in the local farmers (statement b, 56%). Then, they consider the *Arundo* is 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

Source: our elaboration on field survey data

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

Source: our elaboration on field survey data

Concluding remarks

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 more and more often these companies need to deal with many small bio-mass producers and to engineer bio- energy supply chains almost from scratch. In this respect it is more and more relevant to understand the key elements to design effective supply chain mechanisms, and particularly how to develop and manage integration, coordination and cooperation along the chain. In this study we try to address this aspect. Thus this study concerns the analysis of farmers' preferences towards different contract attributes, in order to promote their participation in a bio-energy supply chain through cooperation. In the specific study area engineering novel supply chain is particularly needed for farmers in order to support their income, diversify their production from cereals and to convert marginal areas, often affected by soil erosion hazard, into productive areas. In this study we propose the adoption of biomass crop such as the *Arundo Donax* (also known as *Giant Cane*). This crop has high biomass productive efficiency, showing a significant ability to mitigate soil erosion risk and, based on the prominent biomass market price, it can ensure revenue comparable to wheat. The empirical study has been conducted in an area mostly affected by soil erosion risk and with marginal economic revenues. The analysis considers the attributes of a contract farming schemes and investigates the monetary trade-offs farmers are likely to make. Particularly six contract attributes were 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 and collective action among farmers can be enhanced by contract farming if effective attributes of the contracts can be proposed to them. 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 maximise the likelihood to cooperate. In other words, a collective action in a bio-energy supply chain context implies that one farmer decision is not independent from what other farmers do. Results also show that only the attribute "mandatory requirements of product volume to be guaranteed to buyers" does not contribute to the choice of whether to uptake the proposed contract farming scheme. If we consider the trade-off, in monetary terms, of the other four with the base price, minimum guaranteed price and renegotiation option are valued significantly higher than contract length and training meetings. Particularly if we look at the analysis of trade-offs between contract attributes using a "minimum price guarantee" approach seems to be 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 effective 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, longer contracts with 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 horizon perspective. Also 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 of this study since introducing contract farming schemes in this area arises complex issues, related to the combination of individual and collective dimension of 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 standardised contracts empirical evidence seems to indicate that more "profiled" and "personalised" contract schemes need to be introduced. However very personalised contract conditions may be risky for the buying company, and costly to manage. Moreover 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, however. First, the current study does not explore contract attributes in detail. The way the proposed attributes take form in a formal contract may 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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