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A structural equation modeling analysis of relational governance and economic performance in agri-food supply chains: evidence from the dairy sheep industry in Sardinia (Italy)

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Abstract

This study investigates the factors affecting the inter-organizational relationships and governance of firms in agri-food supply chains and assesses the influence that the current conditions of vertical coordination have on the economic performance of these firms.

Research hypotheses describing the causal effects between the environment, product characteristics, inter-organizational relationships, relational governance, and firm economic performance are formulated and tested using a structural equation modeling approach. Data were gathered from a questionnaire administered via a direct survey to both farmers and processors in a traditional high-quality dairy sheep supply chain in the Italian region of Sardinia: the Pecorino Romano Protected Designation of Origin. Results point out the role of informal contractual arrangements in this local production system characterized by social cohesion, entailing higher product quality and better economic performance. Further, the study highlights the role of trust as a key variable for attaining collaborative paths along the agri-food supply chain, particularly between farmers and processors.

Keywords: Relational governance, Economic performance, Agri-food supply chain, Vertical coordination, Structural equation model, Direct survey, Pecorino Romano, Protected designation of origin (PDO), Marketing

Background

The competitive environment in which agri-food firms operate has become increasingly complex. The numerous factors contributing to the increasing complexity include technological progress, globalization, and the structure of the industry itself (Albisu et al. 2010), which is characterized by the perishable nature of the products (Aramyan and Kuiper 2009) as well as the large number of small- and medium-sized enterprises compared to the small number of suppliers and buyers that often exert market power. Consequently, many companies are now induced to abandon the traditional spot market exchange modality for new and more complex systems of negotiation and coordination.

Hence, a growing number of studies have been focusing on the complex issue of supply chain organization, particularly on the most appropriate inter-organizational relationships and modes of governance that firms should adopt in order to improve their economic performance. The numerous practices that companies adopt include the use of market supply contracts or sales agreements in short- and long-term collaboration or, more commonly these days, a combination of both. In fact, along the continuum between market and hierarchy, there are many intermediate forms of governance, known as hybrid forms, which range from strategic alliances to supply contracts and from partnerships to cooperative agreements between companies (Fischer et al. 2009; Ménard 2004). The growing industrialization of the food sector and the consequent increase in the adoption of vertical forms of coordination and consolidation suggest a need to develop more specific analyses of the relational dynamics in the agri-food chain. The formation of new types of alliances and networks also creates the need for a deeper understanding of emerging intermediate forms of governance between market and hierarchy and the relationships that are established between firms and organizations (Carbone 2017; Chaddad and Rodriguez-Alcala 2010).

In this respect, the dairy sheep sector in the European Mediterranean basin represents an interesting case study, as pasture-based sheep farming systems are mostly located in marginal areas and have an important economic and social role in rural development (Bernués et al. 2011; Riveiro et al. 2013). Nevertheless, the sector has suffered a strong decline in most regions in terms of both holdings and animals (Ripoll-Bosch et al. 2012).

Shepherding and cheese production have a long tradition in Italy as well, especially in the central and southern regions. This is the case of Sardinia, an island in which the dairy sheep sector is particularly important (Furesi et al. 2013).

The socioeconomic importance of the dairy-sheep supply chain is noteworthy especially at the farming stage. In fact, according to the latest official statistics (ISTAT 2012), Sardinia farms breed approximately three million sheep (44% of the total Italian sheep livestock) and provide 56% of the total sheep milk produced in Italy. However, among the 12,000 sheep breeding farms, only 5000 are specialized (ISTAT 2012), and despite the increasing average herd size (about 240 heads per farm), the majority of businesses are still family run and predominantly (or exclusively) make direct use of the labor available within their family (Pulina et al. 2011). Unlike in the past, only a small portion of milk is now processed into cheese on farms, with the rest being supplied to processing firms (Furesi et al. 2013; Idda et al. 2010).

On the other hand, at the cheese manufacturing stage, a noteworthy market shares concentration is observed, as compared to the farming stage. In fact, only six processors account for about 80% of the total amount of cheese produced on the island (estimated at approximately 70,000 tons in 2010). A further significant feature of the processing stage concerns the presence of both cooperatives and private companies. The 25 cooperatives operating in Sardinia have, for a long time, played a crucial role in the region's socioeconomic development. Recently, however, they have begun to face some difficulties resulting from their statutory goal to ensure an adequate return to their members. This entails a low level of profitability, limited investments, and limited innovation capabilities. As for private processing firms, their combined market share is estimated at approximately 60% of the total cheese production. Private firms have

shown substantial vitality and a reduced rate of cessation over the past 10 years. The capitalist nature of such companies and their purpose of maximizing profits and returns on invested capital favor investment plans targeting a continuous modernization of production processes. The hierarchical and top-down components of these organizations also allow for a more streamlined management of strategic operations and production.

Despite the variety of dairy products available, Protected Designation of Origin (PDO) cheeses hold the largest market share. These include Pecorino Romano, Pecorino Sardo, and Fiore Sardo. Among them, Pecorino Romano has become the leading product in terms of both the value of production (over 60% of the total cheese production in Sardinia) and exports. Pecorino Romano is, in fact, the third most exported Italian cheese, following Parmigiano Reggiano and Grana Padano. The USA is the main export destination, where it is used mostly as an ingredient by the food industry. The PDO consortia also play a crucial role downstream in the supply chain, particularly in the processing stage, as 66 processors are members of the consortia. Although most milk transactions today are formalized between farmers and processors by contracts that are based exclusively on the parameters of price and quantity (i.e., issues of quality are not included), important differences exist between processing cooperatives and private industrial processors. Private companies usually impose closed contracts in which prices are determined; alternatively, the price of milk may be set at the beginning of the marketing year. Private industrial processors are, in fact, in a privileged position because they have access to a range of information about markets, and they possess greater bargaining power because of their large market shares. However, these processors also assume most of the risk by bearing potential losses due to negative weather conditions or unexpected events, as there is no contractual provision of risk sharing. In contrast, cooperative processors establish the price only *ex-post* or during the profits distribution process, thus shifting the risk completely to their members.

Examples of positive relationships between operators include those wherein cooperatives provide their members with technical assistance or inputs such as feed and labor and those wherein individual processors take part in farm management decisions or offer services such as milk-quality analysis to their suppliers.

The performance of the whole supply chain has changed significantly over the last 50 years. For a long time, sheep farming was a subsistence activity in Sardinia. However, this condition changed during the 1970s, when the price of sheep products increased, driven mainly by the development of high-quality cheeses, especially the Pecorino Romano Protected Designation of Origin (PDO).

For a long period thereafter, stable consumer preferences, long-standing trade agreements, and the consolidated Pecorino Romano brand ensured favorable market conditions for both farmers and processors, both in the domestic and foreign markets.

Starting from 2008, both cheese and milk price started to suffer the unfavorable conditions on foreign markets, mostly due to the financial crisis and the competition of other cheaper cheeses in the USA. Later in 2015, the recovery in consumption and the evolution of the euro/dollar exchange rate stimulated the US demand for imported cheeses in general and, in particular, for Pecorino Romano, whose export value increased by 20% over the previous year. Since this trend provided a strong incentive for farmers to expand milk production, processors forecasted a strong oversupply and renegotiated milk price during the campaign.

While oversupply has been confirmed, there is still no objective and shared assessment of its size. The lack of information and trust is often pointed out as the main reason for the failure of supply chain coordination that still leads to very low milk prices (ranging from 0.50€/lt to 0.65€/lt), thus jeopardizing the economic sustainability of many small family farms.

Despite these problems, this sector has been the topic of few studies, with the large majority of them focusing almost exclusively on the issues of production, technical efficiency, and profitability (Rancourt and Carrère 2011; Frendi et al. 2011; Furesi et al. 2013; Mantecón et al. 2009; Milàn et al. 2011; Toussaint et al. 2009), whereas to our knowledge, little attention has been paid to relational aspects within the supply chain in the economic literature.

In light of these considerations, this paper evaluates the determinants and effects of relational governance on firm performance in agri-food chains. More precisely, it investigates the factors affecting inter-organizational relationships and governance and assesses the influence that the current conditions of vertical coordination and collaboration have on the economic performance of firms in the traditional dairy sheep supply chain in Sardinia (Italy).

The methodological approach of the study is described in the “[Methods](#)” section, including the formulation of a set of research hypotheses (“[Research hypotheses](#)” section) and the collection and treatment of empirical evidence by means of a direct survey (“[Data and measures](#)” section). The “[Results and discussion](#)” section presents and discusses the results of the model estimations. Finally, we provide some concluding remarks (“[Conclusions](#)” section) and some considerations concerning the limitations of the study and future research prospects (“[Limitations of the study and prospects for future research](#)” section).

Methods

The methodology adopted follows a structural equation modeling (SEM) approach and includes the following steps.

First, based on both a critical review of the relevant literature and interviews conducted with a panel of experts in the Sardinian dairy sheep supply chain (i.e., regional authority officers, presidents of PDO consortia, and members of trade associations), we formulated three sets of research hypotheses, targeting the relationships between the three groups of exogenous factors (namely environmental conditions, product characteristics, and producer-processor relationships) and the two main variables of interest, i.e., relational governance and firm economic performance.

As a second step of the analysis, we set up a questionnaire assessing all the relevant factors included in the research hypotheses and carried out a direct survey of 96 firms in the dairy sheep supply chain in Sardinia to empirically test their relationships.

As a third step, an exploratory factor analysis (EFA) was conducted to determine what items should be included in the models and to assess the number and the validity of the underlying multidimensional constructs.

Then, we framed and estimated a SEM per each set of hypotheses formulated following a linear structural relation approach (Jöreskog and van Thillo 1972). Specifying the model followed an iterative process based on theoretical and empirical analyses until the structural model fit was positively tested.

Research hypotheses

The basic research hypotheses formulated in this study concern the causal relationship between a number of exogenous factors and the types of relational governance adopted by farmers and their economic performance.

Relational governance (i.e., the governance of dyadic relationships) in the supply chain can be defined as the set of practices and behaviors that both sides adopt in order to achieve common goals and to ensure stable relationships (Carr and Pearson 1999). More precisely, relational governance refers to the intermediary mode between market and hierarchy for coordinating various economic activities within the supply chain (Claro et al. 2003), and it is evidenced by mechanisms that can be either (a) relational or (b) transactional in nature (Liu et al. 2009). On the one hand, relational mechanisms (a) focus on the roles of social interactions in economic activities. They also govern exchanges through social standards of expected behaviors that prevent the need for, and are more effective than, purely authoritarian relationships. In fact, social mechanisms have been recognized as effective in controlling opportunism and constructing cooperative behavior in buyer-supplier relationships, especially in local production systems (Granovetter 1992) where social cohesion is strong and where less formal contractual arrangements can be effectively adopted, granting flexibility and reducing transaction costs (Farrell 2005).

On the other hand, transactional mechanisms (b) involve bilateral contractual clauses and specific investments that complement each other, since contracts specify conditions and governance measures that are not covered specifically in investments, whereas specific investments provide extra-economic incentives for an on-going relationship that may not be included in contracts.

The definition and measurement of economic performance has been extensively studied in the economic literature.

Based on the findings of previous research, there is a shared consensus about the expected positive influence of relational governance on performance, thanks to the reduction of transaction costs entailed by interpersonal trust, joint planning, and problem solving (Claro et al. 2003; Zaheer et al. 1998).

The most commonly used indicators of business performance in the context of supply chain management include market data (e.g., selling prices, market shares, etc.), efficiency or financial data (e.g., costs, profit, return on assets, return on sales, etc.), product quality (including sensory properties, shelf life, safety, and convenience), and responsiveness (customer service levels, lead time, etc.) (Aramyan et al. 2007; Kannan and Tan 2005; Zaheer et al. 1998).

According to various contributions in the economic literature, firm size is also an important factor affecting both the type of governance of supply chain dyadic relationships and firm economic performance. The firm size-economic performance relation shows ambiguous results where the size of the firm can positively influence the chain performance due to scale economies (allocative efficiency) while smaller firms can provide a more efficient input use (technical efficiency) (Gereffi et al. 2008; Aramyan 2007).

Three further relevant groups of factors affecting the type of governance adopted and firm economic performance are pointed out in the literature reviewed. These include the following: (i) environmental conditions, (ii) product features, and (iii) relationship among actors.

The environment in which the company operates has significant effects on how it competes and cooperates with other firms within the supply chain. In this regard, Fontana and Caroli (Fontana and Caroli 2003) offer an interesting descriptive model of the environment, articulating the study at three different levels of analysis: extended environment, competitive environment, and business-specific environment. The extended environment represents the complex of conditions and subjects that characterize the wider reality of the firm (i.e., the institutional environment). The competitive environment consists of actors and conditions that directly affect the strategic and operational behavior of the firm. The specific environment represents the factors directly relevant to a particular business area. Firms' relationships are shaped according to the conditions that characterize the environment at different levels. These conditions can be grouped into four general categories: economic condition, technological condition, institutional political condition, and socio-cultural condition.

According to Claro et al. (2003), the characteristics of the environment in which the agri-food chain operates affect its competitive and relational characteristics and identify relationships that the firm establishes with external actors in the accomplishment of its economic activities. In this respect, particular attention is to be paid to technological conditions, the role of associations, and the terms of access to credit (Hobbs and Young 2000).

In light of these considerations, we formulated the following first general research hypothesis:

H1 environmental variables affect both the type of relational governance and the economic performance of firms.

Given the peculiar traits of the supply chain targeted in this study, the first general research hypothesis is broken down into the set of specific research hypotheses described in Table 1.

A second important dimension affecting both the type of governance of supply chain dyadic relationships and the economic performance of firms according to various contributions in the economic literature relates to product characteristics.

Hobbs and Young (2000) and Hunt et al. (2005) evaluated the complex system of interdependence and inter-organizational relationships within agri-food networks, where product characteristics (quality, safety, differentiation, etc.) are introduced as a main factor affecting vertical coordination and supply-chain performance. A further interesting contribution in this direction was provided by Han et al. (2011), who investigated the relationship between quality management practices and the degree of vertical integration.

Fisher (1997) provides a detailed analysis of the impact that the characteristics of products have on the choice of strategies to be adopted in the supply chain. More precisely, the author suggests that the most appropriate supply chain strategy for functional products (with predictable demand) would be the pursue of physically efficient processes, whereas in case of innovative products (with unpredictable demand), supply chain should pursue market-responsiveness.

In fact, lifestyle changes in the recent decades and the new technologies available have induced companies to adapt their supply in order to meet new consumer

Table 1 Research hypotheses investigating the effects of environmental conditions on relational governance and firm economic performance

HP code	Exogenous variable		Endogenous variable	HP description
H1.1	Governance	→ (+)	Milk price	More formal types of governance are associated with better economic performance of farms, i.e., higher milk prices
H1.2.1	Firm size	→ (+)	Governance	Larger firms are more likely to adopt more formal types of governance in their relation with processors
H1.2.2	Firm size	→ (+)	Milk price	Larger farms are more likely to obtain higher prices for their milk
H1.3.1	Technology	→ (+)	Governance	Breeders using modern technologies are more likely to adopt more formal types of governance in their relation with processors
H1.3.2	Technology	→ (+)	Milk price	Breeders using modern technologies are more likely to obtain higher prices
H1.3.3	Technology	→ (+)	Firm size	Breeders using modern technologies are more likely to run larger farms
H1.4.1	Association	→ (+)	Governance	Breeders appreciating the support of trade association are more likely to adopt less formal types of governance in their relation with processors
H1.4.2	Association	→ (+)	Milk price	Breeders appreciating the support of trade association are more likely to obtain higher prices
H1.4.3	Association	→ (+)	Firm size	Breeders appreciating the support of trade association are more likely to run larger farms
H1.5.1	Credit	→ (+)	Governance	Breeders appreciating the financial support of banks are more likely to adopt more formal types of governance in their relation with processors
H1.5.2	Credit	→ (+)	Milk price	Breeders appreciating the financial support of banks are more likely to obtain higher prices
H1.5.3	Credit	→ (+)	Firm size	Breeders appreciating the financial support of banks are more likely to run larger farms

preferences (Molnár et al. 2011). This is particularly important in the agri-food industry, where features such as origin, quality, and safety play an important role and depend largely on the technologies used in the production process (Aramyan et al. 2007).

Based on these arguments, we formulate the following second general research hypothesis:

H2 the product features affect both the type of relational governance and the economic performance of firms

Given the peculiar traits of the supply chain analyzed, the second general research hypothesis is broken down into the set of specific hypotheses described in Table 2.

The third dimension considered as an antecedent for relational governance and economic performance of firm relates to producer-processor relationships.

Handfield and Bechtel (2002) made an important contribution on this issue by stressing that the management of relational forms of governance based on trust leads to substantial improvements in the responsiveness of the entire supply chain, thereby improving lead time and, consequently, the performance of all the parties involved.

Cai et al. (2009) demonstrated the beneficial effect of collaborative practices on the performance of agents involved in quasi-integrated forms of coordination.

Table 2 Research hypotheses investigating the effects of product features on relational governance and firm economic performance

HP code	Exogenous variable		Endogenous variable	HP description
H2.1	Governance	→ (+)	Milk price	More formal types of governance are associated with better economic performance of farms, i.e., higher milk prices
H2.2.1	Firm size	→ (+)	Governance	Larger firms are more likely to adopt more formal types of governance in their relation with processors
H2.2.2	Firm size	→ (+)	Milk price	Larger farms are more likely to obtain higher prices for their milk
H2.3.1	Quality	→ (-)	Governance	Breeders producing milk of higher quality are more likely to adopt less formal types of governance in their relation with processors
H2.3.2	Quality	→ (+)	Milk price	Breeders producing milk of higher quality are more likely to obtain higher prices
H2.3.3	Quality	→ (-)	Firm size	Breeders producing milk of higher quality are more likely to run smaller farms
H2.4.1	Safety	→ (+)	Governance	More frequent milk safety tests are more likely to occur within more formal types of governance in breeder-processor relationships
H2.4.2	Safety	→ (+)	Milk price	More frequent milk safety tests are more likely to be associated with higher milk prices
H2.4.3	Safety	→ (+)	Firm size	More frequent milk safety tests are more likely to be performed for larger farms
H2.5.1	Local origin	→ (-)	Governance	Breeders oriented towards products and processes of local origin are more likely to adopt less formal types of governance in their relation with processors
H2.5.2	Local origin	→ (+)	Milk price	Breeders oriented towards products and processes of local origin are more likely to obtain higher prices
H2.5.3	Local origin	→ (-)	Firm size	Breeders oriented towards products and processes of local origin are more likely to run smaller farms

Nyaga et al. (2010) showed that collaborative activities, such as information sharing, joint report of efforts, and dedicated investments, create trust and involvement that generate satisfaction and improve performance.

Furthermore, Narasimhan and Nair (2005) showed that geographical proximity is a key factor in the creation of forms of governance, such as strategic alliances, that have a positive impact on the financial performance of companies. According to Buvik and Reve (2002), relational links ensure the best performance for both partners in terms of sharing communication and maintaining long-term relationships with suppliers. The relevance of geographical proximity in influencing local production system competitive performances is at the core of a vast body of literature related to clusters or industrial districts (Marshall 1920); Becattini 1989; Porter 1998) and in particular the work of Farrell (Farrell 2005) where spatial proximity can generate efficient informal contractual relationships, mostly in Italian districts where the social cohesion is high and the legal system relatively inefficient.

Based on these arguments, we formulate the following third general research hypothesis:

H3 the characteristics of producer-processor relationships affect both the type of relational governance and the economic performance of firms

Given the peculiar traits of the supply chain targeted in this study, the second general research hypothesis is broken down into the set of research hypotheses described in Table 3.

Data and measures

The empirical evidence needed to assess the research hypotheses formulated was collected through a direct survey carried out by means of a questionnaire.

Given the regional scope of the analysis and the objectives of this study, we chose a judgment sampling approach. In order to select a sample of both farmers and processors actually related to each other in supply-chain transactions and given the importance of the PDO consortia described above, we chose to focus on the processing firms that are members of these consortia and on the farmers supplying them with milk. Drawing from the information provided by the PDO consortia, we invited all 66 processors within the regional PDO supply chain to participate in the survey. As for breeders, we chose to focus only on farms with at least 300 sheep. In fact, this threshold has been used in previous studies to designate small- or medium-sized enterprises that practice farming as their main agricultural activity (Idda et al. 2010). Applying this selection criterion to the breeders that supply milk to processors within the PDO consortia, we targeted a total of 497 farms. Finally, willingness to participate in the survey

Table 3 Research hypotheses investigating the effects of producer-processor relationship characteristics on relational governance and firm economic performance

HP code	Exogenous variable		Endogenous variable	HP description
H3.1	Governance	→ (+)	Milk price	More formal types of governance are associated with better economic performance of farms, i.e., higher milk prices
H3.2.1	Firm size	→ (+)	Governance	Larger farms are more likely to adopt more formal types of governance in their relation with processors
H3.2.2	Firm size	→ (+)	Milk price	Larger farms are more likely to obtain higher prices for their milk
H3.3.1	Trust	→ (-)	Governance	Breeders that trust their commercial partners are more likely to adopt less formal types of governance in their relation with processors
H3.3.2	Trust	→ (+)	Milk price	Breeders that trust their commercial partners are more likely to obtain higher prices for their milk
H3.3.3	Trust	→ (+)	Firm size	Breeders that trust their commercial partners are more likely to run larger farms
H2.4.1	Uncertainty	→ (+)	Governance	The higher the uncertainty perceived by farmers, the more they are likely to adopt more formal types of governance in their relationships with processors
H2.4.2	Uncertainty	→ (-)	Milk price	The higher the uncertainty perceived by farmers, the more they are likely to obtain lower milk prices
H2.4.3	Uncertainty	→ (-)	Firm size	The higher the uncertainty perceived by farmers, the more they are likely to run smaller farms
H2.5.1	Investment	→ (+)	Governance	Breeders who made investments to meet the needs of their commercial partners are more likely to adopt more formal types of governance in their relation with processors
H2.5.2	Investment	→ (+)	Milk price	Breeders who made investments to meet the needs of their commercial partners are more likely to obtain higher prices
H2.5.3	Investment	→ (+)	Firm size	Breeders who made investments to meet the needs of their commercial partners are more likely to run larger farms

was verified by telephone, with a 15.3% positive response rate from farmers (corresponding to 76 units) and 30.3% for processors (20 units), resulting in an overall sample size of 96 statistical units ($N = 96$).

The questionnaire was designed based on a literature review, prior case studies (Claro et al. 2003; Fischer et al. 2009), and also drawing from interviews with regional stakeholders (officers of the regional authority, representatives of PDO consortia, and members of trade associations).

The questionnaires were administered personally; this choice was due to the length and complexity of the structure of the questionnaire itself, which suggested the need to provide support for the interviewees. Prior to conducting the formal investigation, trial interviews were performed on 18 firms, and the final questionnaire was revised based on the results obtained.

The variables assessed and the measurement scales used in the questionnaire are displayed in Table 4.

The types of *relational governance* observed and included in the analysis range from spot market transactions to closer vertical integration. Despite being a latent variable, the *governance* construct coincides with the observable ways in which businesses establish their relationships with their partners in the supply chain, namely “verbal agreements,” “cooperative membership,” and “formal contracts”.

In order to measure the firm’s economic performance using a variable that the actors themselves consider correct and reliable, we refer to the milk price as a synthetic indicator.

The *performance* construct was measured by the average price of milk reported over the previous 2 years.

Following Claro et al. (2003), *firm size* was chosen as the control variable in order to assess its mediating role between governance and firm performance. More precisely, farm size was measured by the number of sheep, processor size was measured by the number of employees, and each was divided into three categories of small, medium, and large firms.

As far as the exogenous variables are concerned, the features of the *environment* identified as influential for the supply chain include technology, credit access, and membership in trade associations.

The items identified as influential within the *product characteristics* dimension are related to product local origin, safety, and quality.

Finally, the characteristics of *farmer-processor relationships* considered are trust in commercial partners, uncertainty, and relationship-specific investments.

Data collected have been processed with IBM SPSS 22.0 and AMOS 22.0 software.

First of all, EFA was conducted to determine what items should be included in the models and what items to discard when they did not load on the investigated dimension. The EFA was also performed to assess the number and the validity of the underlying multidimensional constructs. Finally, the Cronbach’s alpha index was used to assess the reliability of the emerging measurement scale. As a second step of the analysis, we framed and estimated a SEM per each set of hypotheses formulated. Specifying the model followed an iterative process based on theoretical and empirical analyses until the structural model fit was positively tested.

This way of handling the models aims to reduce the distinction between a confirmatory approach (only one model tested) and exploratory approach. Comparing several

Table 4 Items and scales used in the questionnaire

Variables	Items	Scale	Mean	St. Dev.
Governance	GOV What type of relation do you have with your commercial partners?	"1 = verbal agreements," "2 = cooperative membership," "3 = formal contracts"	1.95	0.77
Milk price	MLP What was the average price of milk in the last 2 years?	Quantitative/continuous	0.72	0.79
Firm size	SIZE What is the size of your firm (number of sheep)?	"1 = small," "2 = medium," "3 = large"	2.01	0.72
Dimensions				
Environment				
Technology	TECH <i>(Multi item, $\alpha = 0.75$)</i>			
	TECH1 What type of technology do you use in breeding?	"1 = manual", "2 = semi-automated", "3 = automated"	1.36	0.51
	TECH2 What type of technology do you use in milk production?	"1 = manual", "2 = semi-automated", "3 = automated"	1.31	0.49
Association	ASC Trade associations provide an excellent support for firms	Five-point Likert: from "1 = strongly disagree" to "5 = strongly agree"	2.77	1.34
Credit	CRE Banks provide an excellent financial support	Five-point Likert: from "1 = strongly disagree" to "5 = strongly agree"	1.90	0.88
Product				
Local origin	LOC <i>(Multi item, $\alpha = 0.76$)</i>			
	LOC1 I have a strong connection with Sardinian agricultural and sheep-rearing traditions	Five-point Likert: from "1 = strongly disagree" to "5 = strongly agree"	4.39	0.80
	LOC2 I use production methods arising from the local cultural context	five-point Likert: from "1 = strongly disagree" to "5 = strongly agree"	4.36	0.85
Safety	SAFE My commercial partners perform regular milk quality tests	Five-point Likert: from "1 = never" to "5 = always"	4.66	0.61
Quality	QUA <i>(Multi item, $\alpha = 0.95$)</i>			
	QUA1 Milk is produced with wild breeding	Five-point Likert: from "1 = never" to "5 = always"	4.35	1.11
	QUA2 Milk produced with wild breeding is of superior quality	Five-point Likert: from "1 = strongly disagree" to "5 = strongly agree"	4.45	0.98

Table 4 Items and scales used in the questionnaire (Continued)

Variables	Items	Scale	Mean	St. Dev.
Relationship				
Trust	TRU	<i>(Multi item, $\alpha = 0.94$)</i>		
	TRU1	My commercial partners provide correct information	Five-point Likert: from "1 = strongly disagree" to "5 = strongly agree"	3.63 1.17
	TRU2	My commercial partners fulfill their promises	Five-point Likert: from "1 = strongly disagree" to "5 = strongly agree"	3.59 1.25
Uncertainty	UNC	I know in advance the price of milk	Five-point Likert: from "1 = strongly agree" to "5 = strongly disagree"	2.23 1.45
Investments	INV	I made investments to meet the needs of my commercial partners	Five-point Likert: from "1 = strongly disagree" to "5 = strongly agree"	2.05 1.56

models and/or the existence of equivalent models improves the fit of the structural model to empirical data or to the theory that underlies it. Indexes exist to identify variables that are worth the effort of re-specification. Indeed, it is possible to add or withdraw paths based on empirical criteria (de Marco et al. 2009).

Many absolute and incremental fit indices exist, and to date, a consensus has not been reached regarding which should be reported or what normative threshold standards should be considered (Chin et al. 2008; Hooper et al. 2008).

The former group of indicators includes the following statistics: the chi-square fit test index (CMIN/DF), the normed fit index (NFI), the comparative fit index (CFI), and the root mean square error of approximation (RMSEA).

The chi-square index tests whether an unconstrained specified model fits the covariance/correlation matrix as well as the empirical data. A problem with this test is that the larger the sample size, the more likely it is for the model to be rejected. For these reasons, the chi-square fit test (CMIN/DF) adjusts the chi-square index for the degrees of freedom. Values as large as five are accepted as an adequate fit, but more conservative thresholds are two or three (Arbuckle 2009). The NFI and CFI vary from 0 to 1 and are derived from a comparison of the hypothesized model with the independent model; however, a major drawback to this index is that it is sensitive to sample size, as it underestimates fit for samples of less than 200 units (as in this case). Hence, it is important to calculate the CFI, a revised form of the NFI, which takes into account sample size and is considered to perform well even when the sample size is small (Hooper et al. 2008).

The RMSEA incorporates a discrepancy function criterion (comparing observed and predicted covariance matrices) and a parsimony criterion; it should be less than or equal to 0.05 (0.08) for a good (adequate) model fit (Hu and Bentler 1999).

Results and discussion

The performed EFA suggests that the majority of items load on the appropriate dimensions under investigations, supporting the specification of the three different models (Table 5).

Table 5 Results of the exploratory factor analysis (EFA)

	Product	Relationship	Environment	
QUA1	0.876	0.133	- 0.027	- 0.235
QUA2	0.853	0.203	- 0.025	- 0.272
LOC1	0.826	0.196	0.008	0.109
LOC2	0.783	0.059	- 0.153	0.033
TRU1	0.205	0.877	0.088	0.144
TRU2	0.029	0.868	0.001	0.249
UNC	- 0.051	- 0.785	0.230	0.414
INV	0.077	0.227	0.782	0.087
TECH1	- 0.373	- 0.041	0.655	0.284
TECH2	- 0.577	0.004	0.622	0.258
SAFE	- 0.010	0.183	- 0.575	0.145
CRE	- 0.132	- 0.035	0.238	0.852
ASC	- 0.089	0.268	- 0.108	0.765

Extraction method: principal component analysis
 Rotation method: Varimax with Kaiser Normalization
 Rotation converged in 6 iterations

Moreover, in order to improve the fit of the three structural models to empirical data, some variables (and the related paths and parameters) that were worth the effort of re-specification were withdrawn according to indexes of modification (e.g., standardized residues of the covariance matrix).

The results of the estimation of the three SEMs are presented in the following figure and tables. The first three hypotheses considered, concerning the relations between the type of relational governance and milk price, as well as the mediating effect of firm size, show a quite consistent pattern in each model.

Quite interestingly, contrary to our expectations (H1.1, H2.1, H3.1), we observe a negative effect of *governance* on *milk price*. However, given the specific characteristics of the context analyzed, this result can be easily explained as it shows how less formal contractual arrangements can positively influence the contractual relationship in favor of milk producers.

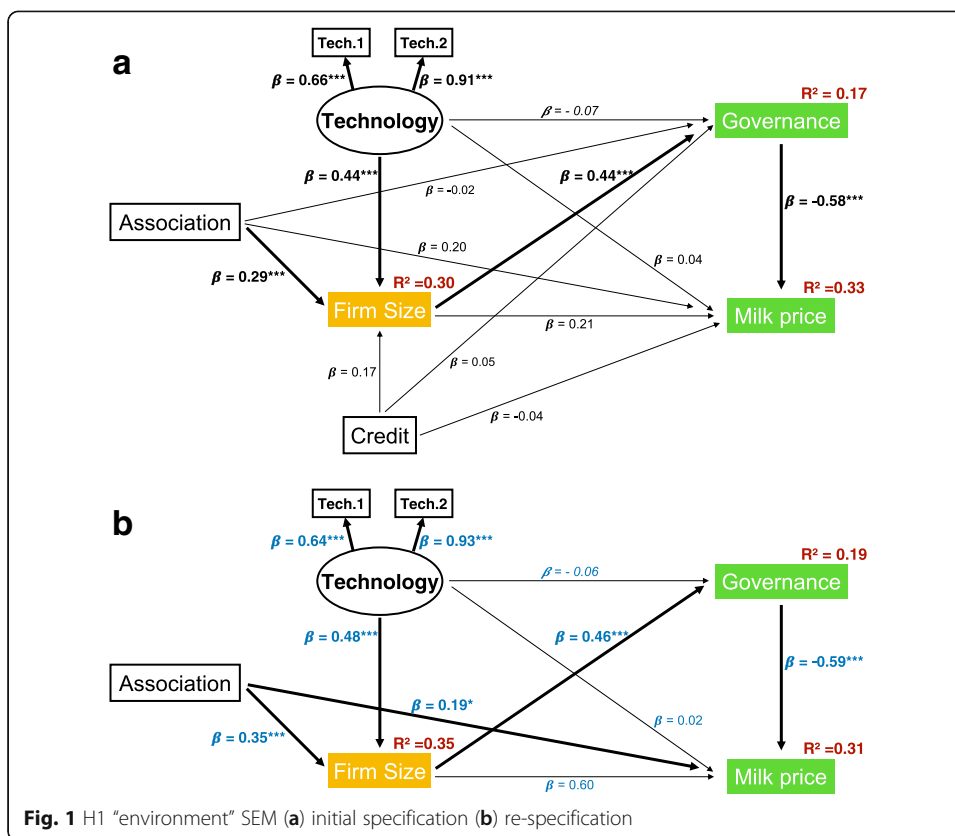
The *firm size* positive relation with *governance* supports the assumption formulated (H1.2.1, H2.2.1, H3.2.1) suggesting a more widespread adoption of formal contracts between large farms and traders operating outside the local market boundaries, where the spatial proximity influence on the efficiency of informal contractual arrangements does not apply.

The expected positive relation between *firm size* and *milk price* is confirmed only when considering the influence of the *product* dimension (H2.2.2).

The results of the first model assessing the effect of the dimension “environment” are displayed in Fig. 1 and Table 6.

The positive relation between *technology* and *firm size* confirms the capacity of larger firms to adopt more sophisticated and expensive technologies and more easily relate to the financial system (H1.3.3).

The positive relation between *association* and *milk price* (H1.4.2) on the other hand shows an expected positive influence of external economies of scale (joint access to market) on the firms’ bargaining power.



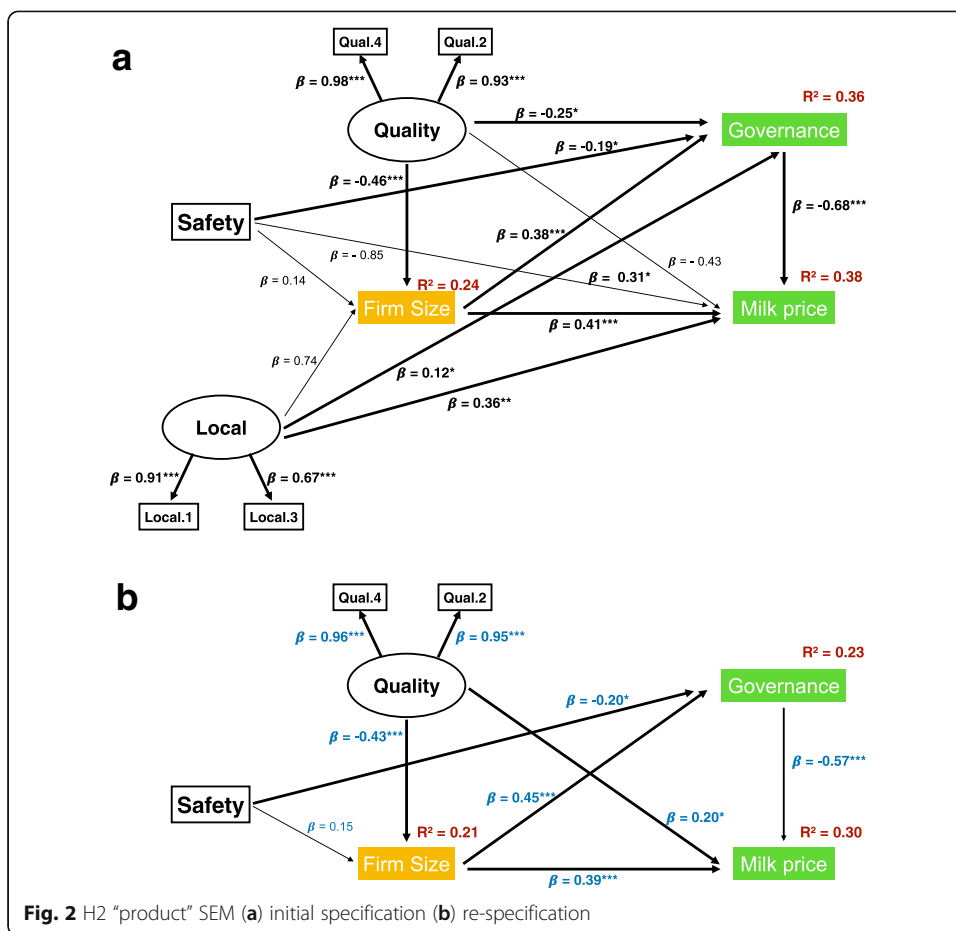
The positive relation between *association* and *firm size* supports the hypothesis formulated (H1.4.3), and it can be explained by the relatively higher managerial skill and less conservative/individualistic attitude of larger firm owners.

It remains to be understood whether the large-sized companies, more frequently members of associations, are also characterized by a prevalence of informal contractual arrangements.

The results of the second model assessing the effect of the dimension "product" are displayed in Fig. 2 and in Table 7.

Table 6 H1 SEM model fit indicators

Indicator	Cut-off value	Calculated value
(a) Initial specification		
CMIN/DF	≤ 2.00 (Bagozzi and Yi 1988)	9.025
NFI	≥ 0.90 (Byrne 1994)	0.692
CFI	≥ 0.90 (Byrne 1994)	0.695
RMSEA	≤ 0.08 (Hu and Bentler 1999)	0.291
(b) Re-specification		
CMIN/DF	≤ 2.00 (Bagozzi and Yi 1988)	1.506
NFI	≥ 0.90 (Byrne 1994)	0.949
CFI	≥ 0.90 (Byrne 1994)	0.981
RMSEA	≤ 0.08 (Hu and Bentler 1999)	0.073



The negative relation between *quality* and *firm size* (H2.3.3) could be explained following the findings of Aramyan (Aramyan 2007) where the smaller firms’ capacity to provide a more efficient input use (technical efficiency) could also translate in a better product’s quality.

The negative relation between *safety* and *governance* contradicts our original assumption (H2.4.1). However, it is consistent with the idea that more informal contractual

Table 7 H2 SEM model fit indicators

Indicator	Cut-off value	Calculated value
(a) Initial specification		
CMIN/DF	≤ 2.00 (Bagozzi and Yi 1988)	6.220
NFI	≥ 0.90 (Byrne 1994)	0.804
CFI	≥ 0.90 (Byrne 1994)	0.822
RMSEA	≤ 0.08 (Hu and Bentler 1999)	0.234
(b) Re-specification		
CMIN/DF	≤ 2.00 (Bagozzi and Yi 1988)	1.594
NFI	≥ 0.90 (Byrne 1994)	0.963
CFI	≥ 0.90 (Byrne 1994)	0.985
RMSEA	≤ 0.08 (Hu and Bentler 1999)	0.079

arrangements, related to local markets characterized by higher social cohesion and control, can positively influence the products' safety.

Finally, the results of the second model assessing the effect of the dimension "product" are displayed in Fig. 3 and in Table 8.

Trust is negatively related to the level of formalization of the contractual relationship, thus confirming our original assumption (H3.3.1) and the findings of Farrell (Farrell 2005) stating that in local production (and consumption) systems characterized by social cohesion and a relatively inefficient legal systems, informal contractual arrangements are more efficient than formal contracts.

The positive relation between *trust* and *firm size* (H3.3.3) can be explained by the possibly more efficient management of both technical and administrative relations between farmers and processors/traders and larger farmers.

The same positive influence emerged when considering *trust* and *milk price*, as we expected (H3.3.2).

Conclusions

This study assessed the causal relationships between the type of relational governance adopted by farms and their economic performance, considering the influence of the three exogenous dimensions: environment, product characteristics, and producer-processor relationships in agri-food supply chains.

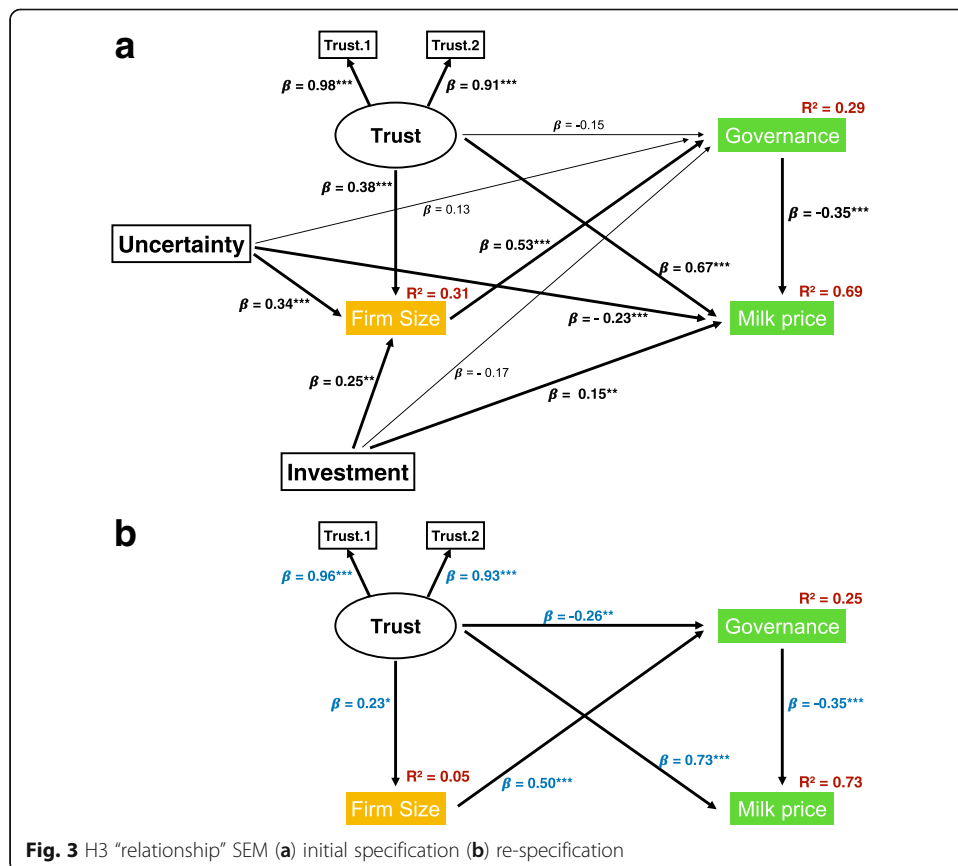


Fig. 3 H3 "relationship" SEM (a) initial specification (b) re-specification

Table 8 H3 SEM model fit indicators

Indicator	Cut-off value	Calculated value
(a) Initial specification		
CMIN/DF	≤ 2.00 (Bagozzi and Yi 1988)	5.296
NFI	≥ 0.90 (Byrne 1994)	0.889
CFI	≥ 0.90 (Byrne 1994)	0.905
RMSEA	≤ 0.08 (Hu and Bentler 1999)	0.213
(b) Re-specification		
CMIN/DF	≤ 2.00 (Bagozzi and Yi 1988)	0.972
NFI	≥ 0.90 (Byrne 1994)	0.990
CFI	≥ 0.90 (Byrne 1994)	1.000
RMSEA	≤ 0.08 (Hu and Bentler 1999)	0.000

The estimations obtained for the traditional dairy sheep supply chain in Sardinia confirm the relevance of most of the relationship assessed under each of the three exogenous dimensions.

The results concerning the relations between the type of relational governance and milk price, as well as the mediating effect of firm size, show a quite consistent pattern in each model.

Quite interestingly, contrary to our expectations, we observe a negative effect of *governance* on *milk price*. However, given the specific characteristics of the context analyzed, this result can be easily explained as it shows how less formal contractual arrangements can positively influence the contractual relationship in favor of milk producers. This result is in line with the findings of Farrell (Farrell 2005) who pointed out that in local production (and consumption) systems characterized by social cohesion, informal contractual arrangements are more efficient than formal contracts.

Another interesting result concerns the expected positive relation between *firm size* and *milk price* that is confirmed only when considering the influence of the *product* dimension.

Overall, the most important environmental factors are technological endowments and association; on the other hand, product features are determined mostly by quality and safety, whereas the relationships are affected mostly by trust.

Relational models in economic theory highlight the importance of trust as a key variable for attaining collaborative relationships and mutual benefits for the parties involved. The study conducted provides further evidence in support of this assumption and suggests that the development of successful cooperation in the Pecorino Romano DOP supply chain in Sardinia is hindered by a lack of trust in farmer-processor relationships.

This calls for a total rethinking of the relationships within the sector, particularly between farmers and processors, who should abandon any conflicts and pursue collaborative efforts. From this perspective, appropriate measures to improve the economic performance of the sector would entail a redefinition of product quality and marketing strategies. The Consortium of Pecorino Romano has already proposed interesting guidelines for repositioning the product on the market by means of quality incentives, organic production, and product differentiation according to aging. Such a repositioning process would also be aided by the implementation of stronger vertical

coordination along the supply chain aimed at distributing appropriate returns for both farmers and processors. The method of determining the price should be revised accordingly, for example, with the development of an inter-professional agreement.

Limitations of the study and prospects for future research

Even though the models adopted and the estimations performed provided satisfactory results, the overall interpretative capacity of this study is hindered by the empirical evidence available. More precisely, we acknowledge that the sample surveyed has two main limitations.

First, it cannot be considered fully representative of the sheep breeding activity in Sardinia. This is not so much due to the overall number of observations gathered, that is comparable to that of previous studies (Idda et al. 2010; Mantecón et al. 2009; Milán et al. 2011; Riveiro et al. 2013). Rather, the limitation is due to the choice of cutting farms with less than 300 sheep off the sample. This choice was made to focus on enterprises practicing sheep breeding as their main agricultural activity and having structured relations with cheese manufacturers. However, it probably entails a partial representation of the sector, that is actually composed of many small family farms.

A second limitation concerns the need to reduce the number of variables in the models to meet statistical requirements, creating a risk of over-simplifying the phenomena investigated.

This is why future research should be conducted on larger and more representative samples, to provide more in-depth insights on further interesting factors, such as investments, uncertainty, and performance.

As far as investments are concerned, the economics of transaction costs and the supply chain management approach regard the specificity of assets as one of the most important variables in the analysis of strategic transactions and modes of governance. However, the results of the SEM estimation suggested that relationships among firms in the supply chain were not influenced significantly by specific investments, i.e., investments made to meet the requirements of the commercial partners. Hence, it would be interesting to understand the reasons underlying the lack of specific investments in this sector by deepening the theoretical analysis of the relative inter-organizational relationships and empirically assessing the relapses on the sector. In this regard, the resource-based view provides interesting elements that can be included in the conceptual framework (Wernerfelt 1995), whereas an empirical comparison of various contexts with similar competitive conditions could be useful for evaluating the role of specific investments in inter-organizational relationships.

Other issues that could be further developed in future research relate to uncertainty. In principle, uncertainty may refer to both the firms' behavior and the environmental context in which they operate. In the former case, uncertainty involves the firms' limited knowledge of the behavior of their competitors and partners, which raises the well-known risks of moral hazard. In the latter case, uncertainty implies the firms' limited knowledge of external changes, such as those in regulations and the market (e.g., consumption and competition). The decision to include only behavioral uncertainty in this study stems from the information gathered on the sector of interest, which indicates the existence of information asymmetries as well as considerably tense relationships between farmers and processors, despite relatively stable overall external conditions in

terms of consumer preferences, trade agreements, and sales trends. Hence, given the strength of the Pecorino Romano PDO brand, we chose to disregard environmental uncertainty and focus on relational uncertainty determinants and implications. However, we must acknowledge that the results obtained did not suggest a significant role for environmental uncertainty in the sector, probably due to new consumption patterns and the increasing market demand for quality. Thus, the inclusion of environmental uncertainty issues in future research could provide a new interpretive key for creating collaborative relationships in the dairy sheep supply chain in Sardinia as well.

A further consideration is that milk prices do not seem to be a variable that can convey the complexity of this sector. Hence, other factors should be considered to assess the economic performance of firms or, better, their relational performance. Furthermore, we could argue that performance measures should be carefully selected according to the specific supply chain and the life cycle stage of the product. As suggested by Aramyan et al. (Aramyan et al. 2007), these factors include not only efficiency and product quality but also responsiveness and flexibility. More precisely, in the case of agri-food products that have already reached their maturity stage (or initial decline), the performance of inter-organizational relationships is significantly determined by the availability and management of both tangible and intangible resources (e.g., knowledge, skills, and know-how) that can support the development of collaborative relationships and forms of governance with greater flexibility.

Authors' contributions

All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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