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Modelling asymmetric information in a food supply chain within Emilia Romagna Region

Francesca Minarelli¹, Francesco Galioto¹, Meri Raggi², Davide Viaggi¹

¹Department of Agricultural Sciences, University of Bologna

²Department of Statistical Sciences, University of Bologna



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1. Introduction

Asymmetric information occurs when parties involved in an economic transaction are not equally informed and does not allow society from enhance the resource first-best allocation. For many years, classic economic did not concentrated on asymmetries since the focus has been the understanding the theory of value (Laffont and Martimore, 2009). However, it remained unexplored how entrepreneur can succeed his profit maximization with its workers objectives having also the necessity of delegating tasks to other firm members. Theory developed by Marschank and Radner (1972) recognises the asymmetric nature of information and focuses on the enhancement of the optimal coordination by mean of a proper information management.

In traditional economic model, players are expected to have perfect information, in reality, this in the majority of the case does not occur. This approach in which actors have perfect information, have changed after Stigler's (1961) paper on the "Economics of Information" and the corresponding development of the research field of New Institutional Economics (NIE). It is well know how George Akerlof (1970) represented one of the pioneer in this field, by examining the consequences of asymmetric information in second hand car market.

Compared to Classical economical model, modern economies require a high rate of interaction among players. Therefore, there has been considerable development in the economics literature of contract design under asymmetric information over the last twenty years in several fields such as agro environmental scheme payments, chain relationships and food quality (Laffont and Tirole, 1993; Salanie', 1998; Laffont and Martimort, 2002). In particular, Antle (2001) stressed the fact that the food market is characterized by imperfect information with asymmetries allocated along the supply chain (Starbird et al., 2007) and which are responsible for a general increasing of costs during economic transactions (Bogetoft and Olesen, 2004). In particular, academics point out on the lack of information on quality, price and security that frequently occur in the transaction along the supply chain until the final consumer (Fernandez 2008).

Food sector by its nature is exposed to unknown characteristics. Quality and safety are in the majority of cases recognizable only after their consumption and so classified as experience or credence good. According to Nelson's classification (1970), experience good refers to attributes identified immediately only after purchasing and credence good refers to attribute that cannot be identified immediately neither after purchasing.

Based on the allocation of the information, in economic transaction two actors are distinguished: the Agent who has the information, and the Principal that make effort to know agent action or good characteristic sold by the agent. The consequences of asymmetric information are moral hazard (after contracting), when the action of the agent cannot be observed, and adverse selection (before contracting), when characteristics of the good is hidden to the principal. In the majority of cases in the food sector, the agent tries not to reveal the food quality characteristic and the efforts made by the principal to reveal hidden information determines distortion in the economic decision leading to inefficient results and the good exclusion from the market.

A case study reported by Gorton et al. (2006) shows how asymmetric information between farmers and processors could have led to milk market failure in Moldova due to the bad milk quality level and how the establishment of robust contract by the company Molmilk had solved the problem. In Moldova, during the Communist period farmers

were characterized by an high level of vertical integration. Privatization determined the break-up of large farms managed by the state and collective farms. The result was the livestock fragmentation. Some Milk processor companies such as Molmilk were forced to collect milk from small rural householders, which in many cases tended to cheat by adding water or lard to milk or passing contaminated milk. Additionally, many collecting stations in Moldova were not equipped with milk quality monitoring system. Therefore, in 1998, around 20% of milk provided by Molmilk from collecting stations was judged unusable. However, Molmilk had paid for the milk provided by rural household at the collecting stations and the damage jeopardized the company's survival.

After this, there has been a considerable and increasing attention on asymmetric information in economic literature over the last twenty years in several fields such as, agro environmental scheme payments, food quality and chain relationships years (Laffont and Tirole 1993; Salanie´ 1998; Laffont and Martimort 2002). In particular, modern economies are characterized by a high rate of interaction among players, which are more and more related to their information exchange conditions. Antle (2001) stressed the fact that the food market is characterized by imperfect information with asymmetries allocated along the supply chain (Starbird et al., 2007) and which are responsible for a general increasing of costs during economic transactions (Bogetoft and Olesen, 2004). The understanding of different economic and social conditions that affect actor collaboration along the supply chain is a key to boost the competitiveness of European agriculture. The solution of information asymmetries is part of this process.

The paper aims to report a review of asymmetric information issues affecting the agri-food chain and main solutions proposed and modeling approaches applied in economic literature to understand asymmetric information along the food supply chain.. This study, provides a list of modeling approaches adopted to solve the different asymmetric information problems addressed in literature between actors along the food chain

The main issues debated in academic literature are reported in the chapter Literature review, then some insight are reported on issues related to methodological aspects followed by discussion and conclusion.

2. Literature review: asymmetric information in the food supply chain

There is a stream of literature that focus on problems of asymmetric information related to food attributes, (Hobbs 2004, Starbird, 2007, McClusky 2000, Cooper and Ross 1985, Elbasha and Riggs 2003). They refer which refers to food safety and food quality, which in many cases are difficult to measure. Therefore, information concerning product safety and several quality aspects (such as ethical or environmental issues) are strongly asymmetrically placed along the supply chain (Starbird et al., 2007).

A critical point is that both quality and safety attributes within the agri-food sector are not always easy to be identified and observed in a conservative way (Holleran et al.1999) along all the agri food supply chain stages. In many case they are credence (food attributes that cannot be determined by consumer even after purchased) or experience (food attributes that can be determined just after purchased) type of attribute.

Food quality and safety have been a topic highly discussed in last 20 years. In particular, food safety because of several issues related to public health. Food quality can have two

meanings. It can be intended as characteristic that a good should meet, i.e. as specific technical attributes compliant to requirement or as a value i.e. the level of suitability to a specific use. In this latter case, the judgement is a subjective matter. Nowadays, the concept of quality is not only related to the efficiency and quality control but it is more oriented to a customer-oriented concept. The adding value of a product, and so the increasing of its quality level, depends on customer expectations. According to Lindgreen and Wynstra (2005) two values are distinguished, one related to buyer supplier relationship and another one to the customer value perception. As stated by Grunert (2005) the concept of quality and safety in agribusiness is mainly driven by actors of the market food chain. In particular, it is acknowledged that supermarket reflecting the customer needs have become the main actors in the food supply chain (Reardon et al., 2003). However, the perception of value is personal (Swartz, 2006) and because of its abstract nature, that referred to consumer beliefs, it is separated from concept such as attribute, norms that usually relate to objective food aspects.

Food supply chain is defined as a “network of food-related business enterprises” (Stevenson and Pirog, USDA, 2013). Therefore, it is characterized by a high level of interactions where the information exchange affect the success of the chain (Icasati-Johanson, 1999). One of the most important factor for the development of partnership among different actor of a supply chain is trust (Johnston, et al. 2004). In scientific literature, two broad approaches to the concept of trust are adopted: the economic and the social (Williamson, 1993; Lyons and Mehta, 1997). For most economists, in particular institutional economics, trust is assumed as opportunistic behaviour, with game theory modelling approach adopted to analyse interaction among agents. The social approach, explored by sociologists and anthropologists, focuses on the development and diffusion of trust in relationships. The classical approach in trust analyses the ways in which individuals are bound together and engaged in collaboration.

The present study does not address trust within supply chain in relation to asymmetries since more related to socio-anthropological approach/matter, Instead, the focus is on opportunistic behaviour under generated by asymmetric information with economic approach.

Some possible solutions are identified in literature to correct asymmetric information in the food supply chain. One consists in acquiring information; however, this implies costs that can increase with the improving information level of accuracy. The second one consists in the vertical coordination by means of contracts or vertical integration. The third option consists in the adoption of food standards, insurance, certification monitored by third parties. The last option is the regulation, when governance applies coordination schemes between private and public agents to promote the compliance of food operators in terms of food safety regulation (Nicita and Scoppa, 2005; Rouvière et al., 2012; Fernandez, 2012).

According to Stringer et al. 2007 the food supply change can be divided in the following stages: agricultural production, processing of raw material, industrial transformation, distribution, consumers (see fig.1). The figure 1 shows how different solution approaches can be allocated in different parts of the supply chain. In particular, supply chain is characterized by having a multiple stage agency interaction. In fact, farmers delegate

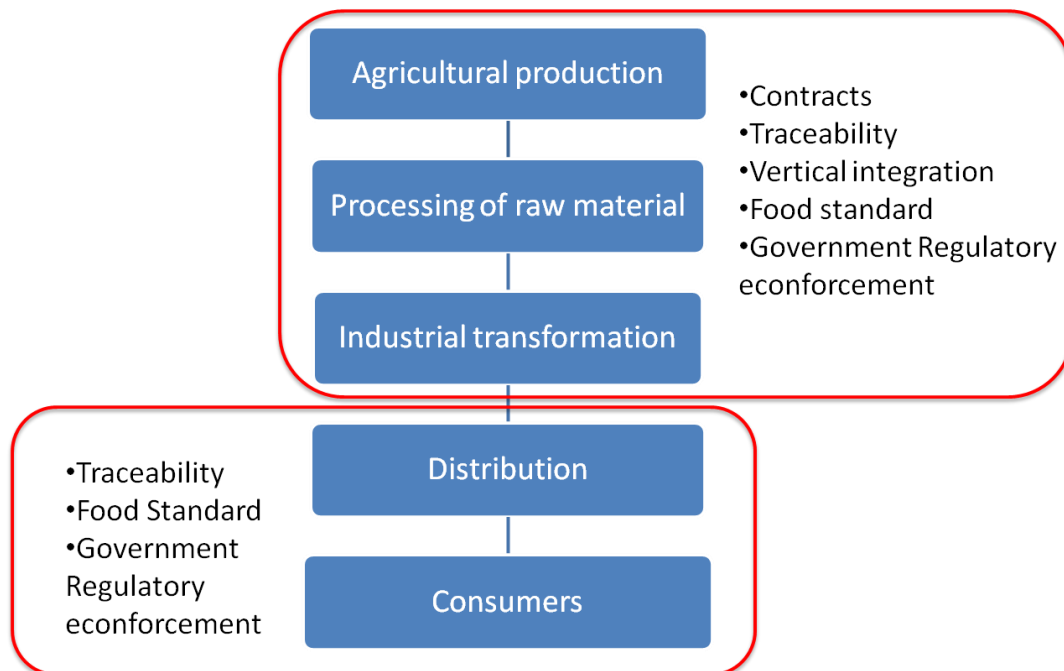
production to downstream processors and processors delegate the raw material production to farmers.

The application of the most suitable solution is based on the type of food attribute considered, (whether is a quality or a safety issue), asymmetries types (adverse selection or moral hazard) and based on the actors involved in the agri-food chain.

The first contract probably appeared in agriculture (Laffont and Martimort, 2002). There is an extended stream of literature on contracts in agriculture, most of them on developed countries (Bogetoft and Olsen, 2002; Goodhue et al., 2004; Fraser, 2005; Fernandez-Olmos, 2008) and few on Eastern European countries (Ferto, 2009; Bakucs, 2013). According to Bogetoft and Olesen coordination by means of contract allows to achieve an optimal production along the production chain.

The main advantages of engaging in contract is from the farmer side a shift of the risk an income stability and a market security. The disadvantages are recognized mainly in a reduction of flexibility in the management and possible penalization in price. For processors, contract solution allows to have stable provision in term raw material and quality.

Figure 1. Solution to asymmetries along agri-food chain highlighted in literature.



Source: author elaboration based on agri-food chain elaborated by Stringler et al., 2007.

Table 1- Main literature on asymmetric information along the agri-food chain.

PROBLEM	ASYMMETRY TYPE	PROPOSED SOLUTION	ATTRIBUTE	MODEL	SECTOR	ACTORS	REFERENCE	MAIN CONTENTS	FINDINGS	REFERENCE
Safety	adverse selection	Contract	Credence	Principal agent defines the bid price in order to segregate unsafe and safe producers	Agri-Food	Producer-Processor	Starbird 2007	2 types of producers: one with low contamination rate (safe producers) one with high contamination rate (unsafe producers) it is safe if meet gov. Standard Producers' capacity exceeds the processor's finite demand so demand can be satisfied by safe producers or unsafe producers.	Regulators: to act on cost failure. Processors: to help design contract that segregate unsafe and safe suppliers Producers: to determine if processor contract is appealing or not	Journal of agricultural and food industrial organization
Safety and quality	moral hazard	Traceability	Credence & Experience	Game Tree- model of ex ante quality verification system post traceability system to demonstrate different function of incentive	Agri-Food	Agri-food chain	Hobbs 2004	ex post traceability to trackback contamination problem ex post traceability used to test allocation liability ex ante traceability to detect experience attribute	Ex-ante traceability system with private market incentive is sufficient as quality verification function. Food Safety attributes require ex-post traceability system with government enforcement.	Agribusiness
Quality	adverse selection	Production contracts	Credence & Experience	Principal agent model to design a proper contract in order to maintain the IP	Wheat market (Identity preserved)	Producer / Processor	McChuskey 2000	The contract role in reducing asymmetric information in agrifood chain.	The Design of a proper contract between processor and IP wheat producer	Journal of food distribution research
Safety	moral hazard	Certification	credence	Game tree to determine the condition in which voluntary approach is adequate to guarantee protection toward consumer	Agri-Food	Agri-food chain	Segerson 1999	Test if voluntary monitoring system is adequate to guarantee consumer protection	For food quality attribute depends on the level of consumer awareness. For food safety attribute the role of government enforcement is essential	Agribusiness
Quality	moral hazard	Label/Monitoring	Credence & Experience	Game tree to define the necessary level of monitoring	Organic	Agri-food chain	McChuskey 2000	The study demonstrates that the minimum necessary level of monitoring depends upon the price of organic food and the discount rate. If the difference is high the probability to be caught must be high in order to compensate the large onetime benefit in cost reduction.	For experience attribute the voluntary system is sufficient (reputational aspect in repeated purchasing). For credence attribute the role of regulator is essential	Agricultural and resource economics

Source: author elaboration

Between academics, Hennessy (1995) stresses the importance of vertical integration as a solution to the increasing demand for safety food. In fact, vertical integration guarantees the disclosure of qualitative and technological food attributes which are problematic to achieve reducing testing cost. However, this solution does not find many applications in practice. In fact, on one side, there is a control of the overall production, but on the other side, there is a total shift of risk to the owner.

In matter of vertical coordination, Worley and McClusky (2000) recognize the important role of production contract. The PA model proposed in their paper, allows to segregates producers with desirable requirement. The model developed focuses on quality type of attribute. In particular, the model should allow the designing of a contract with authentic IP wheat producer. In a similar way, Starbird (2007) explores the role of contract design for food safe attribute. The paper proposes a model that allow segregating safe from unsafe producers based on the failure inspection cost and the bid price. If the bid price for safe contracts is lower than the bid price for unsafe contract, then the processor will chose for the safe contract, vice versa he will chose for the unsafe contract. This can happen when the cost of safety failure (called cost allocation factor) and the production cost is low. In this case, the processor will offer a bid price that segregates unsafe producers. In conclusion, the paper targets: regulator to improve and support traceability system by mean of appropriate cost allocation, producers to determine if processor contract is appealing or not and processors to help design contract that segregate unsafe and safe suppliers.

As previously stated, shifting from producers to the consumer side along the food chain the amount of information decreases. According to some academics, the only way to convey such type of information and so protect the consumer is the application of regulations such as traceability and food scheme certification. Among these, some interesting studies reported are Hobbs (2004), McClusky (2000) and Segerson (1999).

Traceability system has been introduced among possible solutions to asymmetries of food safety and quality attributes (Hobbs, 2004). Hobbs differentiates functions between ex-post and ex-ante traceability and identified a different impact on asymmetric issues. Ex-post traceability has impact on liability and externality costs. Ex ante has impact on quality verification. To test these impacts Hobbs adopts a game three model that allows observing different profit because of firm decisions in adopting traceability decisions and probability of actions imposed by Regulator. Hobbs provides also a traceability system taxonomy in which he suggests, based on the food attribute, the best traceability system. The main evidence from the study is that, for safety issues, the ex-post certification with strong government enforcement is essential, instead, for quality attribute, the ex-ante traceability can also work well imposing third party monitoring system toward firms upstream.

McClusky (2000) analyses traceability issue from the perspective of the consumer analysing problem of false organic food claim. Since organic is a credence type of attribute, the only way for the consumer to know that the product is not authentic is that after some purchases the producer is caught, making then false organic all future products. Once this event occurs, the consumer will not buy anymore that product in the future. The paper highlights the importance of monitoring level in order to prevent false claim and the reputational factor in the modelling approach. Moreover, when retailers and distributor are within the supply chain the organic food market often brings the cost of verifying organic claims, in order to provide required information to the consumer. The study demonstrates that the minimum necessary level of monitoring depends upon the price of organic food (the cost difference of producing organic versus non-organic) and the discount rate. If the difference is higher, the probability to be caught must be high in order to compensate the large onetime benefit in cost reduction. This can be applied to any quality attribute food. In particular, the conclusion underlines the importance of government in standardizes the requirement for organic product claims.

Segerson (1999) has been one of the first academic to analyse mandatory regulation versus incentives for voluntary approach identifying the condition in which a firm would adopt voluntary food safety standard. Findings shows that market can induce voluntary adoption for experience and search food. However, this condition is not suitable for credence food, where mandatory monitoring systems are required. In Table 1 an overview of the literature discussed above is reported.

Table 2. Solutions in response to asymmetry types from Literature review.

		Safety		Quality	
		Adv.Selection	Moral Hazard	Adv.Selection	Moral Hazard
Safety	Adv.Selection	Contract			
	Moral Hazard		Certification		
Quality	Adv.Selection			Production contract	
	Moral Hazard		Traceability		Monitoring systems

One of the main problem arising from Asymmetric information is the goal conflict between two players, the general modelling approach adopted by economics in literature to analyse asymmetries in food sector can be mainly attributed to a strategic game composed by a leader and a follower. As previously, stated, asymmetric information causes moral hazard, when agent undertakes hidden actions against principal after economic agreements, and adverse selection, when agent hides information on services or good before purchasing. Academics address the problem of hidden actions (moral hazard) by means of Principal Agent model approach offering incentives in order to prompt the agent to behave accordingly with the goal's principal. At the same way, adverse selection problems are approached with the same modelling approach that provides a menu of contracts that allow the identification of desired good or services or to aggregate suitable agents. Hence, modelling approaches adopted in literature to explore asymmetric problems come from Game theory. Specifically, in the food sector, academics adopt game tree to analyse problem of moral hazard related to certification or regulation along the food chain and principal agent model adapted from incentives theory Laffont and Martimore (2002) to analyse adverse selection problem (see Worley and McCluskey, 2000; and Starbird, 2007).

In this term, McClusky (2000) addresses the problem of the third party monitoring level necessary to ensure labelling integrity of organic product. Because of the experience and credence attributes, characterizing in food product the concept of one stage game is introduced. In fact, if the buyer and the seller interacts only one time there is a moral hazard from producer side since his goal is to produce at the lowest cost and then adverse selection occurs. If customer have repeated purchasing from producer, the hidden information is unravelled in the following purchasing act. To explore this dynamic a finitely repeated game is developed with standard game theoretic assumption. Therefore, because of the reputational factor due to the long-term relationship, monitoring is not necessary. The action of selling false claim is then prevented.

In table 2, the summary of solution approaches adopted in literature based on the asymmetric information type is reported. Starbird (2007) and Worley (2000) address the problem of asymmetries ex-ante related to adverse selection by means of contracts. With contract, they try to segregate safe/ IP wheat producers from unsafe/non-IP wheat producers. Instead, McClusky (2000), Segerson (1999) and Hobbs (2007) explore

asymmetries related to hidden action (moral hazard) which are addressed by mean of certification, product labelling and monitoring system (public or private).

3. Discussion and Conclusion: AI issues and modelling implications

The literature highlights different solution approaches, which one is the most suitable depends on specific case. In particular, in the case of quality attributes, more insights are necessary to evaluate which possible solution are better between actors at the beginning of the food chain, if contract or certification. Generally, when the main objective is to protect consumer by contamination that can cause serious illness i.e., when asymmetries are associated to externalities or public goods, the role of Government enforcement is essential (Nicita and Scoppa, 2005). Literature stresses out the essential role of institutions providing regulations and acting with penalty in case of non-compliance recognized. In other cases, where soft safety requirements are involved, different solution options can be considered depending on a mix of several aspects related to safety and quality attribute of the product.

McClusky (2000) adds the reputation as a factor that can limit cases of adverse selection and moral hazard. This is true in the case of long-term purchase relationship and for experience food only.

From the extensive literature review carried out emerges that problem of ex-ante asymmetries related to adverse selection are addressed by means of contracts while, ex-post asymmetries related to hidden action (moral hazard) are addressed by mean of certification and monitoring system (public or private). In term of modelling, the principal agent model adapted from Incentive Theory (Laffont and Martimort 2002) is applied to design proper contract able to segregate authentic claimers and then reduce adverse selection effect. Game tree are used to model the adoption of certification system and monitoring systems along the food supply chain in response to moral hazard.

The problem of information asymmetries affects all actors along the agri-food supply chain: farmers, wholesalers and retailers, processors, consumers, third parties (quality agencies) and public regulator. Literature tries in some case to explore asymmetric issues in separate blocks focusing on relationship between few actors, or attributes such as safety and quality.

It can be observed that literature on the topic of asymmetric information along the food supply chain in economic dedicated journal is not extended. Because of the multitude of actors, involved and multidisciplinary issues there are strong linkages with several other scientific fields besides economic one.

In regards to the methodological approaches, the primary role of research should be to understand and rationalize existing practice. In fact, often practitioner design contract without referring to contract theory. Based on these considerations a mix of theoretical based approach to reality and dissemination of information between different agricultural sectors should be carried out in order to improve contract design.

Papers on contract theory analyse one or at most a few problems. This approach is acceptable in order to stylized problems. However, this is a partial approach that is seems not sufficient to face the several issues existing in practice. As argued by Bogetoft and Olsen (2004) the complexity of real world of contracts should request a more systematic

approach able to consider all aspects of a contract simultaneously. It would be necessary to introduce more elaborated multi-dimensional production models (Bogetoft and Olesen, 2004) and to focus higher attention on actual institutional and regulatory settings.

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