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Exploring preferences for contractual terms in a scenario of ecological transition for the agri-food sector: a latent class approach

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Abstract. Governance mechanisms along the agri-food supply chains are increasingly important in a scenario of ecological transition. Under the conceptual and analytical lens of the Transaction Cost Economics, we explored farmers' preferences towards a variety of clauses usually adopted in production contracts. To this purpose, a discrete choice experiment among 190 durum wheat producers in Italy was conducted. Results from a latent class model showed that producers were mainly interested in fixed prices formula and to join shared rules of production but revealed little or no interest for compelling sustainable cultivation techniques and the provision of technical assistance. However, these preferences are heterogeneous across farmers and vary depending on their level of education and previous use of contractual arrangements, with relevant implications for contract design and management.

Keywords: contracts, transition, NIE, latent class analysis, cereals.
JEL Codes: Q13, D23, L14.

INTRODUCTION

There is consensus that the global food system is not delivering as needed on several key metrics, including addressing excessively high rates of hunger and malnutrition, agriculture-driven environmental footprint, unequal distribution of welfare along supply chains, among others (McGreevy et al., 2022). A more recent movement has called attention to the fact that such problems may be better addressed when implementing an ecological transition in food system to respond to shocks and crises stemming from conventional food systems. Cholez et al. (2017) posit that an examination of contractual frameworks is pivotal during this transition, as they can adeptly navigate uncertainties and simultaneously provide clear demarcations of property and decision rights in emerging supply chains. Taken as a whole, this literature highlights the importance of governance considerations for the agro-ecological transition.

Over the last decade production contracts have become increasingly important to enhance coordination along the agri-food supply chain (Mac-

Donald 2015; Vassalos et al., 2016). They can connect farmers with buyers, reduce uncertainty in prices and demand, provide risk sharing against natural disasters and climate related shocks, and in some cases, provide access to inputs technical assistance (FAO, 2017). However, there are at least two main different types of contracts at stake (marketing and production contracts) which differ for several reasons (Dubbert et al., 2021). While in marketing contracts farmers control their assets and production inputs independently by usually determining price, quantity and delivery conditions to secure sales on market (Soullier and Moustier, 2018), production contracts entail the provision of resources – such as production input supply (e.g. seedlings and fertilizer), credit, and other support like extension services or transport of harvest – and quite often they impose a particular production method or input regime to farmers (Otsuka et al., 2016).

Production contracts represent an organizational solution which has been extensively discussed regarding its potential to resolve market limits. They allow farmers to be integrated into modern agricultural value chains by reducing transaction costs and being provided with inputs, technical assistance and assured against price fluctuations (Schipmann & Qaim, 2011; Swinnen and Maertens, 2007).

This type of contracts increasingly aims to engage farmers in delivering high quality products and contributing to environmental sustainability by reducing the use of chemical fertilisers and pesticides. However, in many situations, farmers are hesitant to use written contracts, likely due the fact that existing informal contracts are deeply rooted in traditional social norms (Jäckering et al., 2021). Moreover, farmers may be reluctant because of the high enforcing costs, especially when formal institutions are not well developed (Michler and Wu, 2020).

To sum up, participating in a contract entails trade-off between incentives and costs (Bogetoft and Olesen, 2002). For this reason, if the contract design does not include price incentives and provision of inputs, farmers may be discouraged from participating in the arrangements because they must comply with quality and sustainability requirements and other costly specifications (Abebe et al., 2013; Pancino et al., 2019). Moreover, producers may have different views on and experiences with the advantages and disadvantages related to contracts (Widadie et al., 2020). Consequently, two research questions arise: which contractual terms can lead farmers to adopt production contracts in a scenario of ecological transition? Do farms and farmers' characteristic affect acceptance of contractual terms?

In this background, the first aim of this study is to investigate farmers' preferences towards a wide variety of contractual terms usually adopted in production contracts in the context of the Italian durum wheat sector. The second aim is to determine which and whether farmers and farms characteristics affect the probability of accepting the above-mentioned clauses. In doing so, our paper contributes to filling a knowledge gap on the role of heterogeneous farmers' preferences in affecting contract design, offering insights on the potential acceptance of contractual terms in a scenario of ecological transition. This latter imposes a reduction of chemical inputs and a gradual shift from fossil fuels to cut net greenhouse gas emissions in agriculture.

Accordingly, we first elaborate a conceptual and analytical framework about the effects and the potential acceptance for specific clauses in the agri-food context. Material and methods are then described in detail, mainly revolving around a discrete choice experiment carried out among Italian farmers. Lastly, results from latent class logit estimations are presented and discussed in the lights of the existing literature before final remarks and policy recommendations are delivered.

2. STUDY CONTEXT

We focus on a staple food crop of strategic importance for Italy and for many countries bordering the Mediterranean, such as durum wheat. Italy produces half of the durum wheat grown in the EU-28 (UK included) and it is leader both in the per capita consumption of pasta and in its production (Bux et al., 2022).

Durum wheat represents the main cereal crop in Italy covering about 44% of the total cereal area. Cultivation is widespread in Southern Italy, in marginal areas at risk of abandonment, characterized by few employment alternatives in other economic sectors and in which it is difficult to find an alternative crop. In 2020, 1.2 million hectares (about 10% of the total utilized agricultural area) were sown to durum wheat in Italy for a total production of about 4 million tons. Apulia, with a production of about 760,000 tons, is still Italy's main producer overtaking Sicily, Marche, and Emilia-Romagna (Ismea, 2022). Durum wheat is at the base of a national supply chain of considerable importance, with first and second processing industries generating a turnover of about 5.6% of total Italian agribusiness (Ismea, 2023). Italy is the undisputed leader in the pasta industry, accounting for more than 73% of the EU turnover, with an average production of around 5.3 million tons per year which is a quarter of the total world production (Ismea, 2023). In terms of market outlets, semolina pasta is one of the most important components of Italian

agrifood exports (4.6%), which have grown steadily in recent years and contribute positively to the EU's agri-food trade balance (Crea, 2022).

The Italian supply chain of pasta has evolved over the last decade thanks to the growth in demand for "100% Italian" and high-quality pasta, in order to add value to the national production pasta. As far as quality is concerned, the protein content is traditionally considered the main quality parameter. As for the origin of pasta, despite the increase in the cultivation of national durum wheat, the annual requirement of the Italian milling and pasta making industries is around 6 million tons, against a national production of 4 million tons (Istat, 2024; Italmopa, 2023). Being far away from self-sufficiency, the supply chain is persistently dependent on import (especially from non-EU countries) as a consequence. In order to improve the degree of self-sufficiency and the quality of the provision of durum wheat, a national Fund (named "*Fondo grano duro*") has been established since 2017 incentivizing farmers to sign long-term production contracts with pasta makers (Ciliberti et al., 2019).

Last but not least, in order to contain emissions and increase the environmental sustainability of pasta, both processors and pasta companies promote the adoption of environmental-friendly cultivation techniques, practices and methods (Bux et al., 2022; Stanco et al., 2020). In this regard, the share of utilised agricultural area dedicated to organic durum wheat is particularly high in Southern Italy, with Basilicata at the first place (22.8%), followed by Molise (13.5%), Apulia (13.5%) and Sicily (9.6%). Lastly, Marche (6.4%) is the first region in Center-North Italy (Sinab, 2023). Because of the increasing request for high quality and sustainable productions and due also to public interventions, the number of contractual arrangements between main semolina and pasta producers and farmers (or their organizations) has widely increased all over the country in the last years (Rossi et al., 2023).

3. CONCEPTUAL FRAMEWORK

Recent advancements in Transaction Cost Economics have revealed that hybrid governance mechanisms are largely widespread, with contracts being their primary form (Ménard, 2004). These latter play a pivotal role in fostering ecological transition, aiming to coordinate the actions of a diverse set of actors and integrate different dimensions of sustainability, as noted by Cholez and Magrini (2023). Contractual frameworks are crucial for this transition path, since they can have direct consequences on the use of input and dedicated investments to achieve certain environmental threshold in agri-food systems.

Under the lens offered by TCE, a flourishing literature has analysed contracts as governance structures affected by transactional attributes such as asset specificity and uncertainty (Anh et al., 2019; Cai and Ma, 2015; Key and Runsten, 1999; Mao et al. 2022; Minten et al., 2009; Ochieng et al., 2017; Ola and Menapace, 2020; Permadi et al., 2017; Widadie et al., 2020). Evidence reveals that, on the one hand, some contractual requirements can be associated with high transaction costs, therefore representing a major obstacle for choosing contracts. On the other hand, these latter flourish in presence of collective actions, transparent conditions and trust which help farmers to reduce transaction costs.

Ménard (2018) underscored the importance of assessing contracts based on the allocation of rights between transacting parties as a negotiation process. This refreshed viewpoint facilitates an analysis emphasizing how contracts can help alleviate sources of uncertainty and asset specificity surrounding novel technologies and knowledge and distinctly delineate the rights and responsibilities regarding the benefits stemming from the ecological transition. Consequently, contracts raise crucial questions about the collective strategies that go beyond individual interests and include varied modes of organization, besides market forces. In other words, implementing effective governance is contingent upon the alignment of individual interests with these collective strategies, expanding beyond market-driven relations and incorporating diversified organizational modes, where hybrid coordination and the role of contracts are key (Ménard, 2004).

Such a governance perspective examines the logic behind the adoption of coordination mechanisms to support the relationships among a multitude of agents involved in the ecological transition along the agri-food supply chain. In this paper, we follow previous works dealing with production contracts (Abebe et al., 2013; Polinori and Martino, 2019; Oliveira et al., 2021) matching the econometric rationale of choice experiments, where individuals derive utility from the different characteristics a good possesses, with aspect of contract design. In this approach, contractual terms affect the value (utility) each farmer gain from the choice, which is the difference between revenues and costs (i.e. the profit).

Moreover, according to the discriminating alignment principle of Williamson (1991), each contractual term is expected to affect not only production costs but also transaction costs related to transactional attributes

(mainly asset specificity and uncertainty) associated with contractual conditions chosen. To better capture this effect, we therefore explicitly decompose the value (utility) associated to contractual choices in two components: a positive (i.e. revenue) and a negative one (i.e. production and transaction costs).

As a consequence, we see this expected value as the profit for the farmer i (i = 1, 2, 3 . . .N) from each contractual terms t (t = 1, 2, 3. . .), which we decompose as follows:

$$\pi_{it} = R_{it} - (C_{it} + T_{it}) \quad (1)$$

with π_{it} being the profit, R_{it} the revenue the farmers get from each contractual terms, while C_{it} and T_{it} respectively represent related production and transaction costs.

It follows that since each contractual term brings its own revenues as well as production and transaction costs, alternative combinations of different contractual terms lead to different expected profit configurations. Consequently, all other things being equal, insertion/removal of a contractual term affects both revenues and costs involved, as follows:

$$\sum_j^J \beta Z_{ijk} W_i = W_i R_{ijt} - W_i(C_{ijt} + T_{ijt}) \quad (2)$$

where Z_{ijk} is an index for the alternative j from a choice situation k of contractual terms which are chosen in a contract from an i_{th} farmer, whose individual (and farms') characteristics are represented by a vector W, while β expresses the magnitude of the acceptance of each term. Reasonably, a farmer asked to choose among alternatives is willing to accept a contract including combinations of contractual terms which maximizes his/her expected profit.

3.1. Contractual terms, individual characteristics and farmers' preferences

Henceforth, inspired by previous studies in this field for similar (Soullier and Moustier, 2018) or identical crops (Biggeri et al., 2018; Carillo et al., 2017; Ciliberti et al., 2019; 2022; 2023; Oliveira et al., 2021; Pancino et al., 2019; Rossi et al., 2023; Viganò et l., 2022; Weituschat et al., 2023), we conceptualize both the role of selected but highly relevant contractual terms (related to production techniques, technical assistance, quality requirements and payment solutions) and confounding variables referred to individual (farms and farmers') characteristics. Accordingly, we elaborate research hypotheses to be tested.

Rules for sustainable production

The fact that a farmer chooses a production contract implies the willingness to commit resources to comply with certain production rules (Ciliberti et al., 2019). This seems to contradict basic behavioural assumptions, but in some cases farmers may want to demonstrate their commitment and may prefer a trader that values such an individual effort (given the fact that buyers are able to measure individual commitments, at least after the transaction occurred). Another driver is that farmers' engagement and reputation could lead to higher price premium (Carriquiry and Babcock, 2007; McCluskey and Loureiro, 2005). Moreover, farmers may also believe that opting for a less strict buyer will lead some of them to take opportunistic actions; such an occurrence in turn could contribute to damaging potential common benefits of building a collective reputation (Stanco et al., 2020). In this work, we propose farmers three contractual terms generically referred to production rules: shared and agreed rules, imposed rules or no rules of production. Based on previous literature we elaborate a following research hypothesis (RH 1):

> Durum wheat producers prefer to commit on contractual terms introducing production rules.

Moreover, in a scenario of ecological transition there is increasing evidence that some contractual terms require farmers for the adoption of environmental-friendly practices (Pancino et al., 2019; Rossi et al., 2023). However, adoptions of sustainable cultivation techniques imposing strict restrictions on pesticides, fertiliser or natural resources uses can represent a disincentive for farmers to enter a contract, since this would lead to lower yields and higher unit costs of production (Weituschat et al., 2023). Here, we focus on three specific sustainability requirements related to the durum wheat production cycle: a fractioned supply of nitrogen (that is the most important fertilizer for cereals), the adoption of a cultivation technique that promotes minimum soil disturbance (i.e. no-tillage), and lastly a joined combination of these two practices. Based on previous evidence, we elaborate a research hypothesis (RH 2), as follows:

> Durum wheat producers prefer contractual terms establishing mild sustainable cultivation techniques, rather than strict and costly commitments.

Provision of technical support

The need to access information and assistance on technology, production rules and quality requirements may

motivate farmers toward production contract (Oliveira et al., 2021). In this paper we explore preferences towards three specific contractual clauses on this subject: no technical assistance, the provision of direct technical support thanks to advisors, the provision of remote support by means of a remote decision support system (DSS). The buyer could provide all the required technical assistance so that farmers can benefit of updated and timely research-based information (Rossi et al., 2010). In a scenario of ecological transition, forms of technical assistance provided by buyers can help farmers to understand the reasoning for limiting pesticide and fertilizers use and the benefits of applying a more precise dosage, therefore fostering the adoption of sustainable production techniques (Ciliberti et al., 2022; Šūmane et al., 2018). Therefore, we formulate a research hypothesis (RH 3) related to this type of clause:

> Durum wheat producers prefer contractual terms establishing the provision of technical assistance.

Quality requirements

Maintaining and improving the quality production and ensuring compliance with food safety requirements is crucial in modern agricultural settings. Such an issue is associated with the ability to comply with formal or informal quality standards for farmers (Biggeri et al., 2018; Carillo et al., 2017; Soullier and Moustier, 2018). However, quality remains the main challenge in situations where the agri-food markets do not incentivize it, as farmers may be reluctant to invest their time and energy to improve quality. It follows that related requirements are a major source of uncertainty in agri-food transactions for buyers (Frascarelli et al., 2021). Usually, farmers may choose between low quality requirements, with small incentive to improve quality but low risk of product rejection, and a high-quality option, with higher incentive but larger risk of product rejection. Farmers therefore tend to prefer contract with low quality requirements, all other things being equal , given the uncertainty of farmers about meeting quality standards and due to the lower risk of product rejection (Oliveira et al., 2021). Here we want to test farmers' preferences for different and increasingly demanding quality requirements referred to various thresholds of protein content in durum wheat: in more details, a lower level (>12.5%), a medium-high level (13.5%), and a very high level (14.5%) of proteins. Based on the existing literature a research hypothesis (RH 4) is elaborated as follows:

> Durum wheat producers prefer contractual terms setting in advance lower quality standards and requirements.

Price and payment formulas

The general assumption in the literature is that farmers' motivation to participate in contractual arrangements is primarily to manage market uncertainty with pre-established price formula. These latter refer to the payment conditions farmers agree with, in exchange for delivering an agreed product quality and quantity. Since the mid-2000s price volatility has been a typical feature of prices of grain commodity, driven by several factors as a consequence of increasing linkages among food, energy, and financial markets (Ott, 2014; Santeramo e Lamonaca, 2019; Tadesse et al., 2014). To this regard, the adhesion to properly designed contracts is expected to reduce sources of market uncertainty (Oliveira et al., 2021). This governance solution applies also to the durum wheat supply chain, characterised by strong price instability and asymmetric price transmission along the value chain, which mainly penalise farmers (Viganò et al., 2022). In this paper we want to test farmers' preferences for three different price formulas: fixed, variable (that is, market) and a mixed price option (50% fixed and 50% market price). Thus, based on previous evidence, a research hypothesis (RH 5) is elaborated, as follows:

> Durum wheat producers prefer contractual terms establishing price formula alternative to variable market price.

As for payment modality, fearing opportunistic behaviours, farmers do not like delays and want to avoid issues with payments since they increase uncertainty, particularly when buyers are not trusted (Ciliberti et al., 2023). Moreover, farmers prefer immediate payment over delayed payment to address market uncertainty, also because they need money for purchasing inputs for the next production cycle (Oliveira et al., 2021). In this paper we test farmers' preferences for three different clauses related to payment modality: payment on delivery, deferred payment, and payments in instalments on a monthly basis. Accordingly, another research hypothesis (RH 6) comes out:

> Durum wheat producers prefer contractual terms setting immediate payment.

Lastly, the relationship between contractual terms and farmers' utility and preferences can be affected by some characteristics we intended to control for. The emerging literature on the determinants of farmers' preferences towards contractual terms in the durum wheat sector suggests several of those individual characteristics which must be checked for (Frascarelli et al., 2020; Rossi

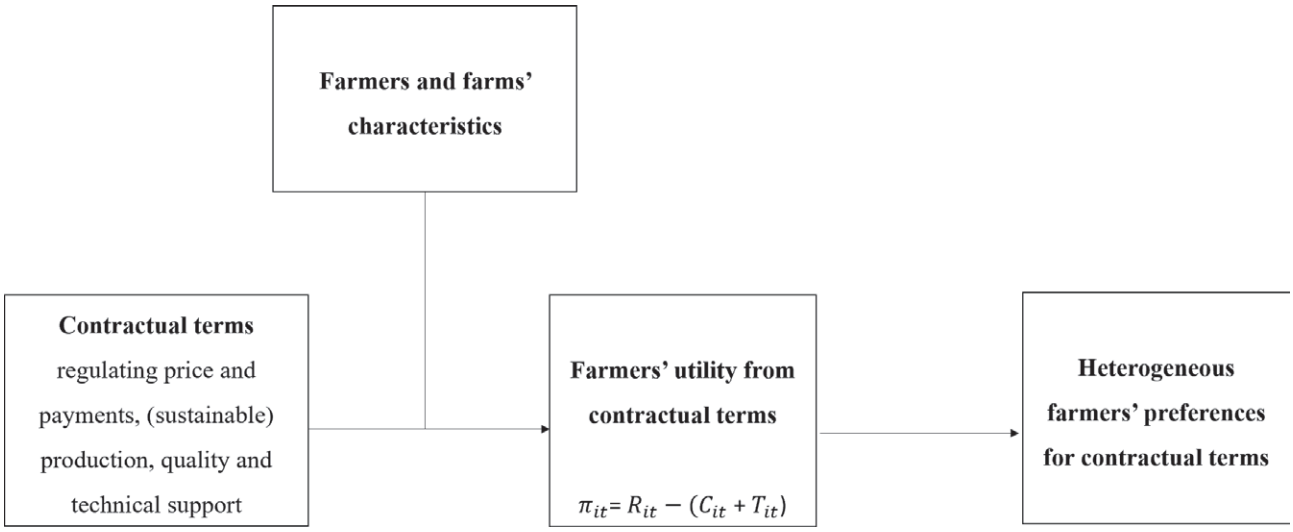

Figure 1. The causal pathway between contractual terms and farmers' preferences.

et al., 2023; Weituschat et al., 2023a;2023b). We decided to select some of the most representative and relevant, focusing on age, education, experience, size, participation in cooperative, and previous use of contracts.

All that said and considered, figure 1 graphically illustrates and resumes the hypothesized causal relationship we conceptualized between specific contractual terms and farmers' utility and preferences, which can be affected by confounding variables related to individual farms and farmers' characteristics.

4. MATERIALS AND METHODS

4.1. Experimental design, sampling strategy and data collection

Discrete choice experiments are frequently performed in economic literature in order to establish individual preferences across items, such as good, services or in our case, contracts (Hensher et al., 2005; Louviere et al., 2010). The experimental design for a choice experiment relies on the identification of a set of relevant characteristics (attributes), which in our case relate to different type of contractual terms and their corresponding levels.

To this purpose, after analysing real production contracts adopted in the durum wheat supply chain over the last years (see Ciliberti et al., 2022 for more details), we also conducted a focus group discussion with key stakeholders to gain a better understanding of which clauses are more relevant for durum wheat producers[1]. These activities helped us to evaluate the relevance of some contractual terms for farmers, so as to decide which attributes and levels to include in our discrete choice experiment. Therefore, based on this evidence, we selected six attributes with three levels each, which are reported in Table 1.

Afterwards, we decided to adopt an efficient design using the software Stata so that contractual attributes and their levels were randomly distributed into 18 choice sets, containing three contracts with six attributes each. Then, choice sets were arranged into 6 blocks and each respondent was submitted to one block with three choice sets only, so as to reduce the number of contracts to evaluate. In detail, for each choice set, each farmer was allowed to specify his preference towards one out of three contracts plus an opt-out option (i.e. "none of the previous contract").

A structured questionnaire (including the choice experiment and an additional section with general information on farmers and farms' characteristics) was then realized to investigate farmers' preferences over contractual terms (see Supplementary material). It was pretested and validated across a small sample of almost two dozens of randomly selected durum wheat producers. As a final step, in order to collect data and information from our study population, consisting of farmers producing durum wheat in Italy, we adopted a purposive sampling strategy. To this aim, trained interviewers

[1] The focus group included 8 participants among representatives of durum wheat producers, input providers, buyers (processors, manufacturers) and experts (agronomists and technical advisors). The aim was to discuss the following questions: which are the main contractual terms included in production contracts? How are they negotiated between producers and buyers? What are the main (emerging) clauses related to environmental sustainability, if any?

Table 1. Attributes and related levels selected for the discrete choice experiment.

Attributes	Levels
Production rules	Not established
	Arranged with the buyer
	Compelled by the buyer
Sustainability requirements	Fractioned use of nitrogen (FUN)
	Minimum soil disturbance (MSD)
	Joined adoption of FUN and MSD
Technical support	Not provided
	Provided by technical advisors
	Remotely provided thanks to a DSS software
Quality requirements	Medium grain protein content (> 12.5%)
	Medium-high grain protein content (> 13.5%)
	High grain protein content (> 14.5%)
Price formula	Fixed price
	Market price
	Mixed (50% market – 50% fixed) price
Payment modality	On delivery
	Deferred payment
	Monthly payments

directly submitted the survey among farmers attending several technical workshops and seminars in Central and Southern Italy (where durum wheat production is mostly located), between late 2018 and early 2020 (until national authorities imposed the lockdown due to the Covid-19 pandemics). As a consequence, the composition of the sample mainly depended on farmers' attendance to these workshops and their willing and ability to correctly fill out the questionnaire in all its sections. Results are based on a sample of 190 completed questionnaires collected among durum wheat producers. No protests from respondents were observed and reported. Table A in the Appendix reports detailed descriptive statistics related to respondents' characteristics. Comparing information with those available for the reference population (Ismea, 2023b; Istat 2024), it comes out that the average size of the sampled farms is way larger than the national one in 2021 (that was 11.1 hectares). However, apart from some respondents located in Central and Northern Italy (Marche and Emilia-Romagna), about 75% of the interviewed farmers came from Southern Italy (with a large share from Apulia, followed by Basilicata), where most of the production (76%) and cultivated areas for durum wheat (69%) were located in 2020 (Ismea, 2023b). Lastly, farmers with less than 45 years represents 13% of the total at national level. Only one out of ten has a degree, whereas almost 60% own a secondary school diploma (Istat, 2024).

4.2. Econometric analysis

In this paper, we follow Pacifico and Yoo (2013) and Yoo (2020) to run a latent-class conditional logit (LCL), which extends the conditional logit by incorporating a discrete representation of unobserved preference heterogeneity across decision makers. Specifically, LCL assumes that there are *C* distinct types, or "classes" of decision makers and that each class *c* makes choices consistent with its own conditional logit model with utility coefficient vector β_c. Suppose that the probability that decision maker *i* belongs to class *c* is given by a fractional multinomial logit specification:

$$\pi_{nc}(\mathbf{\Theta}) = \frac{\exp(z_i\theta_c)}{1+\sum_{l=1}^{C-1}\exp(z_i\theta_l)} \quad (2)$$

where z_i is a row vector of decision maker *n*'s characteristics and the usual constant regressor (that is, 1); θ_c is a conformable column vector of membership model coefficients for class *c*, with θ_C normalized to **0** for identification; and $\mathbf{\Theta} = (\theta_1, \theta_2,\ldots, \theta_{C-1})$ denotes a collection of the $C - 1$ identified membership coefficient vectors.

Under LCL, the joint likelihood of decision maker n's choices is given by

$$L_n(B, \mathbf{\Theta}) = \sum_{c=1}^{C}\pi_{nc}(\mathbf{\Theta})P_n(\beta_c) \quad (3)$$

where $B = (\beta_1, \beta_2,\ldots, \beta_C)$ denotes a collection of the C utility coefficient vectors and each $P_n(\beta_c)$ is obtained by evaluating $\beta = \beta_c$.

In more detail, the model is estimated using an Expectation-Maximization (EM)-Algorithm (Bhat, 1997). Such a model simultaneously estimates preference coefficients for different classes and the probability of an individual to belong to a class based on choice patterns and individual covariates. It therefore extends the previous analysis by incorporating a discrete representation of unobserved preference heterogeneity. As a result, we are able to further check for preference heterogeneity among farmers, since latent class model identifies unobserved groups of individuals with homogenous preferences by using a discrete mixing distribution (Swait, 1994). Lastly, econometric analyses were run using the software Stata 14.2 implementing usual optimization methods for maximum likelihood estimation.

5. RESULTS AND DISCUSSION

Latent class analyses were performed in order to identify classes of durum wheat producers with similar

Table 2. Individual characteristics for each class (mean and standard deviations) and differences.

Main characteristics	Class 1	Class 2	Difference
age (n.)	47.03 (14.22)	48.34 (11.83)	-1.31*
exp_y (n.)	26.63 (14.51)	27.28 (12.38)	-0.65
educ_h (%)	81.50 (38.83)	93.02 (25.50)	-11.52***
coop_m (%)	40.42 (49.08)	39.02 (48.83)	1.40
contr_p (%)	63.88 (48.04)	48.83 (50.03)	15.05***
size (ha)	121.97 (217.27)	305.64 (715.99)	-183,67

***, **, * Denote that mean values of class 1 farmers are significantly different from class 2 farmers at $p < .01$, $p < .05$, and $p < .10$, respectively.

preferences towards contractual attributes. We computed different models with 2 and 3 classes and used information criteria measures to test goodness-of-fit (Yang, 2006). The number of classes was chosen with regard to the Akaike information criterion (AIC), the consistent AIC (CAIC) and the Bayesian information criterion (BIC). We opted for a latent model with 2 classes which minimizes most criteria, in our case CAIC (1207.79 vs 1250.97) and BIC (1174.79 vs 1197.97), revealing the best goodness-of-fit. Table 2 reports the differences of durum wheat producers and their farms across the 2 classes, focusing on relevant control variables referred to individual characteristics.

Looking at Table 2 we are able to identify main differences among members of the two classes of respondents. On the one hand, class 1 group less experienced farmers with lower education and smaller cultivated areas, but with a higher attitude to join collective arrangement and sign contracts to sell durum wheat. On the other hand, class 2 encompasses durum wheat producers with opposite features, therefore more experienced and educated, less collaborative and with bigger farms. However, by using a nonparametric Mann-Whitney U test for continuous data and a chi-square test for dummy variables, statistically significant differences between the two classes emerged for age, high level of education and the use of production contracts.

Looking at the results of the latent class analysis, the majority of contractual terms show significant coefficients in both classes, highlighting relevant preferences towards attributes (Table 3), even if some interesting differences among classes.

First and foremost, we focus on the "no-choice" variable, which was selected in 123 out of 570 "no-choice" situations faced by the respondents[2]. Results reveal a significant but contrasting interest for production contracts across classes. In class 1, the negative coefficient (-1.310) suggests that farmers were significantly keen to reject the "no-choice" option in favour of one of the production contracts they were proposed. This latter was therefore considered more beneficial and reliable than the status quo in order to overcome spot market imperfections and reduce transaction costs, in line with Van den Broeck et al. (2017). On the other hand, the positive coefficient in class 2 (+6.528) shows a significant preference for the "no-choice" option and so against the proposed contractual solutions as a whole, in accordance with previous findings from Schipmann and Qaim (2011) and Blandon et al. (2010).

With regard to production rules, positive and significant coefficients for both terms highlight that farmers in both classes are highly reluctant to rules unilaterally imposed by the processing industry (i.e., the reference variable), but with some interesting differences. Always taking as reference the base level, farmers in the first class prefer shared rules (+0.476) more than no rules at all (+0.369), while in the second class the opposite is true with producers largely preferring a free production process (+2.581) over rules agreed with buyers (+1.950). With all that said, the first research hypothesis is partially confirmed, in line with earlier evidence from Gelaw et al. (2016), showing that farmers usually choose to join contracts since they are willing to commit resources in order to comply with certain production rules and gain reputation. However, at the same time, farmers tend to refuse contractual terms unilaterally imposing techniques and production rules, since they are traditionally concerned and suspicious of any attempt of limiting their decisional autonomy (Ciliberti et al., 2023; Vaissiere et al., 2018).

When asked to reveal preferences towards specific contractual terms setting rules for a more environmental-friendly and sustainable production, farmers reveal heterogeneous preferences across the two classes. While in the first class clauses are not significant, vis à vis a combined use of no-tillage and a fractioned supply of nitrogen (the reference level), farmers in class 2 show a clear and significant preference for a minimum mechanical soil disturbance (+1.256), but also a noteworthy and larger aversion to a lower use of nitrogen as fertilizer (-2.076). This is a signal that, in absence of specific incentives, farmers still look at this type of clauses with low enthusiasm and a certain suspect. They only accept to reduce soil disturbance since – compared to a

[2] In detail, the "no-choice" variable was selected at least in one choice set out of three by 21 respondents, in two choice sets out of three by 15 respondents and in all the three choice sets by 24 respondents, for a total of 60 respondents out of 190 (31.6%) which selected the "no-choice" option at least once.

Table 3. Parameter estimates for the latent class model

Attribute	Level	Class 1			Class 2		
		Coeff.	P>|z|	SE	Coeff.	P>|z|	SE
Production rules	Arranged	0.476	**	0.154	1.950	**	0.968
	None	0.369	**	0.157	2.581	**	1.003
Sustainability requirements	MSD	0.027		0.149	1.256	*	0.671
	FUN	0.049		0.148	-2.076	*	1.199
Technical support	Advisors	0.270	*	0.151	1.090		0.676
	DSS	0.250		0.153	0.004		0.738
Quality requirements	Protein > 12.5%	0.290	*	0.150	1.366	**	0.642
	Protein > 13.5%	0.210		0.154	-1.231		0.797
Price formula	Fixed price	0.680	***	0.160	2.269	**	0.796
	Mixed price	0.419	**	0.166	0.397		0.962
Payment modality	On delivery	0.083		0.153	0.031		0.745
	Deferred payments	0.131		0.153	0.650		0.633
No-choice	:	-1.310	***	0.486	6.528	***	1.601
Class share			0.723			0.277	
Log likelihood			-504.833				
AIC			1075.667				
BIC			1256.799				

Control variables (reference: class 2)

Variables	Coeff.	P>|z|	SE			
age	0.018		0.032	:	:	:
contr_p	0.923	**	0.454	:	:	:
coop_m	0.019		0.473	:	:	:
educ_h	-2.771	**	1.133	:	:	:
exp_y	-0.034		0.032	:	:	:
size	-0.001		0.000	:	:	:

Significance levels: *** 1% ** 5% * 10%

fractioned use of fertilizers – it can ensure a reduction of costs, but with a limited impact on yields and production. As a consequence, the second hypothesis can be confirmed, substantiating the fact that farmers' commitment in environmentally sustainable production is still partial, as it is perceived as a source of disadvantage when compared with farmers' returns from conventional agricultural production (Chèz et al., 2020). The primary reason is that the cost of environmentally sustainable production is considerably higher and that the yield is relatively lower than that of conventional agriculture (Wang et al., 2019).

As far as technical support is concerned, it is interesting to observe that only durum wheat producers in class 1 showed a slightly significant and positive interest (+0.270) for a contractual term introducing such a service (against the reference level "no technical support"), provided that it is offered on field by buyers' trusted technicians and advisors. No significant preferences occurred in class 2 instead. Therefore, even with some caveats, the third hypothesis can be confirmed in the light of the evidence on the acceptance of technical assistance. This result contributes to confirming farmers' interest for support services aimed to foster both innovation uptake and compliance with contractual requirements (Cholez et al., 2023; Martino et al., 2017). In the durum wheat sector, these ancillary services are usually provided when signing a contract, so that farmers can get support from expert agronomists in order to improve grain quality, production yields and profitability (Viganò et al., 2022). Our results confirm that relational contracting fosters process innovation in agri-food chains (Martino et al., 2017). However, a possible interpretation of the results could be that frequent on farm visits or solutions for remote assistance could be seen, by the most dynamic and independent farmers, as a subtle attempt of

controlling their activities and performances, therefore limiting the acceptance of this type of clauses.

Looking at clauses related to quality requirements, results clearly allow to confirm the fourth hypothesis highlighting significant and positive preference for these terms in both classes, but only to a limited extent. It is not by chance that farmers in class 1 and 2 prefer terms imposing the lowest possible qualitative threshold (of protein content) for their product (coefficients are respectively +0.290 and +1.366) vis à vis the most compelling one (that is, protein more than 14.5%). These results are fully in line with previous indications highlighting that these clauses are accepted by farmers because deemed able to reduce source of behavioural and technological uncertainty for farmers, since buyers' requirement are known in advance. However, as expected, farmers tend to opt for less stringent clauses confirming previous indication from Blandon et al. (2010), Oliveira et al., 2021).

When clauses related to price formula are considered, farmers' preference reveal a strong and significant interest in both classes for clauses offering fixed instead of market price. Taking into account this latter option as reference level, in class 2 there is a stronger interest for a guaranteed minimum price than in class 1 (coefficients are respectively +2.269 and +0.680). Moreover, in class 1 durum wheat producers are also significantly attracted by mixed price (+0.419) compared to the base level. That said, empirical evidence corroborates the fifth research hypothesis in accordance with previous empirical studies which highlighted that, all other things being equal, farmers prefer a fixed price option over a variable one (Miyata et al., 2009). Price stability is therefore confirmed to be a major driver of participating in contracts, since it can shield farmers against the volatility which has largely affected cereals since the mid-2000s due to the several circumstances (Maertens and Vande Velde, 2017; Santeramo e Lamonaca, 2019). However, contradicting the common credence that farmers are risk averse, Wang et al. (2011) also showed that based on their characteristics, farmers may have different risk preferences and entrepreneurial attitude, so that a mixed pricing strategy based on certain performance criteria can be sometime preferred to a minimum guaranteed price.

Very interestingly, farmers reveal no significant preference to any type of payment modality compared to the reference level (fractioned monthly payment). Therefore, they make no distinction between payment on delivery and other solutions establishing payments in instalments or delayed. So, the sixth hypothesis must be rejected, in line with the work of Oliveira et al. (2021), but against earlier evidence revealing negative preference for delayed payment (Cai and Ma, 2015).

Lastly, results reveal that only a few control variables can explain differences among the two groups of respondents and their preferences towards contractual terms. In line with previous works, they refer to previous use of contracts and the level of education. On the one hand, earlier experiences with production contracts make farmers more likely to belong to class 1, so more confident and relying on production contracts, as already demonstrated by Van den Broeck et al. (2017). On the other hand, higher level of education (i.e., high school diploma or higher qualification) increase the likelihood of going into class 2, with a significant but negative effect on contract participation in contrast with Widadie et al. (2020) but perfectly in line with findings of Ren et al. (2021) and Miyata et al. (2009).

6. CONCLUSIONS

Implementing innovative and effective governance mechanisms along the agri-food supply chain is of key importance in a scenario of ecological transition, so as to better coordinate actions of a multitude of economic actors in an uncertain context. Adopting the conceptual lens of the Transaction Cost Economics, the present work contributed to the burgeoning literature in this field, investigating whether and how production contracts may play a key role in fostering a better alignment of individual interests with broader collective goals and strategies, integrating also social and environmental dimensions. Focusing on a highly strategic agri-food production in the Italian context, such as durum wheat, we conducted a discrete choice experiment to analyse farmers' preferences for a selected and relevant number of contractual terms, which differently affect source of production and transaction costs. Moreover, applying a latent class analysis we also detected the role played by some individual characteristics questioning the homogeneity of these preferences.

Findings indicated that the path towards the use of contracts able to match both private and public goals is still long for at least two reasons. First, farmers show a strong interest for clauses protecting against market and behavioural uncertainty (fixed price and shared rules of production) but are still hesitant in joining compelling quality and environmental requirements if not properly incentivized or supported. Moreover, technical support provided by the buyer is sometimes seen as a form of control and therefore unwelcome. Second, results are not homogenous across respondents, reveal-

ing that there is need to better take into account the heterogeneity of preferences, overcoming one-size fits all approach to contract design and implementation. To this regard, attention must be paid to the fact that respondents sometimes preferred to not make a choice. This fact signals the existence of a not negligible share of farmers who have different opinions and preferences from other producers as well as different expectations and needs which shall be somehow addressed by stakeholders.

As a consequence, interesting policy and managerial implications follow. In line with the approach of this paper, the importance of implementing an evidence-based and more participatory approach to contract design, negotiation and adoption is noteworthy. Such an action could allow to better tailor contractual terms on producers' characteristics and to reduce their suspicion over such a governance solution, which is often seen as a subtle form of exploitation promoted by buyers to reduce their decisional autonomy over land. Empirical evidence also reveals that another key and central point in a context of ecological transition is to identify and define types of (monetary or non-monetary) incentives to promote the adoption of terms related to sustainable cultivation practices and the adoption of environmental certification.

Even if they still play a limited role in the Italian cereal sector, cooperatives, Producers' Organizations, and Interbranch Organizations can also play a decisive role along this path, reducing transaction costs related to the negotiation and the enforcement of production. Lastly, technical support provided by contract should be better promoted across durum wheat producers, highlighting the strategic role of knowledge and innovation transfer for improving both quality and sustainability of production.

All that said, it must be also considered that this work has some limitation. First, since results were based on a purposive and biased sample of a few hundred durum wheat producers they cannot be generalized, if not with some caution. In this regard, investigating farmers' preferences for contractual terms in a given period of time for a specific production in a certain context at least allowed to reduce potential sources of exogenous heterogeneity. Moreover, another caveat is related to the fact that the empirical analysis relied on a discrete choice model approach, so on stated rather than on observed preferences. Lastly, experimental design imposed to select only a limited number of contractual terms to be analysed, leaving room for future research in this area to evaluate further and different clauses.

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APPENDIX A

Table A. Characteristics of the sampled durum wheat producers and their farms (n=190).

Variable name	Variable description	Mean	sd	Min	Max
age	years of the farmers (n.)	47.24	13.70	18	85
contr_p	use of production contract (y/n)	0.62	0.48	0	1
coop_m	member of a cooperative (y/n)	0.40	0.49	0	1
educ_h	high school or higher qualification (y/n)	0.83	0.36	0	1
exp_y	years of experience as farmers (n.)	26.84	14.01	2	60
size	hectares of farming areas (n.)	164.87	399.82	2.56	3680