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Ecological Economics

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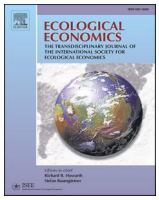
https://doi.org/10.1016/j.ecolecon.2025.108660

Ecological Economics 235 (2025) 108660

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon



ANALYSIS

Designing contracts for the bioenergy industry: The role of swift relational contracting

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ARTICLE INFO

Keywords:
Bioenergy
Contract farming
Relational contracting

ABSTRACT

The bioenergy industry is a core component of the EU approach to reduce its dependency on non-renewable resources while attempting to support biomass producers and farmers in rural areas. However, bioenergy activities also pose governance challenges associated with intensified inter-organizational collaborations and network relations between farmers, bio-industries and other supply chain actors. Often, existing contractual arrangements, such as contract farming schemes, become inadequate and potentially unfair. Given this background, our study addresses how to design more effective contractual arrangements that facilitate bioenergy activities by incorporating farmers' perspectives. Our findings indicate that contracts that in the course of being formal and enforceable, are enriched in relational and procedural clauses are ranked as superior by the weaker party in the relation, i.e. farmers. The identified preferred configuration that we called swift relational contracting contributes to contract theory and ecological economics by providing insights into how relational, flexible and frequently adaptable contractual structures can fit with the requirements of emerging bio-based industries.

1. Introduction

The bioenergy industry is a core component of the European Green Deal (EC, 2019) aiming at meeting net-zero targets and to reduce the EU dependency on non-renewable resources while attempting to support biomass producers and farmers in rural areas (Philippidis et al., 2024). The bioenergy industry is supported by the European Commission (EC) Bioeconomy Strategy (EC, 2018) aiming at further strengthening an economy based on an improved social and environmental sustainability by upcycling and cascading use of biological resources (Carraresi et al., 2018; Biber-Freudenberger et al., 2020), transforming waste and by-products into value-added products such as bioenergy, bio-based materials, and biofertilizers (D'Amato and Korhonen, 2021; Yaashikaa et al., 2022). Incentivizing the introduction of energy crops and biomass production facilities, together with investing in bioenergy refineries, is critical to the success of this strategy. Energy crops, particularly, offer alternative solutions to farmers to differentiate their income streams, mitigate climate risks and enhance resilience at farm level (Cembalo et al., 2014; Cappelli et al., 2025). However, they also create trade-offs in relation to switching decisions, from food, feed and fibre to biomass production, and exacerbating, rather than reducing, use of inputs, carbon emission, and introduction of intensive farming practices (Zilberman et al., 2025). In rural areas and agricultural systems with marginal lands, energy crops, and particularly perennial grasses like miscanthus and giant cane, can represent an effective way to diversify crops, and mitigating environmental risks related to vulnerability to erosion, unfavourable soil texture, or salinization (Cappelli et al., 2025).

Despite the wealth of studies discussing challenges and opportunities of bioenergy crops, there is a tendency to overlook the organizational and contractual aspects of the complex and uncertain activities related to the bioenergy industry (Zilberman et al., 2025). This is a relevant shortcoming, because the further establishment of this industry depends on the possibility of regulating complex and uncertain relations, involving a larger number of biomass producers, to ensure its scalability and adaptability to different socio-ecological contexts (Lopolito et al., 2011; Reise et al., 2012). When compared to the agri-food sector,

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https://doi.org/10.1016/j.ecolecon.2025.108660
Received 10 August 2024; Received in revised form 31 March 2025; Accepted 28 April 2025
Available online 8 May 2025

existing contractual arrangements between bio-based materials producers (e.g. farmers), and bio-energy processors (e.g. bio-refineries), are unlikely to suffice both for *efficiency* and *fairness* 'deficits'. As to *efficiency*, the risk is that actors involved in the establishment of bioenergy activities would simply resort to the more diffused form of sub-contracting in agri-food, often referred to as 'contract farming' (CF) (Ton et al., 2018; Weituschat et al., 2023) - a type sub-contracting in which the agricultural production is purchased in advance to. the downstream firm, usually according to standard clauses equal for all suppliers. We say the 'risk', because, according to the argument proposed in this paper, CF is a form of obligational and hierarchical transactional contract, as such likely to fail in the regulation of complex and innovative transactions (Weituschat et al., 2023). In addition, CF has been subject to criticism for a deficit of *fairness* in regulating exchanges among parties with asymmetric bargaining power (Grandori, 2015), a condition typically arising in bio-based activities, where a single bio-processor concentrates bargaining power. Even in traditional agri-food bargaining conditions, farmers often lament that CF is too 'open' and informal (Otsuka et al., 2016): it does not protect them, as the relatively weaker part in the exchange, from the possible opportunism of the more powerful counterparts. As a result, CF often fails to aggregate the needed critical mass of production, or to reach the desired quality, because of lacking capacity to mobilize growers (Otsuka et al., 2016; Weituschat et al., 2023).

Against this background, our research investigates the design of acceptable contractual arrangements able to enhance the adoption and diffusion of bioenergy crops. More specifically, we aim at answering the following research questions: which clauses and which process of contract definition would increase its probability of acceptance? In what respects can the commonly used form of contract farming be enriched? How can the need for protection from counterparts' opportunism can be combined with the need for flexibility in the face of varying circumstances?

Answering these questions provides information to the party who is in the position of designing the contract - usually the biomass transformer, contracting with the more dispersed counterpart of the farmers. Hence, the crucial information for designing acceptable contracts can be provided by the receivers of the proposal, namely the farmers. The study presented here, therefore, concentrates on farmers' assessment of various possible contractual clauses for bioenergy crops, using a choice experiment testing whether those clauses would in fact be considered enrichments from the viewpoint of the offer receiving, weaker parties, the farmers.

The paper is structured as follows: in the next section we present the conceptual background focusing on the relevance of contract design for bioeconomy activities, and particularly bioenergy crops production and transactions. We then present the methodological strategy we adopted and give accounts of the empirical context and the fieldwork. In section four we present main results, while in section five we present our contribution, leaving to section six the final remarks, including main limitations of our research, and future avenues for expanding on our work.

2. Transactional complexity and contracts in the bioenergy industry

The bioenergy industry relies on intense use and application of biological processes to novel technologies and processes to optimise the production of energy from biomasses (Garnsey and Leong, 2008; Bröring et al., 2020). Often, biomasses and bio-based fuels derived from bioenergy crops have novel properties (Zilberman et al., 2025) and need joint processes of discovery and co-investment, which require to experiment contractual arrangements in a context of intensified inter-organizational collaborations and relations (Nuhoff-Isakhanyan et al., 2017; Bröring et al., 2020). This often increases the organizational and transactional complexity and uncertainty of the bioenergy industry (Lopolito et al., 2011; Carraresi et al., 2018). An established tenet in institutional and organization economics is that higher complexity and uncertainty require a tighter coordination among the involved parties, whereby classic transactional contracts are expected to 'fail' (Williamson, 1981). The underlying argument is that the more complex the transaction, the more costly is to write and enforce complete transactional contracts (Williamson, 1981; Baker et al., 2002).

The regulation of transactions is then expected to shift to other, more 'relational' modes of contracting. This hypothesis has been most clearly stated in Williamson (1979, p. 238), in turn building on foundational works in relational contracting in law (Macneil, 1978): "*'relational' forms of contracting – which may involve arbitration, collective bargaining, and other types of obligational market exchange – are becoming more important and need to be recognized*"; and '*the pressure to sustain ongoing relations have led to the spin-off of many subject areas from the classical and later the neo-classical contract law system, e.g., much of corporate law and collective bargaining', to a 'progressively increasing duration and complexity of contracts', up to a point where 'the fiction of discreteness is fully displaced as the relation takes on the properties of a mini-society with a vast array of norms beyond those centred on the exchange'*. Later works in relational contracting in economics, though, restricted the meaning of RC to 'informal agreements' based on self-enforcement and trust (Baker et al., 2002). The obvious objection is that, if so defined, the domain of effectiveness of relational contracts would be quite narrow and would leave parties exposed to opportunism in any situation with significant conflict of interest. In the present work, therefore, we are rather building on another possible meaning of RC, which was actually central in the original notion: a contract that is 'relational' not because it is informal and sustained by extra-contractual relations, but because the formal contract itself *regulates the relation rather than the terms of exchange*: we can "think of written parts of contractual relations as constitutions establishing legislative and administrative processes for the relation" (Macneil, 1978: 894). In line with this view, subsequent research on complex contracts has in fact shown that relational clauses embodied in contracts can vary from 're-negotiation clauses' (Crocker and Masten, 1991), to specifications of how the parties will communicate and coordinate and according to which procedures they will take decisions, up to who is entitled to what results and to the specification of a variety of non-residual and residual reward and control rights, including bargaining and arbitration procedures (Lerner and Merges, 1998; Grandori and Furlotti, 2019). If so, contracts may be measured, assessed, and designed according to the incidence and relevance of the relational clauses *they include*, from relatively simpler clauses on duration and possibility of re-negotiation up to more constitutional clauses regulating the ongoing cooperation. The extent to which those agreements are negotiated to start with can also be included in the notion of a relational contract, supposed to be able to regulate complex transaction thanks to 'arbitration, collective bargaining, and other types of obligational market exchange'.

Using those dimensions, we can characterize the most common form of contract farming as 'weakly relational'. In fact, CF is a 'simple' form of agreement - a standardized contract regulating the provisioning of services and products between sellers, e.g. farmers, and buyers, sometimes one, e.g. an international agribusiness company or an arm-length trader working on its behalf (Bellemare and Lim, 2018; Weituschat et al., 2023). A contract farming template is often designed and offered unilaterally by a single buyer and service provider (Bellemare and Bloem, 2018; Weituschat et al., 2023). It is in fact the buyer who decides the content or terms of exchange, 'the what', 'the when' and 'the where' of the transactional relation with the sellers (Otsuka et al., 2016).

Therefore, CF typically institutes *a hierarchical order* in the supply chain coordination mechanism (Saenger et al., 2013; Bellemare and Lim, 2018); and is *not negotiated*, but just offered and either accepted or rejected, in a non-cooperative bargaining mode (Sugden, 2008; Alberti et al., 2012). In addition, in contract farming a standardized approach is used to regulate all buyer-seller relations in 'one go', even though farmers, particularly if they are smallholders, have very different

abilities, expertise and attitudes (Abebe et al., 2013; Saenger et al., 2013). Therefore, these contracts tend to *standardize* the agricultural production: while quantity and quality standards are part of the terms of exchange, they do not consider the heterogeneous production and processing conditions that different sellers (farmers) experience (Otsuka et al., 2016; Weituschat et al., 2023). Hence, contract farming, in spite of being often informal, can be characterized by a low relational intensity on all the dimensions highlighted here as relevant: it allows *minimal ex-ante and ex-post negotiation*, and it is *hierarchical,* it does *not include knowledge transfer provisions,* and it is *standard* rather than idiosyncratic- and can be assessed as fit to coordinate the supply chains of relatively standard agricultural commodities and is in fact commonly applied to the provision of commodities in internationalised supply chains (Ochieng et al., 2017).

Instead, we expect that fair and efficient contracts regulating complex and uncertain transactions – as the relations between bio-mass growers and an energy firm - are less hierarchical, more associational, more negotiated ex-ante and ex-post and likely to include more procedural elements regulating the on-going relation (hence possibly even more formal). There is already evidence of the relation between growing uncertainty/complexity and increased relational dimensions of contracts, in other sectors. For example, a large empirical study on contracts in interfirm relations across sectors with different levels of uncertainty and innovation supports the proposition: in high-tech and creative sectors, ceteris paribus, the 'enriched', associational and constitutional component (decision and property rights) in the contract is significantly more specified than in the machinery and construction sectors; in which the operational component (tasks and prices) of contracts is more specified (Grandori and Furlotti, 2019). Nevertheless, for being sustainable and implemented in practice, given the importance that agreements are negotiated both ex-ante and ex-post, some qualifications on bargaining power are needed. The degree of concentration of sectors to which parties belong – farmers/growers versus bio-mass transformers - are different, creating power asymmetries in favour of the latter. Therefore, in principle, farmers should rank higher in utility (i.e. prefer) associated modes of negotiation, reinforcing their bargaining power; with respect to individual modes (which may leave room for more tailored agreements, but also leave farmers with lower bargaining power) (Grandori, 2015). The empirical study presented next includes attributes pertaining to the mode of negotiating contracts, capable to test this conjecture (and actually reserving some surprise on it).

3. Research design and methodology

Our research design and methodological strategy consists of a fieldwork and a discrete choice experiment performed on a sample of 200 farmers interested in introducing bio-energy crops in a rural area in the South of Italy. As the area where the fieldwork was performed is characterized by a substantial homogeneity of type of farms and farming technique, participants were recruited through convenience sampling, meaning they were chosen based on their accessibility and willingness to participate. We illustrate here the features of the context according to dimensions which could support generalization; then, the experimental design.

3.1. Features of the context

The study area covered several municipalities in the province of Avellino, Campania Region. In terms of environmental conditions, and related types of activity, the area shares common and typical characteristics of other rural areas, dominated by the cultivation of cereals and fodder crops for dairy and livestock, and conditioned by a mild continental weather (Cembalo et al., 2014) – such as all the Mediterranean areas. Such conditions are optimal for bio-energy crops (Lopolito et al., 2011), particularly perennial grasses like giant cane, and make this area suitable for investing in new plantations, construction of production facilities, and related logistics (Cappelli et al., 2025). Moreover, bio-energy crops represent a suitable alternative for farmers since they provide a gross return comparable to or higher than conventional crops, like cereals and fodder crops, while reducing risk of soil erosion (Cembalo et al., 2014; Fagnano et al., 2015). They also offer an opportunity for enhance productivity and crop diversity in farming systems with marginal and low productive land (Cappelli et al., 2025).

In terms of business culture conditions, some dimensions on 'atmosphere' and 'trust' are relevant for understanding the sustainability of different forms of inter-firm contractual relations, in particular relational contract forms (Reuer and Ariño, 2007). In those respects, the agri-business sector in the Campania region can be qualified as a 'low trust' culture and a 'weak institutional' support setting. Individualist mindset prevails, the tradition of cooperativism and association among farmers, as well as the public regional support to inter-firm relations, are lower than in other comparable areas (in Italy the region with opposite characteristics on those dimensions would be Emilia Romagna) (Di Liberto and Sideri, 2015). Therefore, the context can be interpreted as not especially favourable to the establishment of the enriched, horizontal and associational relational contracts hypothesized. If they were to be discovered as preferred, the result can be interpreted as valid *a fortiori* in more cooperative contexts.

3.2. Experimental design

The field experiment is rooted in previous fieldwork in the study area since 2013; including focus groups, interviews and a previous experiment on contract farming (Cembalo et al., 2014). This work provided the elements for operationalizing contractual attributes. In fact, among the typical matters of concern in agriculture, the following emerged from focus groups:

- Given that price is pre-defined in the contract its level and the guarantee of a minimum price is always an issue.
- Other critical matters, as it occurs also in franchising and sub-contracting, are the services and transfers of know-how to the sub-contractee, such as training.
- Farmers in this area perceive energy crops as an opportunity for diversification but equally consider it as a rather disruptive innovation with several unknowns related to it. Hence the possibility to renegotiate is often an issue, especially if contract duration is long. An alternative way of achieving adaptability is to shorten the duration so as to be able to renegotiate the conditions.
- There is limited experience of contracting for the production of bio-energy in the area and therefore also on the mode of negotiating them. Hence, those modes are defined in analogy with similar contracts in other zones and industries. As argued above, a relevant alternative is between negotiating individually and idiosyncratically, versus negotiating collectively with possibly higher bargaining power but a more standard contract.

Some of those matters can be measured by suitable indicators of possible relational enrichment of agreements with respect to baseline contract farming: the possibility of negotiating the agreement in the first place; and, as to the terms of contract, the presence of guarantees for the weaker party (minimum guaranteed price for farmers); the additional services provided (e.g. technical support and training) and the duration of contract (configuring an on-going relation); and the presence of renegotiation clauses. The resulting matters are reported in Table 1 and illustrated below.

As to the *scales* used, the base price (45€) was based on prevailing market price in Italy for biomass, at the time of the study (2017), plus or minus a fixed amount randomly generated from a normal distribution with mean €0 and standard deviation 2€ (approximated to the closest integer). In that price range, giant cane production guarantees an income per hectare equal or higher than that coming from arable crops

Table 1
Selected attributes and values of proposed contracts.

Attributes	Values	Range
Base Price	Current market price depending on the market fluctuation: 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 a 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	Presence (1) or absence (0) of mandatory participation to training meetings: values are randomly generated from a binomial distribution.	0 or 1
Ex-ante Negotiation	Mode of negotiation: (1) collective by farmers' association; (2) mediated by a technical commission (3); individual by each farmer with the counterpart. Values are randomly generated from a uniform distribution in the 1–3 interval.	from 1 to 3

(Fagnano et al., 2015). Minimum guaranteed price for farmers (presence = 1 or absence = 0, of a guaranteed price at which given quantities are to be purchased by the buyer) was randomly generated from a binomial distribution. Length of contract follows the giant cane economic cycle (Fagnano et al., 2015), between 3 and 10 years, with each value randomly chosen from a uniform distribution.

For ex-ante negotiation, three options were proposed, according to a nominal scale, operationalizing the ex-ante relational intensity negotiation, ranging from 'individual' (individual direct negotiation between a single farmer and a bio-energy firm representative); to 'technically mediated' (a negotiation between an individual farmer and a technical committee including experts of both parties); to 'collective' (negotiation between farmers association representatives and bio-energy firm representatives).

Moreover, we consider the presence (1) or absence (0) of clauses allowing the renegotiation of contract terms before the end of the contract, and referring in particular to base price, minimum guaranteed price and the duration of contract. We also consider the intensity of service provision as operationalised by the presence (1) or absence (0) of mandatory participation in training meetings provided by the buyer to keep farmers up-to-date on cultivation and farming practices. The *questionnaire* was designed and implemented in 2017, data collected in the autumn of the same year. Two enumerators, agronomists with several years of experience and practice in the area, were hired to perform the interviews focusing on investigating farmers' process (stated) preferences on contractual attributes and configurations. Farmers were randomly selected based on their location, crop specialisation and involvement with cooperatives and producer organisations. The two enumerators first approached the farmer to explain the aims of the fieldwork and survey, and to seek consent. Then they sent them a written questionnaire, used subsequently in a face-to-face interview at the farm premises.

In the end, 200 complete questionnaires were collected. The central section of the questionnaire proposed the discrete choice experiment (Louviere et al., 2000; Hensher et al., 2005), taking also stock of previous studies performed in this specific field for selecting attributes and meaningful questions for the farmers (Lopolito et al., 2011; Reise et al., 2012; Cembalo et al., 2014). To illustrate, interviewees were provided a scenario introducing a detailed description of bio-energy crops, specifically the giant cane (Fagnano et al., 2015), 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. Then the choice experiment was presented, and respondents were asked to make their choice between pairs of contracts defined by different combinations of six attributes (see Table 2).

The combinations of attributes' levels were randomly combined according to the standard recommended procedures for this methodology (Abebe et al., 2013; Cembalo et al., 2014). However, two types of combinations had to be excluded for reason of significance and realism: a) combinations characterized by values of attributes all favourable to farmers, so that they would obviously been chosen thereby revealing no trade-offs; and b) 'unrealistic' combinations of attributes' levels that could not occur together in practice. The info from interviews and focus groups were used to eliminate those combinations from the set submitted through the questionnaires. Once attributes and levels were described and presented, respondents were asked to choose between two contracts, randomly assigned, with different combinations of levels also randomly assigned (Table 2). Respondents had the possibility to choose the most preferred contract or not to choose any of them (opt-out). This task was repeated four times. Debriefing questions followed, providing qualitative clarifications on the reasons for the choices made by respondents.

3.3. Control variables

The first section of the questionnaire included demographic and farmer-specific information useful to control the origins of variance in responses (Table 3). However, as usual in the field, variance was low on those dimensions: the majority of respondents were male (75.5 %) and not very young (50 % comprised between 37.5 and 55.5 years); and the majority of them were entrepreneurs working full time in their own farm (87 %). More useful as control variables, both conceptually and statistically, are *farm scale and scope* and *previous experience* as they may affect the ranking of different types of contracts according to the transaction costs incurred. For example, larger farmers may have more bargaining

Table 2
Example of choice question.

Compare the two following contracts and then answer to the following questions		
	Contract A	Contract B
Base price (euro/ton) price at which your biomass will be bought following the market equilibrium price at national level. This price guarantees an income per hectare equal or higher than that coming from cereal crops	43	47
Minimum guaranteed price presence of a minimum price that will be guaranteed in case market price will be insufficient to cover production costs	YES	NO
Lenght (years) length of the contract: minimum 3 maximum 10 years according to the Giant Cane economic cycle	5	7
Negotiation possibility to negotiate the terms of the contract before the start of the contract. In particular: base price, minimum price guaranteed and length	Collective	Individual
Rinegotiation option possibility to renegotiate contract terms before the end of the contract. In particular: base price, minimum price guaranteed and length	NO	YES
Training meeting Bio-energy firm finances every year professional training courses	YES	NO
After evaluating the above contracts which one would you prefer?		
Contract A []	Contract B []	None []

Table 3
Summary statistics of demographic and farmer -specific variables.

Variables	Mean	sd.	Min	Max
Gender (1 if Male)	0.755		0	1
Age (years)	46.945	12.842	19	94
Full time workers	0.869		0	1
Utilized Agricultural Area (ha)	20.510	20.533	0.5	160
Farm bodies (no.)	8.583	6.100	1	38
Arable crops (ha)	18.339	19.848	0	160
Farms with livestock (1 if yes)	0.409		0	1
Previous participation in contracts	0.305		0	1

power and the transaction with biomass producers may be more complex and specific. Hence, a more relational contract may be both more efficient in regulating the transaction and ranked higher according to preference by farmers. Hence, we controlled for size and diversity of activities here operationalised as extension of area (UAA: utilized agricultural area) and presence of other activities beyond growing (livestock) respectively. Average farm size was 20.5 ha spread, on average, in 8.6 bodies, but larger farms can be twice as large. Likewise, most of the cultivated area is represented by arable crops, roughly 80 % of the cultivate area per farm on average, indicating that all involved farms are suitable to be converted into bio-energy crops.

There is variation in the specialisation of the sampled farms though, with 40 % of them also having livestock activities, by far the most relevant form of diversification in the area; and there are arguments suggesting a positive relation between the scope of activities performed in relation to a given counterpart and the sustainability of relational contracts (albeit conceived only as self-enforcing informal agreements) (Argyres et al., 2020). Besides the farmer and farm characteristics, we also considered other control variables, particularly building on extant empirical literature (see for example Cembalo et al., 2014). For instance, we aimed at controlling for prior contractual experience with a form of supply chain partnership, which is suggested to increase the probability of allying with that partner or adopting that form of contract (Reuer and Ariño, 2007). However, given the newness of activity, we could not consider prior contract relations with a particular bio-energy producer. In addition, preliminary interviews and focus groups indicated that previous experiences in regulating supply chain relations in this area regarded almost only standard contract farming. Even when farmers were organised in a cooperative or association, they were put in individual contact with the bio-firm and offered a standard contract farming agreement (also see Cembalo et al., 2014). Therefore, we controlled for the only proxy available, namely the previous participation in contract farming, which involved 30 % of the sample.

3.4. The analytical model

The analysis used the Random Utility Model (RUM) (McFadden, 2001) that has been extensively used in consumer preferences studies (Cicia et al., 2012; Caputo et al., 2018). Its implementation in contract choice and attributes analysis was introduced by Roe et al. (2004) and, since then, applied in context of the decision to adopt contract farming by Abebe et al. (2013) and Cembalo et al. (2014). This approach implies that when a number of J contract alternatives are showed to the *i-th* farmer, the utility he/she assigns to each *j* contract alternative is a linear, additive and separable function of all the *a* attributes that constitutes the contract:

$$U^{i}_{j} = f\left(\mathbf{x}_{j}\right) + \varepsilon^{i}_{j} \quad (1)$$

where $\mathbf{x}_j$ is a *A*-vector of observed attributes characterising the *j-th* contract. In a RUM, the alternative *j* contract chosen represents the outcome of an expected utility maximization exercise of the farmer. To illustrate, when choosing the contract *j* a farmer will reach the highest utility that, analytically, is $U^{i}_{j} \geq U^{i}_{k}$, with the alternative $k \in J$ and $k \neq j$.

In order to maximize farmer's utility, he/she is assumed to choose the contract alternative with the most desired set of attributes $\mathbf{x}_j$. The probability that a farmer chooses a contract *j* depends by the probability that the utility of alternative *j* is greater than, or equal to, the utility of the all other alternatives, falling in the set of contracts.

$$Pr\left(U^{i}_{j}\right) = Pr\left\{U^{i}_{j} > max\left(U^{i}_{k}, \ldots, U^{i}_{J}\right)\right\} \quad (2)$$

The RUM assumes utility U_j as the sum of an observable component $\mathbf{\Phi x}_j$ where $\mathbf{\Phi}$ is an *A*-vector of unknown parameters and a stochastic component ε_j:

$$U^{i}_{j} = \mathbf{\Phi x}_{j} + \varepsilon^{i}_{j} \quad (3)$$

Parameters in $\mathbf{\Phi}$ are distributed in the sample as a function defined by μ and σ, also known, respectively, as location and scale parameters:

$$U^{i}_{j} = \mathbf{\Phi}^{i}\mathbf{x}_{j} + \varepsilon^{i}_{j} \quad (4)$$

where $\mathbf{\Phi}^{i} = \mathbf{\Phi} + v^{i}$, $v^{i} \sim N(0, \sum_{\mathbf{\Phi}})$. The error term so generated $(v^{i}\mathbf{x}_{j} + \varepsilon^{i}_{j})$ is correlated across alternatives.

When a type I extreme value distribution is assumed for the term error, a logistic regression can be run to estimate $\mathbf{\Phi}$ or $\mathbf{\Phi}^{i}$ parameters (McFadden, 2001). Estimated coefficients measure the overall preferences of farmers toward each level of the contract attributes. In our experiment, four choice tasks, each with two randomly selected alternatives, were presented to interviewees. Each contract alternative represents a different combination of levels for the *A* attributes selected, shown in the previous paragraph. The matrix $\mathbf{x}_j$, characterising the *j-th* contract, has a random nature of combining levels. It includes 1600 profiles of contracts (789 of them unique), presented in four choice tasks to (200) farmers. $\mathbf{\Phi}$ parameters can be estimated with the maximum likelihood estimator for logit model (Amemiya, 1985), using maximum simulated likelihood methods (Train, 2009).

4. Findings

We are going to present the main findings of our research in the following steps. First, we present how sampled farmers responded to the overarching choice alternatives, namely how many contract alternatives they decided to choose. Data was analysed using STATA. Most interviewed farmers choose 3 or 4 possible contracts, with almost 9 out of 10 farmers choosing at least one contract alternative, as reported in Table 4. These simple descriptive statistics indicated that a plurality of arrangements is at least acceptable to the sampled farmers, and an indication of heterogeneous preferences too.

In line with the theoretical and analytical strategy presented above, we have then focused our investigation on the contractual features relevant in the choice of contracts. This phase of the analysis had been articulated in subsequent steps: first we analysed the preferences for each of the contractual attributes, paying particular attention to the relevance of relational attributes.

Then, we defined combinations of attributes forming two ideal-typical contractual configurations – a 'market-like' versus a 'relational' type - defined respectively by minimum versus maximum *values of relational intensity on all contractual attributes,* in order to investigate the role of relational attributes in combination rather than in isolation, and to explore their relations with the preferred modes of negotiating

Table 4
Number of contracts chosen (%).

Variable	Perc.
No contract chosen	11.5
One contract chosen	16.5
Two contracts chosen	14.0
Three contracts chosen	17.0
Four contracts chosen	41.0
At least one contract chosen	88.5

the contract, and with possible factors explaining the heterogeneity in preferences. The main findings for each step are presented in the next two section.

4.1. Preferences for contractual attributes

Table 5 shows the results obtained from the mixed logit conditional regression.

The results concerning the estimated coefficients (random coefficients μ and σ) can be interpreted as follows: the parameters μ measure the effect of increases in the value of the corresponding attribute on the marginal utility of the contract (the probability of choosing the contract), while the parameters σ indicate the effect of those increases on the variance in the probability of acceptance, i.e. it can be interpreted as a measure of the heterogeneity of preferences for a given attribute as its value varies. More specifically, the estimated values of μ show that the contract characteristics that generate greater utility or preference to farmers are (in order of relative importance): base price, presence of a minimum guaranteed price, training, negotiation (ex-ante), renegotiation (ex-post), and contract length; ad that variance in preferences decreases for higher values of attribute relational intensity. Therefore, the results indicate that farmers have a *general preference for relational contracts over standard contract farming,* on most dimensions: adjournments according to market contingencies (e.g. base price and minimum price), adapting and learning (e.g. training) and the possibility of negotiating the contract both ex-ante (negotiation) and ex-post (re-negotiation). There is an exception however, represented by contract duration, whereby shorter lengths are preferred and variance in preferences is larger for longer durations.

These findings suggest that there may be types of farmers or farming conditions that may drive preferences, in some cases and for some attributes, toward a *lower, rather than higher relational intensity* of contracts,. In order to understand the possible factors behind those deviations from expected patterns (and among attributes) we performed an analysis of preferences expressed over configurations of attributes, rather than on attributes in isolation, and explored their connections with farm characteristics, as well as with the preferences expressed over the different types of ex ante negotiation process. The results are presented in the next section.

Table 5
Random parameters mixed logit results.

Dep var.: choice	Coef. (μ)	Std. Err.	z	P > z
No choice	11.58	5.202	2.23	0.026
Length (contract duration)	−0.16	0.039	−4.12	0.000
Re-negotiation (ex-post)	0.65	0.154	4.23	0.000
Minimum price guaranteed	1.76	0.183	9.62	0.000
Training	0.70	0.143	4.85	0.000
Negotiation (ex-ante)	0.16	0.097	−1.67	0.095
Base price (log-price)	4.05	1.850	2.19	0.029
	Coef. (σ)			
Length (contract duration)	0.12	0.055	2.21	0.027
Re-negotiation (ex-post)	−1.07	0.265	−4.04	0.000
Minimum price guaranteed	0.90	0.200	4.53	0.000
Training meeting	−0.29	0.282	−1.02	0.308
Negotiation (ex-ante)	−0.38	0.131	2.91	0.004
Base price (log-price)	0.74	0.121	6.10	0.000

Number of observations 2400 (2400 = 200 respondents * 3 possible choices (A, B, opt-out) * 4 rounds).
Log likelihood = −676.832; LR chi2(6) = 180.08; Prob > chi2 = 0.0000.
Hessian matrix check for stability and convergence diagnostic was performed, as well as a sensitivity analysis check (bootstrap standard error). Results confirm a good stability of the model and are available upon request.
Individual-level preferences heterogeneity analysis was performed. Results are available upon request.

4.2. Preferences for contractual configurations

Based on our theorisation and *dimensionalization* of the relational intensity of contracts, we have defined two ideal-typical contractual configurations defined by the minimum and maximum values in terms of relational intensity of the attributes. Hence, we labelled them *'market-like'* contract farming configuration and a *'relationally enriched'* contract farming configuration. This approach allowed us to calculate the probability of respondents' participation in the two configurations, as if they had to choose between two alternative contracts positioned in an ideal continuum of relational intensity, from very low (market-like configuration) to very high (relationally enriched configuration). From an econometric stand-point this meant to calculate a point probability in the following cumulative (logistic) distribution function (CDF):

$$P_i = \frac{e^{\alpha+\beta_j X_{i,j}}}{1+e^{\alpha+\beta_j X_{i,j}}}$$

where P_i is the probability ranging from 0 and 1. We used the estimated coefficient coming from the random utility model to compute the probability of the two configurations defined as follow:

- Market-like configuration: No minimum price guaranteed, no training, no *Re*-negotiation (ex-post), 3 years contract duration.
- Relationally enriched configuration: With minimum price guaranteed, with Training, with Re-negotiation (ex-post), 10 years contract duration.

It should be noticed that the specific attribute related to the negotiation was kept separate, as it basically operationalises a 'mode' of relationality rather than its intensity. In fact, the values of this variable indicate whether the preferred mode implies a low level of horizontal relationality among farmers, and a high level of relationality in the vertical relations with the buyer (the energy producer in this case) or the other way around. In Table 6 the point probability of choosing one or the other configuration are reported with and without the effects of the presence and mode of ex-ante negotiation. The findings show that *a relational configuration is preferred no matter what the mode of negotiation, and that the mode of negotiation preferred is direct and individual no matter which contractual configuration is preferred* (the probability of entering into a contract increases with more individualized negotiation for both configurations), with a more marked effect on the participation in the enriched contract configurations than market-like ones.

We also controlled whether the heterogeneity of preferences for contractual configurations and mode of negotiation could be related to structural features of the firm, such as farm size, which can affect

Table 6
Likelihood to participate in market-like vs relationally enriched contractual configurations.

Variable: probability of choosing the configuration	Obs	Mean	Std. Dev.	Min	Max
Market-like without negotiation	2400	0.541	0.327	0.237	0.999
Market-like, collectively negotiated (1)	2400	0.564	0.310	0.200	0.999
Market-like, technically mediated negotiation (2)	2400	0.590	0.295	0.155	0.999
Market-like, individually negotiated (3)	2400	0.616	0.282	0.118	0.999
Relationally Enriched without negotiation	2400	0.789	0.186	0.315	0.999
Relationally Enriched, collectively negotiated (1)	2400	0.811	0.167	0.251	0.999
Relationally Enriched, technically mediated negotiation (2)	2400	0.831	0.153	0.197	0.999
Relationally Enriched, individually negotiated (3)	2400	0.848	0.144	0.152	0.999

bargaining power. *Interestingly, no difference was detected*. Then the configuration of preferences should find other explanations, as discussed next.

5. Discussion

The overall pattern of findings supports the tenet that relationally enriched contracts increase the utility for farmers (the 'weaker' party in the transaction) and the likelihood of reaching an agreement in the regulation of transactions to produce biomasses. This general result is consistent with and offers support to the original notion and function of relational contracts: *there is a formal component of relational contracting, focused on the regulation of an ongoing relation, that is robust (increases the probability of acceptance) in new, complex or uncertain activities*. However, some interesting qualifications and refinement have been detected for some relational attributes, namely *contract duration* and *modes of ex-ante negotiation*. As to duration, it behaves differently from other attributes: the probability of acceptance increases with the relational intensity of the other attributes but decreases with duration. One plausible explanation is that the possibility of renegotiation can be achieved through renegotiation clauses present in the contract but also by defining a new contract altogether more frequently. This result aligns with previous findings related to the tendency of farmers to limit or avoid long-term arrangements (Weituschat et al., 2023). Hence, whereas the activity is new and there is limited experience on the most suitable form of contract, long durations, albeit conceivable as 'more relational', may be judged as hazardous. The preferred combination of attributes configures an agreement that is relationally intense but frequently redefined. Not unconceivable indeed. Actually, the need for relational agreements combined with shifting participants and short duration of collaborations has been noticed in innovative sectors, such as creative industries (Meyerson et al., 1996). In that research, those prominent authors in organization theory proposed the notion of 'swift trust', capturing the need for disentangling the possibility to trust from the duration and long-lasting relations, thereby offering the required flexibility in agreements (Blomqvist and Cook, 2018). They argued that trust can be swift if supported by mechanisms other than partner-specific knowledge and experience, such as institutional certifications and roles, and social control. Here we are unveiling that swift relationality may also be compatible with and supported by sufficient richness in other relational formal guarantees embodied into contracts, configuring a form of 'swift relational contracting'. Uncertainty and lack of experience may also explain the heterogeneity of preferences on contractual configurations and the homogeneity of preferences for an individual negotiation of, as indicated in previous empirical studies on bioenergy farming in rural areas (Lopolito et al., 2011). It has been documented that the variety of contractual forms used in sector of activity is higher at the outset and shrinks over time, as the more effective forms of contracting are experimented and learned (Suchman, 1995; Mayer and Argyres, 2004). The lack of knowledge, and the need for learning, about the parameters characterising a transaction itself, has been considered one of the factors behind the observed heterogeneity of contractual forms in the regulation of the same transaction (Ménard, 2013). Engaging in bioenergy activities has this novelty features, hence the heterogeneity in preferred contractual configurations can, at least in part, be attributed to that learning phenomenon – also considering that our analyses excluded a systematic connection of those preferences with firm characteristics that might affect transactional parameters (as firm size, hence bargaining power) and the transaction itself is the same for all.

In addition to indicating a further relational dimension of contracting, our specific findings refine the rare previous propositions available on the connections between negotiation and efficient governance and contractual structures, which hypothesized that 'weaker parties' generally attach greater utility to agreements that are not only more relational toward the counterpart, but also among themselves (Grandori, 2015). The results obtained here do not square well with that proposition and suggest that it should be refined. First, that relation is likely not to be linear, as the weaker party faces a trade-off: the utility from 'idiosyncratic deals' may well offset the utility from greater bargaining power. A second refinement has to do with a likely mediating effect of the context; in the studied setting qualifiable as 'low trust' and 'weak institutions' one. In the specific case considered, in fact, also based on debriefing interviews, there are elements indicating that the utility from associating among farmers is perceived as low, due to the weakness of both farmer associationism and regional support; which may affect the preferred mode of contract negotiation, favouring individual deals.

In sum, our findings shed light on how to resolve a core/important problem faced in the bioenergy industry. It is said that, in the innovative activities in the bio-based industries collaborative projects and networking are a key aspect (Garnsey and Leong, 2008; Bröring et al., 2020). However, the capacity to mobilize suppliers is still not high at today. The variety of partners, technology platforms and production systems in this industry (Philippidis et al., 2024; Zilberman et al., 2025), invites for a more explicit consideration of the role of heterogeneity from the supply side of biomaterials, which constitute the first step to ensure a successful valorisation of biological streams and/or farming products or by-products in this industry (Carraresi et al., 2018). The identified preferred enriched form of relational contracting contributes to the scholarship investigating conditions for the further expansion and establishment of a bioenergy industry, particularly in terms of scalability and adaptability. As to scalability, our findings contribute to understanding how those challenges can be met by increasing the relational intensity of contracts, and on which dimensions. Moreover, the consideration of both ex-ante and ex-post relationality allowed us to unveil that paying attention to both makes a difference in reaching agreements. As for adaptability, the distinction among types of negotiation process leading to an agreement revealed the value of idiosyncratic deals and partner-specific contracts for matching the possible heterogeneity of conditions and preferences; particularly in contexts of 'low trust'/'weak institutions'.

Further research may corroborate the ensuing possible conjecture that associated forms of negotiation may be preferred in context characterized by higher trust and stronger institutions. The disentanglement of contractual clauses into attributes that may or may not be combined in different contractual configurations allowed to identify what can be considered a new contractual configuration; that may be called '*swift relational contracting*': a form of relational contract that, in the course of being relationally intense, is not necessarily long in duration.

6. Concluding remarks

The bioenergy industry is a core component of the EU strategy to reduce its dependency on non-renewable while attempting to support biomass producers and farmers in rural areas. Notwithstanding, extending bioenergy activities also pose relevant governance challenges associated with intensified inter-organizational collaborations and supply chain relations between farmers, bio-industries and other supply chain actors. As we have highlighted in this research, often existing contractual arrangements like contract farming schemes, can become ineffective and potentially unfair. Our study has addressed the crucial issue of exploring how to design more effective contract that facilitate farmers' adoption of bioenergy crops. Our findings indicate that contracts that in the course of being formal and enforceable, are enriched in relational and procedural clauses are ranked as superior by the weaker party in the relation, i.e. farmers. The identified preferred configuration that we called *swift relational contracting* contributes to contract theory and ecological economics by providing insights into how relational, flexible and frequently adaptable contractual structures can fit with the requirements of emerging bio-based industries. In terms of future research our contribution can pave the way to expand investigations of farmers preferences for contractual arrangements in different empirical

contexts, including socio-ecological and political conditions. It also invites to further expand the notion of swift relationality outside the bioenergy crop setting, as a way of enriching our understanding of limitations and potentials of contract farming in agriculture. In addition, swift relational contracting can have general relevance far beyond the considered bio-based industry setting. In an innovative economy, activities that requires intense coordination and frequent changes in partners or in contract format are in fact not rare; as well as the emergence of new transactions, for which transactional parameters and efficient forms of contracting have to be learned. As to theoretical implications and generalizations, an analytical generalization relating these findings to relevant theories, is that they square well with a broad view of relational contracting not limited to mere informal agreements, but encompassing also complex formal agreements including a variety of relational clauses. Moreover, the notion of 'swift relational contracting' can usefully extend the envisaged menu of possible contractual forms generally conceived and comparatively assessed, as a form responding simultaneously to needs for flexibility and frequent adaptation and to needs for intense coordination.

CRediT authorship contribution statement

Stefano Pascucci: Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Anna Grandori:** Writing – review & editing, Writing – original draft, Conceptualization. **Massimiliano Borrello:** Writing – review & editing, Writing – original draft, Conceptualization. **Luigi Cembalo:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

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