Deliverable 3.2

Asymmetric information assessment on a selected value chain

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Summary

1. Introduction on TASK 3.2

The SUFISA project focuses on the identification of sustainable business strategies for primary producer that are affected by the imperfection of the market. It is known that market imperfections do not allow an efficient market working and resources allocation. As part of the SUFISA project, Work Package 3 aims to analyse the impact onf market imperfection in the efficiency and performance of farmers (objective 3 of SUFISA project).

Task 3.2 focuses on Assymetric information (AI). In the specific, this task includes two main actions:

1. **Expert based analysis** of the relevance of information asymmetries in the performance of agriculture value chains trough a Delphi exercise (15 experts EU-wide). As a background in preparation of this action, a consistent literature review on Asymmetric information along the food supply chain has been carried out.
2. **Modelling of the effects** of Asymmetric information on chain performance (for a selected value chain based on the case study selection in task 2.1).

The expert-based evaluation is intended to yield a simplified but broad evaluation, while the model provides higher detail on a specific case study. The model uses inputs from the expert-based evaluation, both to select priority issues and for identifying appropriate mechanisms.

With the term Asymmetric Information, we mean a situation in which the parties involved in an economic transaction have different levels of information related to the transaction, either related to the characteristics of the goods or services involved or to the actions taken by the other parties (Nicita et al. 2005; McCluskey, 2000). A classical example is a consumer not knowing some characteristics of a good she intends to buy, which are instead well known to the seller. Asymmetric informaton can negatively affect the market functioning and chain relationships and it is considered among causes of market imperfection, and can lead to a marke failure.

The Deliverable 3.2 has the aim to present the results of this activity wth a focus on a model of behaviour under asymmetric information for a selected supply chain. In particular, the modelling part aim to capture tha beahviour between a primary producer and an intermediate dealer such as a cooperative or or a producer association or a producer organization.

2. Literature review

2.1. General asymmetric information literature

Asymmetric information occurs when parties involved in a transaction are not equally informed; this does not allow society to achieve first-best allocation of resources. There has been a considerable increase in attention on asymmetric information issues in economic literature over the last twenty years in several fields, such as agro-environmental scheme payments, food quality and chain relationships (Laffont and Tirole, 1993; Salanie´, 1998; Laffont and Martimort, 2002). In traditional economic models, players are expected to have perfect information; in reality, this in the majority of the case does not occur and hence information asymmetry also affects the ability of models to represent real life situations. 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 hown George Akerlof (1970) represented one of the pioneer in this field, by examining the consequences of asymmetric information in second hand car market. 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 et al., 2004).

Based on the allocation of information, in economic transactions two actors are distinguished: the Agent who has the information, and the Principal that make effort to know the agent action or good the characteristic sold by the agent in order to provide incentives suitable to guide the agents to take decisions maximising the principal own utility. 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 or of the agent 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, leading, potentially, even to the good exclusion from the market.

2.2. Asymmetric information in the food supply chain

In particular, academics point out the lack of information on quality, price and safety that frequently occur in the transaction along the supply chain until the final consumer (Fernandez, 2008). Agri-food sector by its nature is exposed to unknown characteristics of the goods. Quality and safety are in the majority of cases recognizable only after their consumption and so classified as experience or credence good. In some cases, even consumpion does not allow to recognise some features a good, for example process information. 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. Many actions in terms of regulation and policies have been undertaken in order to control attributes in the food transactions, however there is still need to improve these conditions in order to achieve a more efficient and competitive market of European agriculture.

There is a stream of literature that focuses on problems of asymmetric information related to food attributes, (Hobbs, 2004; Starbird, 2007; McClusky, 2000; Cooper et al., 1985; Elbasha et al., 2003). These papers refer 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).

Food quality and safety are two different issues that have been highly discussed in the last 20 years. In particular, this applies to food safety because of several issues related to public health. 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 acknowledge that supermarkets, reflecting the customer needs, have become 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 concepts such as attribute, norms that usually relate to objective food aspects. The food supply chain is defined as a "network of food-related business enterprises" (Stevenson et al., 2013). Therefore, it is characterized by a high level of interactions, in which the information exchange affects the success of the chain (Icasati-Johanson, 1999). One of the most important factors 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 approach and the social approach (Williamson, 1993; Lyons et al., 1997). The present study does not address the trust within supply chain in relation to asymmetries since is more related to a socio-anthropological approach.

2.3. Solutions identified in literature

Some possible solutions are identified in academic literature to correct asymmetric information in the food supply chain. One consists in acquiring information; however, this implies costs that can increase with improving the level of accuracy of the information collected. A second one consists in the vertical coordination by means of contracts or vertical integration. Another option consists in the adoption of food standards, insurance, certification monitored by third parties. In addition, also Regulation is possible, in which governance applies coordination schemes between private and public agents to promote the compliance of food operators in terms of food safety regulation; it represents a strong instrument to reduce source of information failure (Nicita et al., 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 (Figure 1) . In particular, supply chain is characterized by having a multiple stage agency interaction. Figure 1 shows how different solutions can be allocated in different parts of the supply chain.

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.

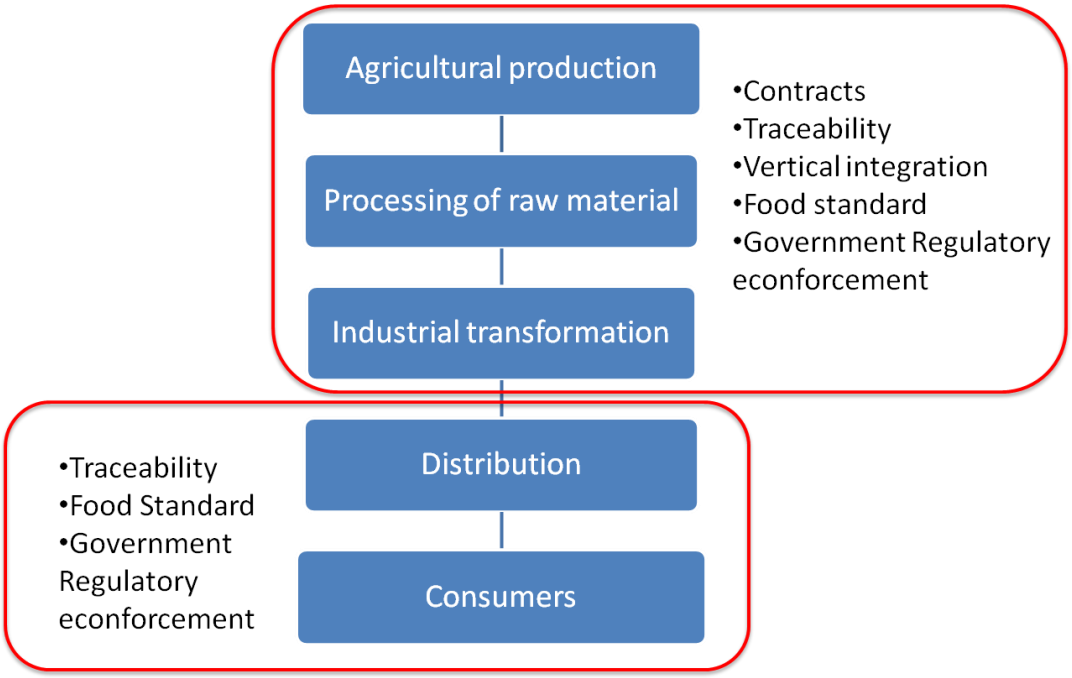


Figure 1. Solution to asymmetries along agri-food chain highlighted in literature. (Source: author's elaboration based on agri-food chain elaborated by Stringler et al., 2007).

2.4. Food standards

Starting in the mid-1990s, European retailers, faced by food safety crises, began to intervene heavily in producers' practices by imposing standards for grower practices far more demanding than the public Minimum Quality Standard (MQS). The retailers also developed new methods of signalling these efforts to consumers by creating private labels; in addition, a number of agreements between retailers and producers were developed in order to market products with strong quality and safety guarantees to consumers. (Codron et al., 2005). Food standards have been introduced to minimize the risk to suffer coordination failures along the food chain. Basically, there are two type of food standards, public and private. Public standards aim to ensure that social food safety and quality objectives are addressed and private standards aim to meet the market demand of consumers. Private standards are used by Private organizations to increase profits through both facilitating product differentiation (providing incentives to suppliers to make asset-specific investments, driving consumers to satisfy their desire for product diversity), reducing costs (Rilling, 2002) and reducing risk (Starbird, 2007).

2.5. Coordination (contracts)

Coordination is required when it is difficult or expensive verify the (agent) work. The food sector is highly characterized by credence and experience goods i.e., for which attributes are not observable. When attributes are not observable, there is a problem of product differentiation due to a lack of information, or information failure. In particular, in the information economics the case of non-verifiability together with decentralized information is problematic in contract design and prevent collectivities from achieving the first best allocation of resources.

Between academics, Hennessy (1995) stresses the importance of vertical integration as a solution to the increasing demand for safe 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.

The different types of coordination, referred as the economic arrangements aimed at synchronizing the transfer of inputs/outputs from different stages of the production chain up to the final consumer, is extremely relevant in the functioning of agri-food market. In particular, the contract is an essential means in coordination allowing the achievement of an efficient production along the production chain (Bogetoft et al., 2004). 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 western countries (Gattiker et al., 2004; Fraser, 2005; Fernandez-Olmos, 2008) and few on Eastern European countries (Ferto, 2009; Bakucs, 2013).

The imbalances of power between the end links of the chain, famers and retailers represents the most relevant aspect that needs to be addressed in order to reduce market inefficiency. The increasing globalisation and concentration of the process in some main retailers has led to an imbalanced trading where 13.4 million farmers and 310 thousands food industry across EU have to relate with few retailers. This leads to a pressure at the farm-gate prices, increased also by the perishable nature of agricultural product. In order to mitigate this problem, the existence of fair contractual arrangement between parties is essential (Copa Cogeca, 2016).

Contracts are the instruments used to coordinate transactions to meet food standards requirements between buyers and suppliers. Within contract relationships in the agro-food sectors, scholars recorded different means to incentivize compliance with contract requirements: price premiums (Farina et al., 2005), technical assistance, input credit, quality premium, stable access to market, income stability (Berdegue et al., 2005). In fact, in response to the greater market instability and increased price volatility of European farm systems within the food supply chain, the Agricultural Markets Task Force (EU) has recently highlighted the need of more “contractualization” (European Commission, 2016). In several European countries, contracts are not written and sometimes legitimate late payments in commercial transactions. Currently written contracts are not mandatory; only some Member States made written contracts compulsory (France, Italy, Lithuania, Spain, Poland) or this occurs for specific cases (such as milk sector).

The literature reports an increasing of contract use in agro-food sector transactions for differentiated product (Jang and Olson, 2010). Product differentiation often is due to quality attributes, which according to Codron et al. (2005b) are numerous: sensory (appearance attribute such as size and colour), health or nutrition, process (welfare, ethical aspect such as organic) and convenience. In particular, the first three attributes originate at the farm production stage. The use of contracts for product differentiation in agro-food sector at the farm production stage has been widely explored in literature. Some examples are provided by Gorton, (2006) McClusky, (2000), Segerson, (1999) Bogetoft, (2004). Gorton et al. (2006) describe the adoption of a contract to prevent information failure in milk market in Moldavia. The main issue was related to the low quality of milk in terms of fat content provided by farmers. The buyer offers in the contract a benefit that incentivizes the supplier who satisfies the MQS for milk in protein content. Worley and McClusky, (2000) recognize the important role of the production contract, designing a contract that allows selection of Identity Preserved wheat producers’ by using a benefit. The contract proposed in the paper follows the theory of incentive that try to differentiate producers based on the premium

price. In a similar way, Starbird (2007) explores the role of contract design for food safety attribute. The paper proposes a model that allows segregating safe from unsafe producers based on the failure inspection cost and the bid price.

The main advantages of engaging in contract is from the farmer side a shift of the risk (Martinez, 1999) an income stability and a market security. The disadvantages are recognized mainly in a reduction of flexibility in the management (Skully, 1998) which is usually compensate by a price premium (Key, 2004). However, there can be also possible penalization in price in case the spot market offers a higher bit price. Nevertheless, for processors, contract solution allows to have a stable provision in term of raw material and product quality (Worley, 2000).

Segerson (1999) has been one of the first academic to analyse mandatory regulation versus incentives for voluntary approaches identifying the condition in which a firm would adopt a voluntary food safety standard. Findings show 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 recommended.

2.6. The Agency problem in the agri-food chain

Contracts, in the field of the food supply chain, have primarily been studied as performance incentive tools (through their payment systems) or via the transfer of decision rights (Bouamra-Mechemache et al., 2015). These studies are based on standard hypotheses that view the contract as a complete and optimal coordination tool. This theoretical and normative vision of contracts is, however, counterbalanced by a more realistic approach offered by the agency theory. Coordination among actors in the agro-food chain is a typical agency problem (Ménard et al., 2004; Cook et al., 2008). This problem arises when the desires or goals of the principal, the buyer, and agent, the supplier, conflict and it is difficult or expensive for the principal to verify what the agent is actually doing (or what are the characteristics of the agent). The focus of the agency theory is on determining the most efficient contract to govern the principal-agent relationship given assumptions about people (e.g., self-interest, bounded rationality, risk aversion), organizations (e.g., goal conflict among members), and information (e.g., information is a commodity which can be purchased). In the literature, two aspects of the agency problem are cited, moral hazard and adverse selection. Moral hazard refers to lack of efforts on the part of the agent. Adverse selection refers to the misinterpretation of ability by the agent (Eisenhardt, 1989). For the food supply chain, the agency problem appears to be particularly evident in the fresh products sector (meat, and fruits and vegetables) where food safety issues are in fact more acute (relative to other sectors) due to the high product perishability and vulnerability to pathogenic agents (Unnevehr, 2000) and fraudulent behaviour is more frequent (Ependitis, 1998). The magnitude of these forms of coordination failures is also amplified by the fact that the fresh products sector is characterized by atomized production structures. Those risks led retailers to become involved far more than in the past in the choice of production technology and practices used by their suppliers, in particular via the imposition of private standards related to production practices: notebook records of production practices, codes of Good Agricultural Practices (GAPs), and farm insurance schemes (Codron et al., 2005). The choices made by each retail chain in this context are conditioned by individual factors, but also by sectorial characteristics. The retailers' strategies in fact depend on the level and content of MQS, their degree of credibility in the eyes of consumers and their capacity to enforce contracts (Codron et al.,2005).

With respect to the last issues, the regulator capacity to enforce contracts is linked to its capacity to discriminate suppliers and to monitor compliance. The impossibility to accurately monitor compliance dis-incentivizes investments in ensuring the contracted product specification by producers (Hennessy, 1996) and increases the risk to suffer frauds (Ependitis, 1998; Giannakas, 2002), while, the inability to discriminate suppliers increases the risk of failing to meet the contracted requirements to the detriment of both buyers and suppliers (Baker et al., 2002; Starbird 2007). The last two issues are particularly relevant when buyers take decisions on differentiating goods according to intangible attributes, as organic versus conventional food. By considering frauds, it is alleged that, in the southern states of the EU, mislabelling of conventional product accounts for between 15% and 40% of the organic labelled produced (Ependitis, 1998). In this respect, Giannakas (2002) provided a theoretical explanation about the effect of mislabel conventional food as organic. By considering the risk to fail to meet the food specification defined by the contract, for the produce sector in US it was estimated a rate of pesticide residues above the legal limits in between 30% for organic products and 50% for conventional products (Baker et al. 2002). In this respect, Starbird (2007) provided a theoretical explanation about the fact that, in a multiple agency problem, both intermediate buyers and suppliers might fail to meet the contracted standards. The magnitude of this failure might condition the buyer's willingness to invest for high standard levels, differentiating the product. This is also conditioned by the buyer capacity to discriminate suppliers with respect to their different attitude to expose the intermediate buyer itself to a market failure.

3. Expert Based Analysis (EBA)

3.1. Rationale and methodology adaptation

The main purpose of the EBA is to explore the relevance of information asymmetries in the performance of agriculture value chains. The action was envisaged to involve about 15 experts EU-wide with the purpose of carrying out a two-steps Delphi exercise. An open identification of asymmetric information and mechanisms through which they affect performance is the purpose of this action.

In order to achieve these results a Delphi questionnaire has been created based also on finding from the literature review carried out previously. The literature analysis has related not only to asymmetric information but also to Delphi methodology.

Based on findings from literature review and on selected stakeholder interviews a first version of the Delphi questionnaire has been developed. In particular, the questionnaire has been structured in a way to gather expert insights and opinions on solution to reduce information asymmetries.

The first draft of the questionnaire has been tested between two experts and coherently adapted. The revised questionnaire has then been sent by email with the invitation to participate to a panel of experts. The selection of the panellist has consisted in 20 EU-Wide experts. After sending two remainders, nevertheless only one response has been collected. The alternative action pursed has been to convert the Delphi into an on-line questionnaire version. The questionnaire has been developed on Survey Monkey (see annex) and from October 2016 invitations have been sent by email to around 70 experts. Two remainders have been sent in the period from November to January). The on-line questionnaire has been structured in two parts A and B. The first part A is

composed by general questions on market imperfection and asymmetric information issues. The second part B more focused on contracting issues. We obtained six questionnaires, not all of them completed.

Give the difficulties in having a representative group of respondents on such a broad issue, AI has also been addressed in connection with interviews carried out in WP2 for the case study on Pear in Emilia-Romagna.

3.2. Results

Form the EBA we gather six questionnaires. Respondents are from Germany (manager), Ireland (academic), Slovenia (manager), Bulgaria (academic) and Italy (managers). According to expert responses', the fruit sector is particularly affected by lack of transparency of information on quality, this last aspect is especially stated in country such as Italy and Germany. The lack of information transparency on safety for the fruit sector is highlighted in Germany. Instead, the main issues in relation to market power are referred to sugar, meat and milk sector. In particular, quality aspect concern the size (Bulgaria), the colour (Slovenia) and cereal protein content (Italy). Safe aspects are related to level of chemicals in fruit and mycotoxin in cereal.

According to expert statements, the use of contract is mandatory in some countries such as Bulgaria and Germany, instead is not mandatory in Italy and Ireland. However, experts form Germany and Bulagaria state that the main form of transaction for farmers is the spot market.

It is recognised the important role of contract in genereting a stable farm income from Bulgarian and German experts. In additon to this, expert from Italy and Ireland are aware of the important action of contract in promoting quality and safety aspects. In general all experts agree on the essential contribution in the risk reduction for farmers. Bulgarian expert consider the contract a proper coordination tool along the food supply chian, in particular, at the Distribution level (fig.1)). On the contrary, from German expert side's the contrat rapresents a tool to be applied between primary producers and intermediate dealers.

One expert from Italy reports that contracts not only work well in reducing the problem of information transparency but also in reducing general transaction costs. In fact, the monitoring activity can be partially reduced in presence of contracts. However, there are some cases in which monitoring is not sufficient in guaranteeing the product authenticity. This is the case of product characteristics related to the application of unobservable practices, such as the organic or ethic aspects and in some cases qualitative aspects. Experts agree that the contract before planting or at least before harvesting, represents a beneficial tools especially for farmers because ensures income stability and the reduction of risk. However, the majority of food operators are not using it, in particular primary producers.

The investigation about AI has been in depth analysed in the pear sector of Emilia Romagna region during the case study analysis carried out in the Work Package 2. This action allows gaining a better understanding of the relevance and of the organisation of the sector. The region Emilia Romagna is the first pear producer in Italy. Pear producers can be distinguished in Small-Medium size producers (20-30 ha) which are run by young entrepreneurs, multi crops (fruits, cereal) and with different quality standard levels. They convey all the production to organization such as cooperative and

experts highlight that there are efficient and inefficient farms. In addition, there are large farm size (about 300ha), located mainly in the Ferrara province, which are highly specialized in pear, production and more oriented to a spot market and sometimes auctions.

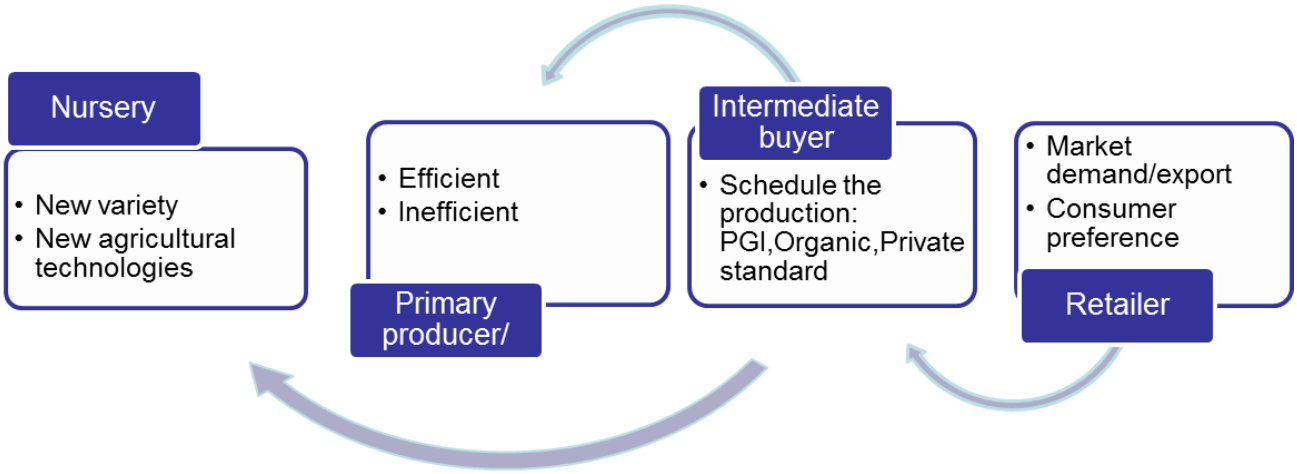


Figure 2. Upstream strategy development.

Our target of study is represented by small and medium farm sizes, which convey their production to cooperative. Experts highlight that cooperatives arrange the production among their members in order to meet market requirements (prescribe manly by big retailers and consumers). Hence, strategies are set by the cooperative that are planned based on market trends. As illustrated in Figure 2. , strategies are developed upstream. Consumer preferences are detected by retailers then pass to intermediate dealer or cooperative that influence not only future farmer productions but affect also the development of new fruit varieties and new technologies. In particular, in order to meet different market segmentations, which are based on different standard levels expressed by retailers, the cooperative or the intermediate buyer distribute the production between efficient and inefficient farmers.

Besides mandatory safety requirements which are related to phitosanitary standards that must be satisfied by producers, the pear sector is characterised by market segmentation with different quality requirements (organic, PGI, high quality). In many cases these standard are not yet observable or detectable at the time of purchasing which is the case of “credence good”. The fulfilment of these standard in agriculture implies the application of specific agricultural practices that cannot be fully observed by the buyer, in many case represented by the cooperative.

Cooperative allocate the different type of productions based on farm capability of compiling to specific quality level requirements. The cooperative need to match the different quality level produced by the farmers with the right market segment. Farmers, in order to meet specific quality standard, adopt different agricultural practices facing different production costs, which are not observable by the Cooperative. The nature of the problem is ascribable to a Principal Agent problem that imply the existence of asymmetric information in which the principal (buyer or cooperative) can not have a complete information on the action/practices adopted by the agent (farmer).

4. Modelling of the effects of Asymmetric information on chain performance

4.1. Introduction

In this section of the study, we contribute to investigating the issue of AI by designing a typical agency problem including different sources of information failure and analysing how these sources of information failure might condition buyer's willingness to pay for high quality standard levels. This is to offer a theoretical explanation about why there is still a poor creation of public and private standards, especially with respect to environmentally friendly practices, in particular for fresh fruit and vegetables (Codron and Giraud-héraud 2005).

Though the mathematical model is developed having in mind quality issues, the structure of the problem can be to a large extent be similar also for safety issues, as the two domains partially overlap though being clearly different concepts. For this reason, the practical background problem is described in relations to both safety and quality issues.

4.2. The problem

Despite the increasing consumer's awareness of food safety and quality, there is still a poor creation of public and private standards relatively to safety/quality-increasing practices, especially for fruit and vegetables. The Governments unwillingness to create new standards in this field is justified by the fact that there is not yet any proven safety crisis with respect to fruit and vegetables products (Codron and Giraud-héraud 2005, Uyttendaele et al., 2014). The main concern of governments is to regulate pesticide residues by prohibiting dangerous products and by fixing maximum dosages. In any case, the use of pesticides must be monitored. Such monitoring is indeed onerous if it is done systematically. Rather than increasing monitoring by increasing public expenditure, European governments prefer to partially depend on the private sector, increasing their legal responsibility and promoting the emergence of private standards and monitoring these standards by independent certification bodies. In the produce sector (fruit and vegetables), pesticides are applied at the farm level, and thus the standards are of the types "good agricultural practices". The main issue for governments and retailers is at what level the public and private standards should be set.

An increase in the public minimum quality standard (MQS) might reduce the incentives for retailers to adopt their own private standard (PS) or might induce a sectorial concentration as farms drop out due to increased costs (Ecchia and Lambertini, 2001; Lutz et al., 2000), while the absence of MQS might not contribute in creating awareness among consumers, indirectly disfavouring the creation of PS (Codron and Giraud-héraud 2005). Namely, as the MQS decline, the interest of the retailer in a differentiation strategy using a PS becomes stronger. As the MQS rises, so do the costs incurred by suppliers and retailers to differentiate the product from the generic one; for the producer, these are production and reporting costs; for the retailer, these are the costs of monitoring and the cost to incentivize the participation of supplier to the more restrictive private standard. When the MQS is very high, the retailer no longer has an interest in selling the PS product and the entire product line then converges to the generic products, meeting the MQS only (Codron and Giraud-héraud 2005).

A theoretical approach to explain Product safety/quality differentiation was developed by Giraud-héraud et al. (2003). This approach was essentially developed to explain how the distribution of the

bargaining power between the contracting parties (buyers and suppliers) might affect product quality differentiation. With the present study, we offer a complementary perspective where the standard differentiation strategies of the contracting parties are conditioned by the presence of information failures and by the existence of MQS requirements.

Usually, retailers specify production practices and producers, for their part, record and certify their production practices through independent certification body. Third party monitoring does not avoid the risk to fail to meet the contracted requirement by both suppliers and buyers (Ependitis, 1998; Giannakas, 2002). The differentials in requirements for producers, in prescriptions, and in price, are determined by the degree of competition among chains and the targeted consumer segment.

The agency relation between producers (agents) and retailers (principal) is formalized in Laffont and Tirole (1993). A recent application of the principal-agent problem for the food sector is offered by Starbird (2007). Specifically, Starbird (2007) set up an agency problem between retailers and suppliers including food safety failure issues. The Starbird model was developed to describe the behaviour of a supplier facing the problem to define a single contract to discriminate 'safe' and 'unsafe' suppliers. With the present paper, we enrich the agency problem addressed by Starbird assuming that the intermediate buyer designs multiple contracts with suppliers to differentiate the market, differing with restrictions on agricultural practices (conventional, low input, organic, etc.).

To benefit of a premium price for high quality levels, farmers must comply with a set of production rules (requirements) that are assumed to be more restrictive than the production rules implemented for low quality levels. Such food quality characteristics are not fully observable by the buyer. In addition, it is assumed that the costs faced by the farmer to comply with the contract requirements increase with increasing restriction on agricultural practices. Moreover, Farmers' are assumed to differ from each other in the cost faced to comply with contract requirements and in the probability to fail to meet the same contracted requirements. On its part, the intermediate buyer is exposed to a food quality failure that increases with increasing quality restrictions.

Both the retailer and its suppliers, farmers, are assumed to be profit-maximizers. Farmer's willingness to implement good agricultural practices is conditioned by the price premium offered by the retailer to join the relevant quality specification, by farmers' adaptation costs and by farmers' exposure to a food quality failure. The retailer willingness to differentiate the market with respect to food quality issues is then conditioned by the price offered by the market, by the probability of missing to meet market requirements, by the payments that the buyer must offer to compensate the effort faced by the supplier to meet the buyer's quality requirements and by the costs faced to incentivize the provision of high quality product by suppliers. These costs include a premium to incentivize the selection of contract for high quality products by efficient producers and an efficiency loss caused by the design of a sub-optimal contract for low quality products to dis-incentivize the it's selection by efficient producers. For instance, efficient producers, who are characterized by low production costs, might wish to enter in the market for low quality requirements if they find it more profitable. Such decision might penalize the profits of the buyer. To dis-incentivize such decision, then, the buyer might offer an additional premium for products with 'high' quality requirements and/or to change the condition contracted for 'low' quality requirements (lower prices and lower quality requirements).

In the following sections, we will deal with the problem above in three steps. The first step addresses farm discrimination assuming that farmers differ from each other in the cost they face to comply with production rules. In a second step, we include the assumption that the buyer is exposed to the probability to suffer a food quality failure and that this probability increases with increasing food quality restrictions. In a third step, we include the assumption that also farmers are exposed to the probability to suffer a food quality failure and that this probability differs with farm's types. Finally, we analyse the quality strategies of the retailer in response to different MQS scenarios

4.3. Farm discrimination based on production cost

The following optimization problem analyses the (profit-maximizing) behaviour of an intermediate buyer (retailer) in setting up a quality differentiation strategy based on unobservable attributes of a product. Without loss of generality, the intermediate buyer is assumed to be a price taker (not able to influence the market) and to be the solely food chain nexus between farmers and consumers. Under such hypothesis, the Buyer quality differentiation strategy is, in turn, conditioned by the characteristics and behaviour of his supplier (farmers). In setting up the problem, we rely on the following additional main assumptions:

- the quality of the product itself cannot be detected by the consumer, by the retailer or by the producer directly observing the product; on the contrary, quality can be only detected based on the certification by retailer, based, in turn, on (perfectly enforceable and monitored without costs) prescriptions contracted with the producers but that cannot be perfectly monitored (i.e. use of pesticide, that can be only partially detected based on analyses on pesticide residues);

- as a result, the buyer cannot simply pay the farmer based on the measured quality of their product, but needs to contract appropriate instruments of quality assurance (i.e. by imposing the adoption of specific agro-environmental practices by farmers or organic practices);

- it is assumed that the product price on the buyer market is a continuous function of the product quality level so identified and that, for simplicity, it is increasing and proportional to the quality level such that, $p'(q) > 0 = C$ and $p''(q) = 0$;

- without loss of generality, we consider that there are two farm types, differing each other for their cost of compliance to quality standards. We assume that compliance costs are strictly increasing and twice differentiable such that, $c'(q) > 0$ and $c''(q) > 0$;

- the retailer knows that there are two farm types and their compliance cost function, but cannot tell, for a generic farm, the farm type it belongs to;

- the retailer can set differentiated contracts, one for each farm type, implying different payments and different quality standard levels, but, due to the previous assumption, cannot allocate each contract to the type of farm it is designed for; hence there is an adverse selection problem.

Without loss of generality, we qualify the two types of producers as 1 and 2, where farm' type 2 is the 'inefficient' farm' type facing higher adaptation costs, c, for producing goods with quality requirements, q, such that $c_2(q) > c_1(q)$. Moreover, the difference between the cost faced by the two farm types increases for increasing quality levels, such that $c_2'(q) > c_1'(q)$ for all values of q. Now we assume that the principal designs two contracts, one for low quality levels, $\underline{w} = \{\underline{v}, \underline{q}\}$,and one for high quality levels, $\overline{w} = \{\overline{v}, \overline{q}\}$, respectively. Under such condition, farmers are assumed to choose the contract that will, presumably, ensure them higher profits, such that:

$$U_i(v^*, q^*) = \max_{\overline{w},\underline{w}} \left\{ \overline{v} - c_i(\overline{q}); \underline{v} - c_i\left(\underline{q}\right) \right\} \quad \forall\, i = 1{,}2 \qquad (1)$$

Thus, farms profit functions are conditioned by the quality specification contracted with the buyer, $\overline{q} and\ \underline{q}$ and by the relevant prices, $\overline{v}\ and\ \underline{v}$. The profit of the buyer is, then, given by the difference between selling and purchase prices:

$$\prod = \delta[p(\overline{q}) - \overline{v}] + (1 - \delta)\left[p\left(\underline{q}\right) - \underline{v}\right] \qquad (2)$$

Where, $\overline{q} and\ \overline{v}$ and $\underline{q}\ and\ \underline{v}$ are the Buyers decisional variables used, respectively, to set up contracts for good produced with restricted prescriptions to meet high quality levels by the more efficient farm and for good produced to meet lower quality levels by the less efficient farm; *p(q)* is the retailer selling prices which is function of the quality level contracted with the producer; δ is the probability that the buyer receives a lot of goods produced with restricted prescription. This probability depends on the frequency (representativeness) of each farm' type. On the basis of the assumption made so far, to maximize profits the Buyer should contract for each farm type the highest quality level they could provide at the lowest price they might wish to accept. Ideally, the Buyer should contract restricted prescription with the farmers' types characterized by low adaptation costs and who are presumably capable to meet 'higher' quality levels, such as to guarantee them a profit of $U_1(\overline{v}, \overline{q}) = \overline{v} - c_1(\overline{q})$ and should contract less restricted prescription with the farmers' types characterized by high adaptation costs and who are presumably not capable to meet 'higher' quality levels, such as to guarantee them a profit of $U_2\left(\underline{v}, \underline{q}\right) = \underline{v} - c_2\left(\underline{q}\right)$.

By substituting the profit function of both farm types into equation (1), we obtain:

$$\prod = [\delta\big(p(\overline{q}) - c_1(\overline{q})\big) + (1 - \delta)\left(p\left(\underline{q}\right) - c_2\left(\underline{q}\right)\right)] - \left[\delta U_1(\overline{v}, \overline{q}) + (1 - \delta)U_2\left(\underline{v}, \underline{q}\right)\right] \qquad (3)$$

The first term in between square brackets in the right hand side of eq. (2) is the allocative efficiency, i.e. the gain due to the production of products of a certain quality based on the difference between market price and production costs, while the second term between square brackets is the information rent, which is the rent agents derive from having information concerning their costs not provided to the principal. Equation (3) makes explicit that the objective of the principal is the same as maximizing the expected profit, minus the information rent of the agents.

To let the farmer' join the contract with the Buyer the following participation constraints must be satisfied:

$$\overline{v} - c_1(\overline{q}) \geq 0 \qquad \text{or,} \qquad U_1(\overline{v}, \overline{q}) \geq 0 \qquad (4)$$

$$\underline{v} - c_2\left(\underline{q}\right) \geq 0 \qquad \text{or,} \qquad U_2\left(\underline{v}, \underline{q}\right) \geq 0 \qquad (5)$$

With perfect information, the Buyer knows the costs function of each individual farmer and discriminates farmers without the need to introduce any incentive. Under such circumstances both equation (4) and (5) are satisfied with strict equality and the second term of the right-hand side of equation (2) is equal to zero. With such hypothesis, we obtain a first-best optimal contract design satisfied by the following equilibrium respectively for the farm type *1* and *2* (demonstration in appendix 1):

$$p'(\overline{q}^*) = c_1'(\overline{q}^*), \qquad p'\left(\underline{q}^*\right) = c_2'\left(\underline{q}^*\right) \qquad (6)$$

For both farm' types, the equilibrium is reached when marginal prices equal marginal production costs. However, farmer's production costs are not observable by the buyer, that is, the Buyer cannot discriminate farmers with respect to their production attitudes. As a consequence, the Buyer is not in the condition to offer the right contract to the right farm. He can simply offer a menu of contracts. Then, farmers can freely choose the best option (contract) among the contracts offered by the Buyer. Thus, each farm typology choses the right contract if the following incentive compatibility constraints are also satisfied:

$$\overline{v} - c_1(\overline{q}) \geq \underline{v} - c_1\left(\underline{q}\right) \qquad \text{or,} \qquad U_1(\overline{v}, \overline{q}) \geq U_2\left(\underline{v}, \underline{q}\right) + \Delta U\left(\underline{v}, \underline{q}\right) \qquad (7)$$

$$\underline{v} - c_2\left(\underline{q}\right) \geq \overline{v} - c_2(\overline{q}) \qquad \text{or,} \qquad U_2\left(\underline{v}, \underline{q}\right) \geq U_1(\overline{v}, \overline{q}) - \Delta U(\overline{v}, \overline{q}) \qquad (8)$$

Under such condition, the retailer must provide the right incentives to induce farmers to select what is the most appropriate contract on is part (i.e. self-select through the choice of the contract). Formally, to quantify such incentives equation (2) must be maximized subject to equation (4), (5), (7), and (8). Considering the assumption made for the two farm types, the participation constraint for the inefficient supplier, equation (5), and the incentive compatibility constraint for the efficient supplier, equation (7), hold with strict equality. As a result, we obtain an optimal contract design by satisfying the following equilibrium for the two farm types (demonstration in appendix 1):

$$p'(\overline{q}^*) = c_1'(\overline{q}^*), \qquad \boldsymbol{p}'\left(\underline{q}^{SB}\right) = c_2'\left(\underline{q}^{SB}\right) + \frac{\delta}{(1-\delta)}\left[c_2'\left(\underline{q}^{SB}\right) - c_1'\left(\underline{q}^{SB}\right)\right] \qquad (9)$$

With respect to the former problem, the principal slightly relaxes the requirements contracted with the inefficient farm type, $\underline{q}^{SB} \leq \underline{q}^*$, reducing the expected efficiency of the contract causing a surplus loss due to the lower quality contracted (which affect both parties involved in the transaction at different levels[1]), and offers a premium to the efficient type, $\overline{v}^{SB} \geq \overline{v}^*$, to incentivize the supply of goods produced with very restricted quality requirements.

[1] In this particular case, the utility of the 'inefficient farm' type is always zero and the loss is up to the Buyer. In reality, the surplus loss should include also consumers (intentionally excluded as the focus of our paper is about a specific segment of the value chain).

Indeed, by assumption the second term of the right hands side of equation (8) for the inefficient farm type is positive as $c_2{}'\left(\underline{q}^{SB}\right) > c_1{}'\left(\underline{q}^{SB}\right)$. As a consequence, $\boldsymbol{p}'\left(\underline{q}^{SB}\right) > c_2{}'\left(\underline{q}^{SB}\right)$. Because of the carachteristics of the revenue function of the buyer and of the cost function of the supplier, the first derivative of the revenue is greater than the first derivative of the costs only when $\underline{q}^{SB} < \underline{q}^{*}$. This condition causes an efficiency loss to the condition contracted with the 'inefficient' farm' type. In addition, as equation (4) and (5) are satisfied with strict equality we have that $\overline{v}^{SB} = c_1(\overline{q}) + [c_2\left(\underline{q}\right) - c_1\left(\underline{q}\right)]$. Again, by assumption $c_2\left(\underline{q}\right) > c_1\left(\underline{q}\right)$, as a consequence $\overline{v}^{SB} > c_1(\overline{q}) = \overline{v}^{*}$. From this last equation it follows that the retailer offers a price premium to guarantee the selection of the contract for high quality requirements by the 'efficient' farm' type, whose magnitude increases with increasing quality standard levels contracted with the 'inefficient' farm' type. From this evidence it can be inferred that the reduction of efficiency of the contract selected by the 'inefficient' farm' type is compensated by a consequent reduction of the price premium needed to incentivize the selection of the contract for high quality standard by the 'efficient' farm type. Thus, the optimal solution is found when the reduction of the marginal efficiency of the contract designed for the 'inefficient' farm type equals the marginal benefit obtained by reducing the premium offered to the 'efficient' farm's type.

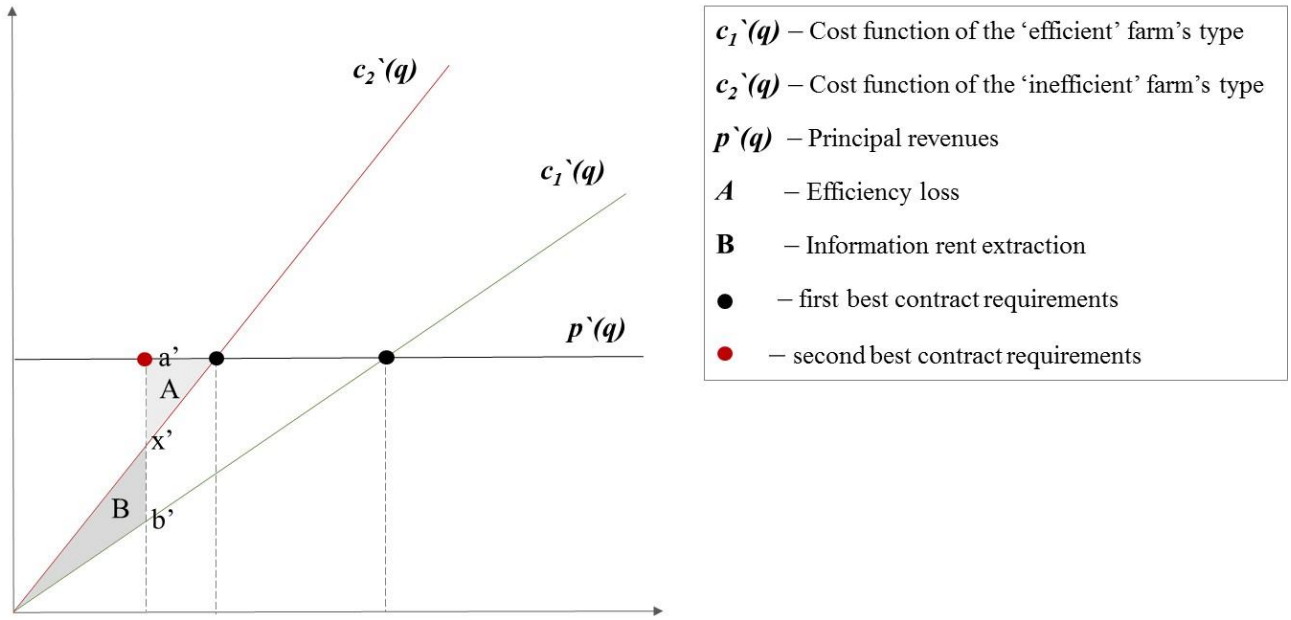


Figure 3 - Graphical demonstration of second best optimal contract to incentivize the selection of the contract with restricted quality requirements by the 'efficient' farm's type.

Figure 3 shows a graphical representation of the solution of the problem in the presence of information asymmetries, equation (9). The area A represent the Principal's income foregone because of the reduction of the expected efficiency of the contract bargained by the Principal with the 'inefficient' farm's type. The area B represents the information rent extraction paid by the Principal to the 'efficient' farm's in the form of a premium price. The balance between the efficiency loss faced by the principal (as the Utility of the 'inefficient farm' type is always zero) by relaxing the quality levels contracted with the inefficient farm type, and the premium price offered to the 'efficient' farm type to let him reach high quality levels is conditioned by their marginal values trends

for decreasing quality levels. For construction, with decreasing quality level contracted by the Buyer with the 'inefficient' farm' type, increases the marginal efficiency loss of the contract and decreases the marginal premium needed to let the 'efficient' farm type joint the contract. The equilibrium is reached when the overall information rent extraction is minimized, that is when the marginal efficiency loss (segment a'x' in Figure 3) equals the marginal reduction of the premium (segment x'b' in Figure 3). With a reduction of the quality level contracted by the buyer with the 'inefficient' farm' type below the equilibrium point, efficiency loss would not be compensated by the marginal reduction of the premium.

4.4. Farm discrimination based on production costs and market failure probabilities on the side of the Buyer

Now we analyse the principal problem introducing market failure probabilities. The profit is determined by the differences between selling and purchasing prices weighted by the probability to suffer a market failure, $\pi(q)$, namely, the probability that the Retailer, the intermediate buyer, fails to meet the declared quality requirements:

$$\prod = \delta\left[p(\overline{q}) - \overline{v} - \pi(\overline{q})\left(p(\overline{q}) - p(q_0)\right)\right] + (1-\delta)\left[p\left(\underline{q}\right) - \underline{v} - \pi\left(\underline{q}\right)\left(p\left(\underline{q}\right) - p(q_0)\right)\right] \quad (10)$$

This probability is assumed to be a twice differentiable continuous function of the quality levels and with first and second derivatives greater than zero, $\pi'(\overline{q}) > 0$, $\pi''(\overline{q}) > 0$. If the good sold for the market with high quality standard requirements fails to meet the expected requirements, then the good will be priced as would be for the standard market, for quality level q_0. In this simplified model, it is assumed that, when this happens, $q \geq q_0$ for each market and that the Retailer bears a cost whose value is the differences on prices for the two markets, p(q) - p(q_0).

Note that:

$$\left[p(q) - v - \pi(q)\left(p(q) - p(q_0)\right)\right] = \left[(1-\pi(q))p(q) + \pi(q)p(q_0) - v\right] \quad (11)$$

i.e. the expected selling price is the average of the price for the quality level q and of the price for the minimum quality level established by the market, weighted by the probability of failing to pass inspection.

By substituting the profit function of both farmer' types into equation (10), we obtain:

$$\begin{aligned}\prod = &\left[\delta\left(p(\overline{q}) - c_1(\overline{q}) - \pi(\overline{q})\left(p(\overline{q}) - p(q_0)\right)\right)\right. \\ &\left. + (1-\delta)\left(p\left(\underline{q}\right) - c_2\left(\underline{q}\right) - \pi\left(\underline{q}\right)\left(p\left(\underline{q}\right) - p(q_0)\right)\right)\right] - \left[\delta U_1(\overline{v},\overline{q}) + (1-\delta)U_2\left(\underline{v},\underline{q}\right)\right]\end{aligned} \quad (12)$$

To provide incentives for farmers to join the contract that maximize the buyer expected profits, the Principal must guarantee the fulfilment of participation and incentive compatibility constraints, already defined in the former section.

With perfect information, the Retailer is able to discriminate agents without introducing any incentive and both the participation constraints, equations (4) and (5), are satisfied with strict

equality. With such hypothesis, we obtain a first-best optimal contract design characterised by the following conditions respectively for the farmer type *1* and *2*:

$$\boldsymbol{g}'\left(\overline{q}^{*}, \pi(\overline{q}^{*})\right) = c_1'(\overline{q}^{*}), \qquad \boldsymbol{g}'\left(\underline{q}^{*}, \pi\left(\underline{q}^{*}\right)\right) = c_2'\left(\underline{q}^{*}\right) \tag{13}$$

Where, $\boldsymbol{g}'\big(q, \pi(q)\big) = \boldsymbol{p}'(q)[1 - \pi(q)] - \pi'(q)[p(q) - p(q_0)]$ for both farmer' types. $\boldsymbol{g}'\big(q, \pi(q)\big)$ is the retailer revenue that equal marginal prices weighted by the risk faced by the Retailer to fail to meet market requirements. The optimal solution is reached when farmer marginal production costs equal the retailer marginal revenue. The magnitude of the risk faced by the retailer to fail to meet market requirement increases with increasing restrictions on quality requirements and is conditioned by the probability of failing to meet market expectation and by the penalty incurred by this failure, that is by the differences in price between the high quality market and the standard market.

As for the previous problem, we now remove the assumption of perfect information, as the principal cannot discriminate agents according to their production attitudes. Thus, the principal must provide the right incentives to induce farmers to self-qualify by selecting the most appropriate contract. Formally, to quantify such incentives equation (12) must be maximized subject to equation (4), (5), (7), and (8). Considering the assumption made for the two farm types, the participation constraint for the inefficient supplier, equation (5), and the incentive compatibility constraint for the efficient supplier, equation (7), hold with strict equality. As a result, we obtain an optimal contract design satisfied by the following equilibrium for the two agent's types:

$$\begin{aligned} &\boldsymbol{g}'\left(\overline{q}^{*}, \pi(\overline{q}^{*})\right) = c_1'(\overline{q}^{*}), \\ &\boldsymbol{g}'\left(\underline{q}^{*}, \pi\left(\underline{q}^{*}\right)\right) = c_2'\left(\underline{q}^{SB}\right) + \frac{\delta}{(1-\delta)}[c_2'\left(\underline{q}^{SB}\right) - c_1'\left(\underline{q}^{SB}\right)] \end{aligned} \tag{14}$$

With asymmetric information, the Principal relaxes the requirements contracted with the inefficient farm type, $\underline{q}^{SB} \leq \underline{q}^{*}$, reducing the expected efficiency of the contract, and offers a premium to the efficient type, $\overline{v}^{SB} \geq \overline{v}^{*}$, to incentivize the supply of goods produced with restricted quality requirements. However, both conditions are now affected by the probability of failure through the term $\boldsymbol{g}'\big(q, \pi(q)\big) = \boldsymbol{p}'(q)[1 - \pi(q)] - \pi'(q)[p(q) - p(q_0)]$. Otehr things equal, for a postive probability of failure, the optimal contracts are for quality levels lower than in the previous case.

Figure 4 shows a graphical representation of the solution of the problem in the presence of information asymmetries including the Principal risk to suffer a market failure, equation (14). According to the former case, in the presence of probability failures the problem solves with non-efficient contracts for the 'inefficient' farm type. The difference with the former problem is that the risk to suffer a market failure (the risk of failing to meet market requirements) causes a reduction of expected prices and quality requirements affecting both quality standards.

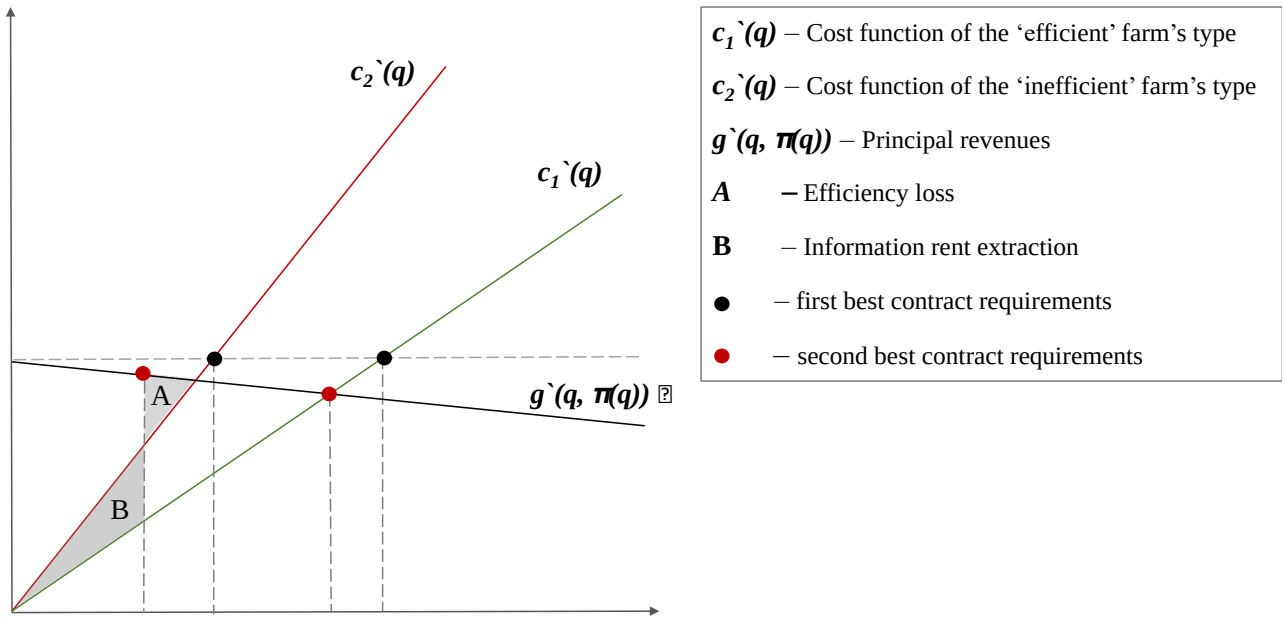


Figure 4 - Graphical demonstration of second best optimal contract including the effects of adverse selection and of the Principal risk of failing to meet market requirements.

Indeed, the slope of the marginal revenues curve is negative as both the risk of failing to meet market requirements and the relevant penalty increases with increasing restriction on quality requirements. The behaviour of the Principal impacts also farm's income. Indeed, the premium obtained by the efficient farm's type to adhere with more restrictive quality requirements is lower than the premium obtained when the Principal do not suffer any risk to undergo a market failure.

In summary, the inefficiencies generated by the presence of information failures depicted in figure 2 are: 1) the Principal income foregone because of the reduction of the expected efficiency of the contract bargained by the Principal with the 'inefficient' farm (area A); 2) the information rent extraction paid by the Principal to the 'efficient' farm in the form of a premium price (area B).

4.5. Farm discrimination based on production costs and market failure probabilities for both contracting parties

With respect to the problem faced in section 4.4 we include an additional source of information failure on the side of the agent. Differently from the former problems, the agents' profit function is now described by the following equations: $U_1(\overline{v},\overline{q}) = \overline{v} - c_1(\overline{q}) - \pi_1\overline{v}$ for the product with 'higher' safety attributes provided by the farm type characterized by low adaptation costs, and$U_2\left(\underline{v},\underline{q}\right) = \underline{v} - c_2\left(\underline{q}\right) - \pi_2\underline{v}$, for the product with 'lower' quality attributes supplied by the farm type characterized by high adaptation costs. π_1 and π_2 are the supplier failure probabilities which represent the risk to fail to meet Buyer's requirement. These probabilities varies with farm types and are independent from the quality of the product. Namely, the risk to fail to meet Buyer's requirement faced by the supplier is assumed to depend on supplier characteristics, while the risk to fail to meet Costumers requirements by the Retailer is assumed to increase with increasing

quality standard levels. In addition, it is assumed that if the product sold by the supplier fail to meet buyer requirement, then the product is not purchased.

As for the former problem, in the absence of perfect information, equation (12) must be maximized subject to equation (5) and (7) satisfied with strict equality. The only difference from the previous problem is that the agents' profits take the form discussed in this section. The optimal contract design is satisfied by the following equilibrium for the two agent's types:

$$\begin{aligned} \boldsymbol{g}'\left(\overline{q}^{*}, \pi\left(\overline{q}^{*}\right)\right) &= \frac{{c_1}'(\overline{q}^{*})}{1-\pi_1}, \\ \boldsymbol{g}'\left(\underline{q}^{*}, \pi\left(\underline{q}^{*}\right)\right) &= \frac{{c_2}'\left(\underline{q}^{SB}\right)}{1-\pi_2} + \frac{\delta}{(1-\delta)}\left[\frac{{c_2}'\left(\underline{q}^{SB}\right)}{1-\pi_2} - \frac{{c_1}'\left(\underline{q}^{SB}\right)}{1-\pi_1}\right] \end{aligned} \tag{15}$$

The equilibrium solution described by equation (15) slightly differs from the one described in the previous section by equation (14). The difference is in the presence of a new source of information failure on the side of the supplier. The supplier suffers the risk to fail to meet buyer's requirements. With increasing probability of failure on the supplier side, increases the expected costs faced by the supplier to comply with the quality requirements agreed with the Buyer. This condition causes new standards equilibrium for both farm' types. Differences in failure probabilities among suppliers affect also the rent extraction suffered by the 'inefficient' farmer' type to incentivise the selection of the high quality standard contract by the 'efficient' farmer' type. The rent extraction increase when $\pi_2 > \pi_1$, otherwise it decreases.

Figure 5 shows a graphical representation of the solution of the problem in the presence of information asymmetries including the Principal risk of incurring in adverse selection and the risk to suffer a market failure for both the contracting parties.

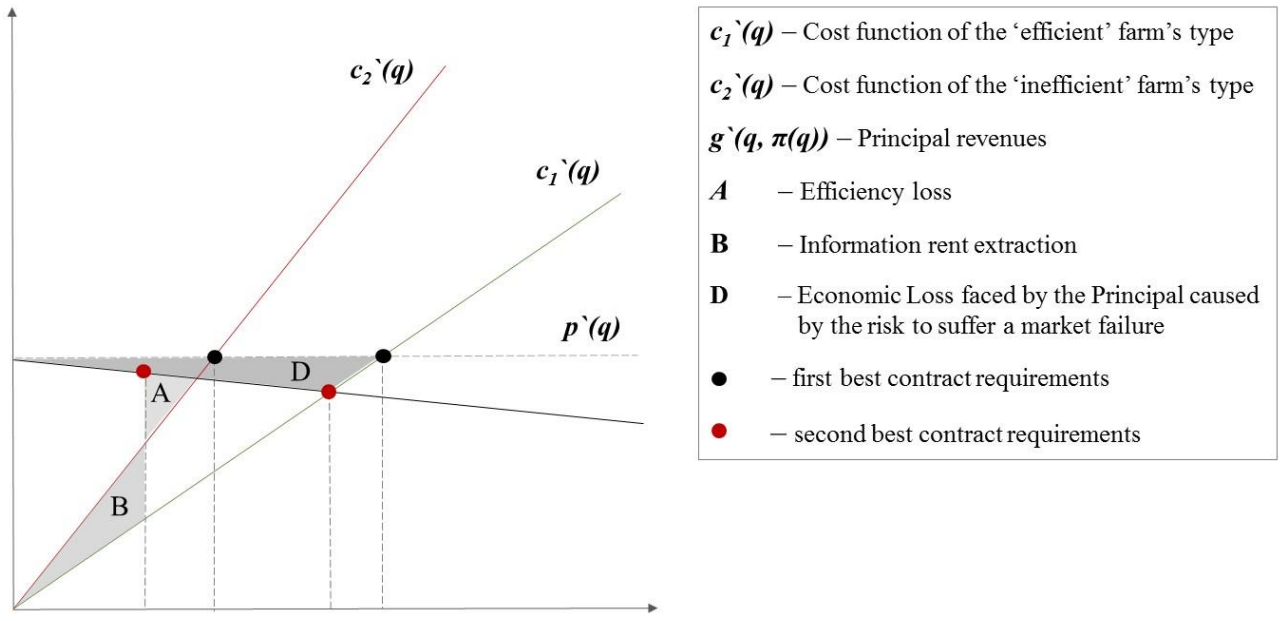


Figure 5- Graphical demonstration of second best optimal contract including the effects of adverse selection and of the risk of failing to meet market requirements for both contracting parties

With the introduction of this new source of information failure suppliers are less likely to meet the quality standards contracted with the retailer. As a consequence, the retailer will suffer an information failure caused by the risk of failing to meet costumer' requirements and by the risk of failing to obtain the quality required by the market. The last source of failure might also affect the magnitude of the rent extraction needed to let the 'efficient' farm type chose the contract for high quality standards, more or less justifying the retailer willingness to operate in the high quality standard market.

In summary, the inefficiencies generated by the presence of information failures depicted in figure 3 are: 1) the Principal income foregone because of the reduction of the expected efficiency of the contract bargained by the Principal with the 'inefficient' farm (area A); 2) the information rent extraction paid by the Principal to the 'efficient' farm in the form of a premium price (area B).

4.6. Retailer market strategies in response to different MQS scenarios

Without loss of generality, we come back to the first problem, section 4.3, where the only source of information failure is the impossibility by the principal to discriminate agents.

Differently for the former problems, the agents' profit function is now described by the following equations: $U_1(\overline{v},\overline{q}) = \overline{v} - \{[c_1(\overline{q}) + \alpha[c_1(\overline{q}) - c(q^{MQS})]\}$ and of $U_2\left(\underline{v},\underline{q}\right) = \underline{v} - \{c_2\left(\underline{q}\right) + \alpha[c_2\left(\underline{q}\right) - c(q^{MQS})]\}$. A compensation payment is included, $\alpha[c_1(\overline{q}) - c(q^{MQS})]\}$, where $0 \leq \alpha \leq 1$. This compensation payment is a cost for the principal and a revenue for the agent and is considered a minimum payment offered by the Principal to the Agent to compensate the adaptation costs faced by the same Agent to accomplish with contract requirements. Thus, the payment offered by the Retailer to the Supplier must compensate the costs faced by the Supplier to deliver the product plus and additional premium to motivate his engagement into the contract.

The magnitude of the compensation payment, $\alpha[c\left(\underline{q}\right) - c(q^{MQS})]$ is conditioned by the presence of public MQS level. It is assumed that if the supplier must accomplish with public MQS, then, part of the adaptation cots needed to accomplish with some PQS are already partially satisfied. Thus, it would be less costly for the Principal to compensate Supplier efforts. Under such hypothesis, with increasing MQS decreases the compensation payment. We remind that the compensation payment is a cost for the principal and a revenue for the agent and is considered a minimum revenue share achieved by the Principal and offered to the agent to let the agent subscribe the contract.

As for the problem in section 4.3, in the absence of perfect information, equation (2) must be maximized subject to equation (4) and (5) satisfied with strict equality.

The only difference from the previous problem is that the agents' profits take the form discussed in this section. Under such hypothesis, the equilibrium is then obtained by the following equation:

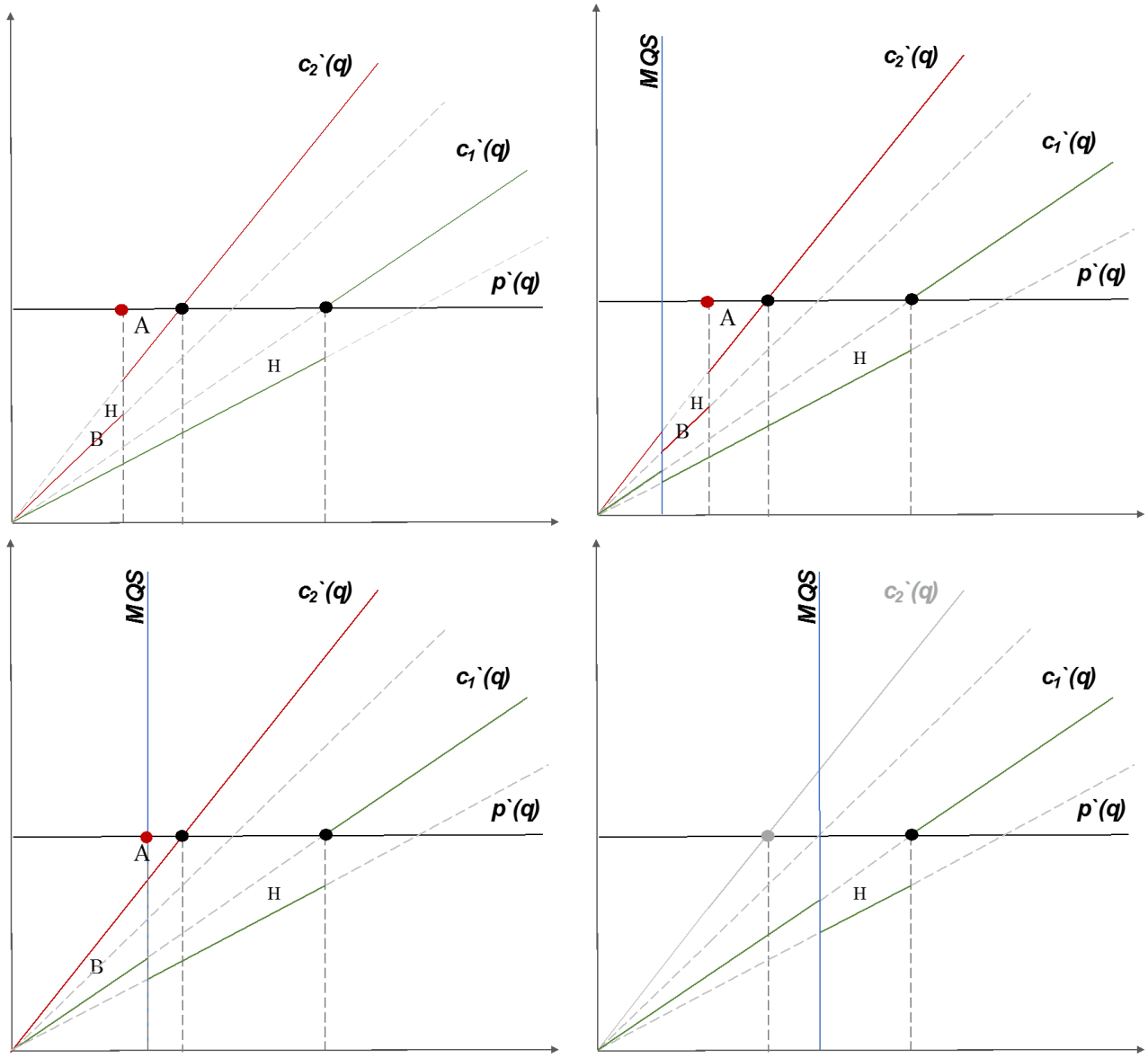
$$\begin{aligned} &\boldsymbol{g}'\left(\overline{q}^*, \pi(\overline{q}^*)\right) = (\mathbf{1}+\alpha)c_1'(\overline{q}^*), \\ &\boldsymbol{g}'\left(\underline{q}^*, \pi\left(\underline{q}^*\right)\right) = (\mathbf{1}+\alpha)c_2'\left(\underline{q}^{SB}\right) + \frac{\delta}{(1-\delta)}(\mathbf{1}+\alpha)[c_2'\left(\underline{q}^{SB}\right) - c_1'\left(\underline{q}^{SB}\right)] \end{aligned} \tag{16}$$

The compensation payment influence the equilibrium inducing the Retailer to slightly relax the condition contracted with both farmer' types.

Now we introduce an additional MQS constraint for both farmer' types:

$$\underline{q} \geq q^{MQS}, \qquad \overline{q} > q^{MQS} \tag{17}$$

With equation (17) we introduce a constraint implying that the quality standards defined by the retailer cannot be lower than the public MQS. The bonus offered to the agent is reduced by the fact that the agent must already comply with some commitments before entering into the contract. The MQS in Figure 6 i drives the Principal to set up its own standards as the introduction of such public standard it reduces the compensation payment needed to let the agent enter in the private scheme, area C. When the MQS is binding for the less efficient type, then the Principal willingness to introduce its own private standards might be inhibited. The Principal will be less able to discriminate contracts. As a result, the costs needed to incentivize farmers to enter in the private contract will increase, Figure 6 ii. With respect to Figure 3, the Principal cannot relax the condition contracted with the inefficient farm type because of legal constraints and the rent extraction needed to let the efficient farm type enter in the contract is maximized. Moreover, if the MQS are too severe, that is, higher than the quality standards reachable by the 'inefficient' farmer' type, it might happen that to let the agent enter n the contract, the Principal might need to share with the farmer some of the costs needed to enter in the market, area F in Figure 6 iii. The magnitude of this cost might then inhibit the Principal willingness to differentiate contracts, letting some farmers drop out of the contract. The consideration made so far will be further amplified if considering all the sources of information failure considered in the present paper.



$c_1`(q)$ – Cost function of farm's type 1

$c_2`(q)$ – Cost function of farm's type 2

$p`(q)$ – Principal revenues

A – Efficiency loss

B – Information rent extraction

MQS – Minimum Quality Standard

H – Compensation payment

● – first best contract requirements

● – second best contract requirements

Figure 6 - Graphical demonstration of second best optimal contract including the safety strategies of the retailer in response to the imposition of MQS.

5. Discussion

This deliverable addresses the issue of AI through two complementary approaches, i.e. expert based analysis and modelling, both supported by a consistent literature review. Each of this action is affected by several limitations, that are analysed in the following discussion.

As for the expert-based analysis, the primary limitation encountered relates to the small number of experts willing to participate into a Delphi exercise. This is remarkable, not only in comparison of the usual amount of experts required in order to develop a Delphi, but also in comparison of the variety of chain-specific information issues emerging from this study.

On this aspect, the experience carried out in the project highlighted indeed a clear practical and methodological difficulty in the expert selection and in using expert knowledge to meet the needs of understanding for this issue. Indeed, while there is a general recognition of the magnitude of information failure issue in the farming sector and in the food chain, it is very difficult to find experts capable and willing to deal with this issue. In fact, from the experience carried out emerges that few experts have a sufficiently wide frame of the problem to be able to contribute beyond a single very narrow topic. This is demonstrated also by the considerable number of respondents who have skipped specific questions related to information asymmetries.

In addition, the modelling exercise has several limitations. The main one concerns the fact that it focuses on a single step of a food chain. In reality, the problem of information asymmetries is wider and articulated affecting all actors along the agri-food supply chain: farmers, wholesalers and retailers, processors, consumers, third parties (quality agencies) and public regulator. In fact, the 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.

6. Conclusion: AI issues and modelling implications

This deliverable discusses the problems related to AI in food chains. The literature highlights different approaches and solutions; which one is the most suitable depends on the specific problem. In particular, in the case of quality attributes, the literature explores different options, but it is recognised that more insights are necessary to evaluate which possible solutions are better between actors at the beginning of the food chain (e.g. Between contracts 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 highly valued externalities or public goods, the role of Government enforcement is essential (Nicita et al., 2005). The 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, it emerges that the 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 ad

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 contracts able to segregate authentic claimers and then reduce adverse selection effect. Game theoretical approaches are used to model the adoption of certification system and monitoring systems along the food supply chain in response to moral hazard.

It can be observed that the literature on the topic of asymmetric information along the food supply chain in economic dedicated journal is not particularly extended, most likely due to the difficulty in performing formal studies on this issue. Also, because of the multitude of actors involved and of the multidisciplinary issues there are strong linkages with several other scientific fields besides economics.

The model-based empirical example reported here highlights first some well known feature of AI, notably the market collapse or underdevelopment of high quality production. This causes higher costs of the transactions. The models indeed highlights that solutions are possible but with a cost, in particular in terms of direct transaction costs and rents. In addition, the model highlights the interaction among different instruments and, in particular, how the possibility to define quality standards might be inhibited by the risk to suffer a market failure. This condition might threaten the competitiveness of some food chain.

The model highlights the main variables affecting the impact of AI: differentiation of costs among farmers and differentiation of failure possibility (independently from costs). At least the former can be considered as a good proxy of the likelihood of potential emergence of market distortions due to AI. Also, the degree of observability of the quality can be considered a good proxies. On the other hand, more differentiated WTP by consumers for higher quality levels on non-observable features can increase the effect of AI.

In addition, the model highlights how in presence of asymmetric information in order to prompt and guarantees a high quality product from high efficient producers is necessary to relax MQS for low efficient farmers, hence determining an introduction of lower quality product into the market.

The results also hint at the institutional issue of the role of intermediate chain actors in providing a segmentation in both direction of consumers and farmers and in ensuring the consistency between them.

The proposed model can be object of future developments and application to other actor of the food chain. In addition to quality aspects, it can find different applications regarding other food characteristics that comes from the application of unobservable practices; this can be the case of some ethical or environmental issues.

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Appendix 1

In the following solve the optimization problem first not considering the occurrence of adverse selection (case 1) and then considering the occurrence of adverse election (case 2) with the purpose to highlight the way how adverse selection may condition the quality policies of the cooperative.

Case 1 – Absence of adverse selection: both participation constraints are satisfied with strict equality, while incentive constraints are not binding:

$$\prod = [\delta(p(\overline{q}) - c_1(\overline{q})) + (1-\delta)(p\left(\underline{q}\right) - c_2\left(\underline{q}\right))] - \left[\delta U_1(\overline{q}) + (1-\delta)U_2\left(\underline{q}\right)\right]$$

$$U_1(\overline{q}) = 0$$

$$U_2\left(\underline{q}\right) = 0$$

$$\prod = [\delta(p(\overline{q}) - c_1(\overline{q})) + (1-\delta)(p\left(\underline{q}\right) - c_2\left(\underline{q}\right))]$$

$$\boldsymbol{p}'(\overline{q}^*) = c_1{}'(\overline{q}^*), \qquad \boldsymbol{p}'\left(\underline{q}^*\right) = c_2{}'\left(\underline{q}^*\right)$$

Case 2 – Occurrence of adverse selection: μ is the shadow prices for the quality of the product attributed by the efficient supplier; λ is the shadow prices of the rent extraction caused by the inefficient supplier.

$$\prod = [\delta(p(\overline{q}) - c_1(\overline{q})) + (1-\delta)(p\left(\underline{q}\right) - c_2\left(\underline{q}\right))] - \left[\delta U_1(\overline{q}) + (1-\delta)U_2\left(\underline{q}\right)\right]$$

$$U_1(\overline{q}) = U_2\left(\underline{q}\right) + \Delta U\left(\underline{q}\right)$$

$$U_2\left(\underline{q}\right) = 0$$

$$\prod = [\delta(p(\overline{q}) - c_1(\overline{q})) + (1-\delta)(p\left(\underline{q}\right) - c_2\left(\underline{q}\right))] - \delta U\left(\underline{q}\right)$$

$$p'(\overline{q}^*) = c_1{}'(\overline{q}^*), \qquad \boldsymbol{p}'\left(\underline{q}^{SB}\right) = c_2{}'\left(\underline{q}^{SB}\right) + \frac{\delta}{(1-\delta)}\left[c_2{}'\left(\underline{q}^{SB}\right) - c_1{}'\left(\underline{q}^{SB}\right)\right]$$

Annex 1: WP3 On-line questionnaire

Copy of Market Imperfection- Asymmetric information

Welcome to SUFISA Survey

Thank you for participating in our survey. Your feedback is important.
The aim of this questionnarie is to collect expert opionions on the imperfect information related to safety and quality food attributes in the Agri-food supply chain. The questionnaire consists of two parts: A and B. We aim to have part A complete. If you have the chance you can proceed filling part B.

Copy of Market Imperfection- Asymmetric information

Part A

1. Personal data (will be treated anonymously)

Name:	
Gender:	
Age:	
Country:	
Level of education:	
Job Position:	
Sector:	
Years of working experience:	
At which stage of value chain: Producer-Processor-Distributor-Consumer	

2. Professional experience as?

3. In your sector, what are main market imperfections affecting competitiveness of the agri-food supply chains?

	Fruit & Vegetables	Olive oil	Sugar	Cereal	Meat	Milk	Wine
Market power	☐	☐	☐	☐	☐	☐	☐
Price transparency information	☐	☐	☐	☐	☐	☐	☐
Transaction costs	☐	☐	☐	☐	☐	☐	☐
Lack of transparency information on quality	☐	☐	☐	☐	☐	☐	☐
Lack of transparency information on safety	☐	☐	☐	☐	☐	☐	☐

Other (please specify)

4. Can you briefly report non-compliances that mostly affect competitiveness in your sector/commodity?

5. In your sector, which of the following parameters are mostly affected by non-compliance during purchasing?

	Food Quality	Origin	Ethic	Food Safety	Stage of supply chain
Product supply chain					

Other (please specify)

6. Can you report some of main issues related to quality and/or safety non-compliance based on geographical distribution (please specify the location you are referring to)

In your region	
At European level	
At world level	

7. In your sector, which of the following solutions seem more effective in reducing non-compliance for quality and safety aspects.

	Agricultural production	Processing of raw material	Industrial transformation	Distribution	Consumer
Contract	☐	☐	☐	☐	☐
Certification	☐	☐	☐	☐	☐
Vertical/Horizontal Coordination	☐	☐	☐	☐	☐
Regulatory enforcement	☐	☐	☐	☐	☐
Traceability	☐	☐	☐	☐	☐

Other (please specify)

Thanks for your contribution so far. The part A of the questionnaire is terminated, if you have time and you are interested in providing your insights on aspects related of contract, certification and form of cooridnation, you can procede in filling part B of the questionnarie.

SUFISA

Copy of Market Imperfection- Asymmetric information

Part B

8. Which is the most common form of transaction for famers?

Please specify for which type of product

9. Is the use of written contract mandatory in your sector or country?

- ☐ Yes
- ☐ No

10. Do you think that the adoption of written contract can

- [ ] Contrast imbalance power between retailer and farmers
- [ ] Ensuring quality or safety aspect
- [ ] Ensuring constant supply to processor
- [ ] Reduce risk for farmer
- [ ] Ensuring farmer income
- [ ] Other (please specify)

11. How often, in your sector of expertise, deferred payment to famers occurs in the transaction

Never	Seldom	Sometimes	Often	Always	N/A
☆	☆	☆	☆	☆	○

12. How often deferred payment to famers occurs in the transaction

- ○ Never
- ○ Seldom
- ○ Sometime
- ○ Often
- ○ Always

13. Is this aspect formalised in a written contract?

- ○ Yes
- ○ No
- ○ Other (please specify)

14. In written contract which of these aspects are made explicit:

- ◯ Price
- ◯ Quality
- ◯ Safety
- ◯ Origin (PDO, PGI, etc.)
- ◯ Ethic
- ◯ Quantity
- ◯ Payment modality
- ◯ Delivery
- ◯ Other (please specify)

15. Can you report parameter constrains required by contract for a product of your knowledge? (ex. for quanlity fruit size, for quantity tons fo product, for safety level of contaminat...)

Please specify the type of product	
Parameter for Quality	
Parameter for Safety	
Parameter for Origin	
Parameter for Ethic	
Parameter for Quantity	
Parameter for Payment modality	
Parameter for Delivery	

16. Are inspections and standard requirement levels sufficiently strict to assure consumers? (please report also the type of parameter you are referring to)

17. How much high is the frequency of false authentic?

- ◯ 0%
- ◯ 25%
- ◯ 50%
- ◯ 75%
- ◯ 100%

Please, specify type of product and parameter to you are reffering to

18. How much high is the frequency of inspection failure (detection of false claim) from producer side?

- ◯ 0%
- ◯ 25%
- ◯ 50%
- ◯ 75%
- ◯ 100%

Please, specify type of product and parameter you are reffering to.

19. Which certification type are mostly requested to farmers in your sector in order to engage in contract?

	Certification	Sector
Requested from Industrial Processor		
Requested from Retailer		
Requested from Consumer		

Other (please specify)

20. Is horizontal coordination relevant for contrasting Asymmetric Information?

- ◯ Yes
- ◯ No

Please specify which type of coordination form?

21. Is vertical coordination relevant for contrasting Asymmetric Information?

- Yes
- No

Please specify which type of coordination form?

22. Is the role of Cooperatives relevant for farmers in your country as a form of coordination?

- Yes
- No

23. Besides Cooperative which are other forms of coordination relevant in your country?

24. For which of the following aspects the role of cooperative is important:

- Reduce Market power of processors/retailers
- Solve/reduce safety issues
- Solve/reduce quality issues
- Stability of supply for processors
- Technical support for farmers
- Storage of raw material
- Increase price stability

We would like to express our gratitude for your attention and collaboration. If you would like to be informed on findings of this research please leave your e-mail

25. e-mail: