Economic aspects of segregation between GM and non-GM Crops along the Food Supply Chain

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Abstract

This work provides a methodological framework for the analysis of the Italian supply chain for non-GM soybean meal, with particular regard to the upstream stages between overseas producers, international traders and feed manufacturers. Using the information collected from a set of interviews with industry representatives, we describe the organizational arrangements that agents adopt to minimize transaction costs. Consistently with transaction cost economics, we examine the impact of asset specificity and uncertainty on the coordination arrangements. We focus on two dimensions of uncertainty, namely: product-quality uncertainty and environmental uncertainty. We argue that the actual organizational arrangements between transactors are consistent with the theory: whereas product-quality uncertainty and some degree of asset specificity would lead to vertically integrated forms of governance, environmental uncertainty operate in the opposite direction.

1. Introduction: the market for non-GM products

The worldwide area dedicated to GM crops has been steadily increasing over the last 20 years and to date more than 150 million hectares are devoted to these varieties (Kalaitzandonakes, 2012). In countries where these technologies are available, the rate of adoption is generally high. According to data provided by the USDA, the United States, with 69.5 million hectares of genetically modified crops planted in 2012, are the largest GM crops producer in the world. Brazil is the second largest producer, with nearly 36.6 million hectares of genetically modified maize, soybean and cotton in 2012/2013 marketing year. The adoption rate of GM soybean reached 85% in 2011/2012 (21 million hectares), whereas the share of GM cotton was about 32% (490,000 hectares) and that of GM maize 67% (almost 10 million hectares). By July 2012, Brazil had 34 genetically engineered crops approved: 19 maize varieties, 9 cotton and 5 soybeans. Argentina is the third largest producer of GM crops: almost 15% of GM crops world production. The country´s area dedicated to GM crops was 23.6 million hectares in 2011/2012:19 million hectares for soybean GM varieties, 4 million hectares for maize and 575.000 hectares for cotton. Almost all the soybean and cotton area is planted with GM varieties, while 92% of the maize area is cultivated with GM varieties. Overall, there are 24 GM varieties approved in Argentina, including 3 soybeans, 8 maize and 3 cotton (USDA, 2012). Although these figures provide a clear picture of the adoption of GM varieties around the world, most data refer to the supply side of the market. in particular, data from farmer surveys and projections from seed sales can provide an accurate estimate of the cultivated area (Kalaitzandonakes, 2012). Nonetheless, the conversion of production data into volumes of downstream derivatives is not an easy step: one of the main issues is related to the fact that part of the non-GM production may be marketed as GM because of some marketing difficulties. Data regarding the production volume of Identity Preserved (IP) non-GM crops are even more challenging to derive: in addition to the former problems, non-GM IP crops require stricter and tighter control over the supply chain, the endorsement of a third party certifier and a deeper commitment of all parties involved. That is, the supply of non-GM crops provides a blurred figure of what the size of the non-

GM IP crops market could be. Therefore, most estimates rely on trade data, although they mostly provide upper limits rather than ranges (Kalaitzandonakes, 2012). Available information shows that the demand for non-GM crops in the three most relevant destination markets (EU-27, South Korea and Japan) remained stable over the last ten years. According to the European feed industry association (FEFAC), non-GM feeds account for almost 15% of the EU compound feed production. Poultry is the sector with the strongest demand for non-GM feed, as a significant part of poultry meat is sold under some sort of quality labels (i.e. organic) that require non-GM feeding. The European Union is almost self-sufficient for maize; only 10% of the internal consumption relies on imports, nearly 6.2 million of metric tons (MMt), 75% of which (4.65 MMt) are non-GM, originating mainly from Ukraine and Brazil (USDA, 2012). Instead, the European Union is a net importer of soybeans and soybean meal, with non-GM varieties mainly imported from Brazil. Although the rate of adoption of GM corn and soybean varieties in Brazil has been steadily increasing over the last few years, this country is still the largest world exporter of non-GM soybean and maize products mainly towards EU-27, Japan and South Korea. India and China are also large producers of non-GM soybean, but they do not contribute to trade: China does not export soybeans at all, mainly because of the large internal demand for protein feedstuff, while safety issues hinder India from exporting soybean meal (Tille et al., 2012). Italy, like many other EU member states, does not allow the cultivation of GM crops, which makes the national production of maize and soybean 100% non-GM. Nevertheless, Italy is the first European producer of soybeans but, similarly to other member states, it relies heavily on international markets for soybean meal in order to satisfy the internal consumption, primarily from compound feed producers. Data on Italian soybean meal imports show that Italy imports were up to 2.15 MMt in 2010, 170,000 non-GM (hard IP); given a national production of about 1.315 MMt in 2010, 361,260 tons from (non-GM) domestic seed crushers, the availability of non-GM soybean meal amounted to 531,260 tons. None of the imported soybean meal is soft-IP. Given a national consumption of 3,5 MMt in 2010, the domestic non-GM soybean meal production satisfies only 15% of the demand. Italy imports non-GM soybean meal mostly of from Brazil. Roughly 95% of the imported maize (1.9 MMt in 2010) comes from other European countries, with the largest share from Germany and France, where GM varieties are not allowed. Only 5% of imported maize is from Ukraine and Latin America and it is not clear whether this product is non-GM. Imports of non-GM soybeans are basically zero; only in years of scarce domestic harvests imports may turn positive and significant.

2. Survey

We investigated the structure of the Italian supply chain for maize and soybean through a number of vis-à-vis interviews with representatives from enterprises which were considered as the most relevant to the production systems. Each interview lasted between 2 and 3 hours; case by case, questions were organized in a framework developed on the basis of a deep and comprehensive review of the available literature regarding the structure, the organization and the governance of the supply chain (for GM and non-GM crops) (Boccaletti et al., 2012). This framework consisted of two broad and structured questionnaires, addressed to investigate the upstream and the downstream part of the supply chain. Downstream respondents were experts and representatives from the feed, retail, soybean crushing and livestock breeding industry, those involved in upstream operations were primarily from large international trading companies and port operators. The questionnaires were pre-tested with market experts, resulting in modifications of the questions. These market experts were mainly from associations of producers, therefore with deep knowledge of the feed industry and its major trends. The first questionnaire, which intended to investigate the downstream part of the supply

chain, is structured into six sections. The first section refers to the vertical and horizontal structures of the supply chain and asks also some preliminary details on market concentration and vertical integration. The second section considers the market for primary processed maize and soybean as well as the market for compound feed, listing questions on trade data and domestic production volumes. Sections three and four focus on the governance aspects of the supply chain, including terms of trade among actors and pricing mechanisms. The last two sections are dedicated to the market and management of non-GM segregated products along the supply chain and to the role of certifiers. The questionnaire for the upstream operations was actually more difficult to build and validate. Following the lack of information regarding how international traders organize their transactions and manage product and information flows, we faced a certain degree of uncertainty in drafting the framework. For example, we haven't been able to pre-test it, and therefore we made progressive adjustments as the interviews proceeded. The questionnaire is structured into four sections, The first section identifies how the product and information flows are shaped, with emphasis on contractual arrangements and liabilities. The two following sections investigate the operations and responsibilities at the port level whereas the final section refers to the physical transportation of the product from the origin to the destination country.

In this work we decided to focus primarily on the upstream portion of the supply chain. Figure 1 provides a representative flowchart of these exchanges. Based upon the information obtained from representatives of international trading companies, our aim was to describe the transactions between major overseas producers of non-GM soybean meal, international trading companies and domestic producers of non-GM feed. The management of product and information flows from the field to the export terminal together with the following unloading and storage phases in dedicated facilities at the destination port are the key steps for segregation between GM and non-GM commodities (Aquino et. Al, 2010; Co-Extra, final report, 2009) . Therefore, we concentrated on two main transactions: the first between two Brazilian corporations (which aggregate non-GM soybeans and produce non-GM soybean meal) and the main international traders; the second between international trading companies and national feedstuff producers.

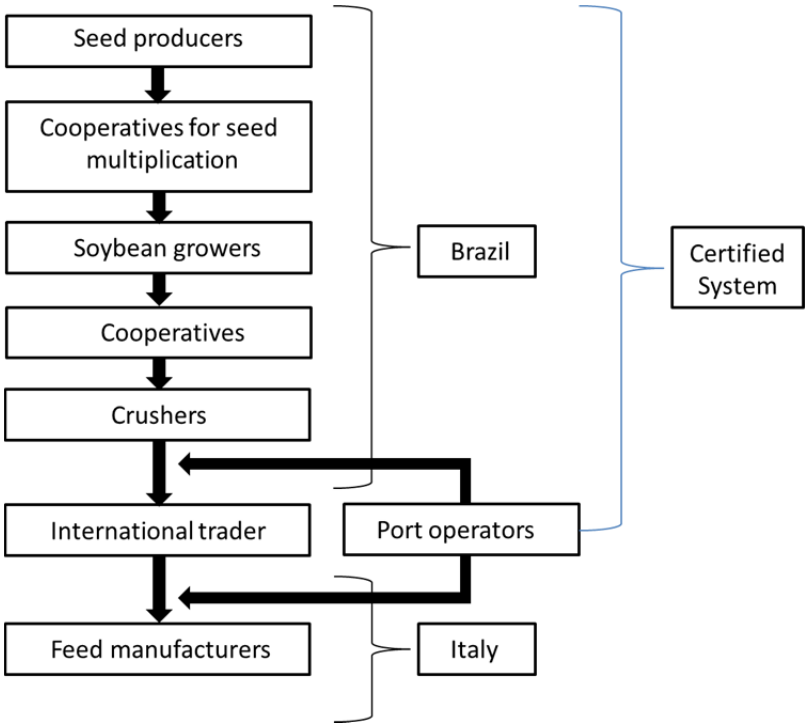

Figure 1. The Italian supply chain for soybean meal. Source: Personal interviews, 2012.

3. Methodology

Building upon Williamson (1975, 1979, 1981, 1991) and Ménard (1996, 2004, 2005, 2010) , we aimed at organizing the information from the interviews using a Transaction Cost Economics (TCE) approach. The objective is to describe the nature of the relationships between an upstream actor and a downstream one through the analysis of the determinants of economic organizational structures, namely: asset specificity and different types of uncertainty. The core of the theory refers to whether a transaction is performed more efficiently within a hierarchical structure (i.e. within a firm) or by unrelated agents (i.e. market governance); the scope of the analysis relies on the transfer of goods and services. How this transfer occurs is the main outcome of interest. TCE also asserts that agents carrying out transactions are rationally bounded, risk neutral and in some cases they behave opportunistically in presence of asymmetric information. Although the neoclassical perspective of transactions considers market governance as more efficient than vertical integration because of the role played by competition and the reduced burden of bureaucracy, certain dimensions of transactions and the above mentioned characteristics of economic agents, may lead to market failures. The specificity of the assets involved (transaction-specific assets), the frequency of the transaction itself and the level of uncertainty (which is mainly related to the bounded rationality and opportunistic behaviour of the agents involved) represent the three main dimensions which may cause markets to fail in representing the most efficient environment for transactions. Market fails because transaction costs arise, making transactions through pure market governance inefficient; these costs refer to search for ex-ante information, ex ante and ex-post monitoring costs. Market failures suggest that, for some degree of asset specificity, uncertainty and frequency of the transaction, hierarchical structures could perform better than markets. Williamson defines three main economic organizations under which transactions can be established: market, hybrid forms and hierarchy. Hybrid forms are organizations between the market governance and hierarchical structures; according to the core of TCE, all hybrids share some common characteristics. In particular, Ménard (2004) emphasizes the following three.

Resource pooling: whatever the hybrid form is, the agents involved converge in organizing their activities through inter-firm cooperation and coordination, so that investment decision relevant to the exchange are made jointly. The choice of the partner becomes a central issue.

Contracting: coordination relies mostly on contracts, which differ by nature.

Competition: parties within an hybrid form often compete against each other and also tend to compete with other arrangements. Formal mechanisms to discipline partners, solving conflicts and avoiding free-riding become crucial.

Menard (2004, 2010) revisited the diversity of hybrid organizations proposed by Williamson, providing the idea that the decision to adopt one form of hybrid organization over another is linked to the logic of transaction costs (Réviron and Chappuis, 2005). Hybrid forms based on trust (which operates as a weak form of governance) are those which are closest to the market governance; on the other hand, formal governance includes hybrid forms sharing more characteristics with hierarchies than with market governance. Relationships characterized by trust fit with a low degree of assets specificity, while formal governance structures are associated with higher investments in transaction-specific assets. Between these two forms of hybrid organizations we may find relational networks and leadership: the former, differently from trust, presents formal rules which formally define the relationship, the latter is a hybrid form coordinated by a leader with a key position along the supply chain.

Concerning the three dimensions which drive transaction costs, the classical TCE view (Williamson, 1991) emphasizes the predominant role of asset specificity in determining the properties of the economic organizations for transactions. Asset specificity refers to the degree to which the assets employed within a specific transaction can be redeployed for other uses without sacrificing productive value. According to the main theory, as asset specificity increases, redeployability gets lower and interdependency between parts increases, fuelling opportunistic behaviour under market governance. In his review on the diversity of hybrid forms, Menard (2004) supports the hypotheses that the most important property affecting the form of alignment between parties is the degree of specificity of the assets involved.

A second important dimension is uncertainty: this transaction costs determinant arises either when the relevant contingencies surrounding a transaction are to a large or small extent unpredictable to be formalized into an ex-ante contract, or when performances cannot be easily predicted and verified ex-post. The issue of uncertainty on quality is central to the supply chain for non-GM goods. Uncertainty in transactions where the quality of the goods involved is relevant originates from a problem of information asymmetry between agents; the lack of information affects primarily the buyer, unable to identify 'plums' from 'lemons'. According to Akerlof (1970), with information asymmetry the weak side of a transaction (the buyer) faces a "moral hazard" problem and faces a higher risk of finding a bad partner. Additionally, information asymmetry protects bad partners if they cannot be easily separated from the good ones (Révion and Chappuis, 2005). Some authors recognize several types of uncertainty: environmental uncertainty, behavioural uncertainty, technological uncertainty (i.e. uncertainty related to product's quality) and volume uncertainty (Walker and Webber, 1984). Williamson (1991) also states that the role played by uncertainty on the degree of vertical integration or coordination is related to the degree of specificity of the assets. That is, increased uncertainty in presence of a nontrivial degree of asset specificity suggests that continuity between the transacting parties becomes important and adaptive capabilities are necessary, thus rendering market governance less preferable than other organized structures (i.e. firms or hybrids). Nonetheless, hybrid forms, in presence of transaction-specific assets, are perceived as less valuable as uncertainty gets larger. In fact, hybrid adaptation is bilateral in nature but mutual consent is hard to achieve with very high levels of uncertainty. However, there are several studies addressing the role of uncertainty without accounting for its interaction with asset specificity, or at least they do not focus on the combined effect of uncertainty and assets specificity. These studies try to understand whether uncertainty may cause either hierarchical or market oriented organizations independently from the specificity of the assets involved (Ashwin et al., 1999; David 2004; Geykens, 2006; Lee et al., 2009; Wei et al., 2012). In the case of segregated supply chains for non-GM goods, we expect uncertainty to play a key role in shaping the organizational forms by virtue of the higher transaction costs generated by both market conditions (price changes, total transaction volumes, characteristics of the demand) and agents' behaviour (suppliers' unpredictability, regulatory uncertainty) (David and Han, 2004). Consistently with TCE (Ménard, 2010), prior research (Jap, 1999; Klein et al., 1990) supported the effectiveness of hybrid forms of governance in presence of a nontrivial (but not very high) level of uncertainty; in fact, uncertainty renders both market governance and hierarchies less effective and the adoption of hybrid organizational structures may mitigate the problems of evaluation and monitoring caused by uncertain environments (Ashwin et al., 1999; Lee et al., 2009). This is particularly true when it comes to uncertainty related to market turbulence and unpredictabile demand and supply conditions (Ashwin et al., 1999; Lee et al., 2009; Wei et al., 2012). Considering uncertainty in marketing products with different qualitative levels, buying goods requiring a minimum quality standard through the market forces the buyer to entrust the supplier and to accept the risk, since the quality level depends exclusively on the latter. Whereas different forms of signalling could help the buyer in a preliminary selection of the suppliers, the goodwill

between transactors must be guaranteed with a specific organizational structure able to avoid opportunism and cheating (Réviron, 2000). In this case, non-trivial level of uncertainty calls for a tighter control of the buyer over the supplier.

Transactions characterized by a very high level of uncertainty are less likely to be organized in hybrid forms, since mutual consent is generally not feasible (Lee et al., 2009). In fact, as uncertainty gets larger, hybrid organizations have to deal with major coordination issues: this translates into a higher effort for accommodating adaptation (in order to keep flexibility), control (in order to maintain the process unaffected) and incentives (to prevent opportunistic behaviour). In that case, either unilateral forms of governance (Wei et al., 2012)or market-oriented structures are preferred to hybrid forms of governance[1]. However, some authors (Ashwin et al., 1999) assert that, being the organizational structures dynamic dimensions, this sharp distinction is actually poorly defined and changeable.

In this work, we mainly focus on the role played by the different types of uncertainty in shaping the organizational structure of the transaction between Brazilian providers, international traders and Italian feedstuff manufacturers.

		Transaction Costs		
		Market governance	**Hybrid**	**Hierachy**
Transaction Specificity of Assets	*High*	++	+/-	-/--
	Low	-/--	+/-	+/++
Quality-related Uncertainty	*Low*	--	+/-	+/++
	Non-trivial	+	--	+
	High	++	+	--
Environmental Uncertainty	*Low*	-/--	-	+
	Non-trivial	+	--	+
	High	-	++	-

Table 1. Theoretical expectations.

4. Supply chains for Non-GM soy meal

In order to reduce quality-related uncertainty, Brazilian producers of non-GM soybean meal, the international trading company and feed manufacturers have developed an organizational structure which relies on highly formalized contracts and provides for a traceability and certification system covering all the steps along the supply chain, from Brazilian growers to Italian port operators. The upstream part of the chain is built and validated by large international certification bodies in partnership with the Brazilian crushers and represent a necessary feature for the product to match the requirements from Italian feed manufacturers.
In one of our case study, the Brazilian crusher established partnerships with individual farmers and wholesalers that implement the segregation of non-GM soybeans. The certifier approves the soybean meal as

[1] Refer to table 1 for a review of the determinants of transaction costs and their impact on within different organizational arrangements, .

non-GM by certifying each stage of the traceability and monitoring system, including: production and multiplication of seeds, grain production, industrial processing and delivery for export.

- At the seed production and multiplication stage, the crusher inspects and approves the entire process through a set of activities that ranges from the production of seeds by companies authorized by the Ministry of Agriculture, to the distribution of the seeds to soybean growers. Seeds multiplication is carried out by specialized cooperatives. The company is also in charge of monitoring the distribution of the seeds from the cooperatives to multipliers, seed planting, seed harvest and storage in dedicated silos.
- Grain production is also inspected and approved by the crusher; at this stage the task of the Brazilian company is not limited to monitoring and includes testing procedures for the absence of GM events. Transportation of the harvested soybeans is a sensitive step of the production system and implies systematic strip testing on chronologically numerated batches. All the information is recorded and maintained for system certification.
- Industrial processing involves samples collection every two hours, as soybeans are unloaded into the processing plant. Twice a week, composite samples are PCR-tested at an accredited laboratory. Composite samples are to be kept for one year.
- The crushing company's monitoring activity intensifies in the last stage, because the risk of contamination of non-GM products with other loads at the port terminal is very high. Certified procedures for export include: sampling when trucks are loaded; machinery and personnel cleaning before truck unloading or ship loading operations; daily physiochemical test on composite samples[2]; the issue of one Transaction Certificate of Compliance for each shipload; once the product is loaded on the ship, one further sample is taken for PCR analysis to certified laboratories: results are disclosed while the vessel is still on its way to Europe. The Brazilian crushing company eventually forwards product certification papers to the trader, who requires such documents (in addition to any other formal document the company might require) when the payment is done (Pelaez et al., 2010).

On his part, the international trader must deploy a system which guarantees the compliance with the 0.5% threshold required by Italian customers. The trader is responsible for ship's hold cleaning and inspection before the meal is loaded and tested. Cooperation and coordination between the parts involved in these activities is crucial for achieving a low level of presence of GM events into the cargoes.
Product management at the destination port is another critical step, and the implementation of best management practices helps to avoid commingling and adventitious presence. Therefore, it is important for international dealers to rely, on the one hand, on process-certified terminals and, on the other hand, to coordinate the activities of any actor involved in port operations, namely: terminals, shipping agents, port supervisors and finals customers. In particular, terminals are bound to employ dedicated cells, properly cleaned before non-GM soybean meal is being loaded; besides, terminals are also required to unload products by means of dedicated vacuums and blades. Last, terminal's operators (and any other port operators involved in handling these products) shall be trained so that they could manage both GM and non-GM products, avoiding the two products to mingle with each other. Port elevating can be operated by the terminal

[2] Composite samples are homogenized and then strip tested. If tests turn out positive, samples are individually tested for batch identification.

itself or multinational trading companies can lease it to other structures: what is important is that GM and non-GM batches are stored in dedicated facilities with shipping documents kept separately in order to avoid products misplacement. When the product approaches Italy, the trading company arranges to unload non-GM dedicated ship's holds in certified terminals, storing the product into certified warehouses. The product certification that the international marketing company requires from upstream producers has no legal value in Italy and the trading company is liable if the product does not match the agreed threshold, at least down to the loading on feed manufacturers' trucks. Although upstream documents are eventually forwarded to the final customer (with any other certificate that the trader received at the ship load point), the imported product receive no further certifications. As a consequence, the international trader, together with port terminal managers, shipping agents, port supervisors and finals customers, jointly signed a protocol for the management of non-GM products which extends from inbounding vessels to truck delivery. This protocol is perceived as a valuable asset by international traders' most important customers. Additionally, PCR tests are eventually carried out when the meal is warehoused at the destination port; these cross tests are carried out on a behalf of international trader's customers prior the purchase and before the product is loaded on trucks and moved to storage or processing facilities. Cooperation and coordination between all the actors involved in these activities is once again crucial to guarantee an acceptable level of presence of GM events into the dispatched cargo.
Customers are responsible for transportation from the port to the processing facilities and to any further stage.

5. Factors of uncertainty: hypothesis and results

5.1 Quality

When we refer to product quality, we consider non-GM IP products as goods with higher quality compared to conventional ones. It is not our purpose to discuss whether the actual quality of non-GM IP soybean meal is effectively higher than its GM alternative; however, since the former requires higher investments in product quality management (i.e. coexistence measures at field level, segregation practices for harvesting, transportation, crushing, etc.) and receives a higher price, we made the distinction based upon the extra costs necessary to give the non-GM IP status to a batch of soybean meal.The uncertainty related to product quality refers to the risk of commingling the non-GM IP soybean meal with a GM one. In this context, commingling would translate into a downgrade of the product's qualitative status, with several economic consequences for the entire supply chain.

Consistently with the theory concerning information asymmetry and product quality, we recognize the following cases:

- Upstream risk of commingling: the primary risk that international traders must protect themselves against are: incurring in a batch containing more than 0,5% of EU-approved GM events (the threshold level required by the international trader when purchasing non-GM soybean meal from Brazilian producers), getting a batch containing unapproved GM events or containing more than 0.9% of EU-authorized GM events. If tests for unapproved GM events are positive, if the product was intended for the European market, the ship can still change its destination while surfing the

ocean[3]. The international trader has to find quickly an alternative non-European destination for the product to avoid a long stop at the dock (in-port daily costs are very high); moreover, the product is usually sold at a lower price. The price could be even lower if a backup destination is not promptly available and the product needs to be sold as soon as possible. On the other hand, if the GM events in the batch were approved ones, then the product is still marketable in Europe, at a lower price. The reduced price is not enough to cover the additional management costs for the segregated supply chain uncovered.

- Downstream risk of commingling: the international trader is still liable in the case of non-compliance with the threshold required by the buyers at the destination port. Even if the international trader purchased the product with a presence of GM events less than 0.9%[4] (i.e. the legal threshold adopted in the EU), the threshold required by feed manufacturers at the destination port is usually 0.5%. Consequently, the international trader reduces the risk applying the lower limit of 0.5% to the Brazilian producers. If the content of GM events in the soybean meal batch in the destination port is above the threshold, the trader is bound to market the product as GM to other potential customers. If the product has already been unloaded, the trader has also the costs of stowing and maintaining the product in dedicated warehouses. Non GM feed manufacturers bear the risk of marketing a product with a presence of GM events greater than the legal threshold. In this case, the batch would be typically sold to other customers at lower prices with a loss in terms of trust and reputation. On the other hand, if the feed manufacturer is integrated downstream, the economic loss is related to the temporary shortage of feed; this forces the company to buy non-GM feed directly from the market at higher prices. In both cases, the production process is interrupted and plants require careful cleaning with further delays.

Uncertainty related to product quality may cause relevant monetary and non-monetary losses borne by non-compliant agents, but with negative spillovers also on other steps of the supply chain. Therefore, the negative economic impact at stake calls for organizational arrangements able to reduce this uncertainty.

With reference to our methodological framework, we expect a non-trivial level of uncertainty to be controlled through hybrid organizational structures. However, as quality uncertainty changes from a non-trivial degree to a high one, the effort to maintain the process unaffected is such that the buyer has a strong incentive to adopt a tighter organizational form, stricter than just the hybrid one.

5.2 Environmental factors

Besides the uncertainty based on quality, we recognize other types of uncertainty which are mainly linked to environmental factors, i.e. to unanticipated changes in the circumstances surrounding the buying firm, with firms unable to write and enforce contracts which account for all future contingencies (Lee, Yeung, and Cheng 2009). We call this environmental uncertainty (Walker and Webber, 1984; David and Han, 2004):

- Supply-side uncertainty: As we already stated in the first section of our work, the availability of non-GM soybeans has been steadily decreasing over the last decade, with the main

[3] The product is PCR-tested before it is loaded on ship's holds at the destination port. Test results are eventually available when the vessel is under way.

[4] This value represents the legal threshold below which the product has not to be labelled as GM (Reg. 1829/03).

international producer (Brazil) increasing the area under GM soybean varieties up to 80% of the total soybean area (or even further). The availability of non-GM soybean meal for international traders and domestic feed manufacturers is primarily related to the opportunity cost of producing GM soybean products by Brazilian farmers and processors. Several factors affect costs, ranging from the management of the supply chain, to the price differential between GM and non-GM soybean meal resulting from the market gap between the increasing demand for GM soybean, especially from China and India, and a steady supply. The availability of non-GM product generates an opportunity cost issue also for the international trader. In fact, the shrinking dimension of such market niche would further reduce the already low logistic efficiency (Source: interview, 2012) along the supply chain of non-GM goods and, on the other hand, the uncertainty at the demand level may sustain the decision to market GM soybean only, especially with a strong demand for conventional products from developing countries. Domestic non-GM feed manufacturers are bound to own or retailer-driven technical specifications and, more generally, to specific supply chains for non-GM feedstuff to supply non-GM livestock breeders (Soregaroli et al., 2013). Being part of this particular supply chain may reduce the incentive for feed producers to switch to GM feed. However this would highly depend on the availability of substitutes for the non-GM IP Brazilian soybean meal. This issue is to date highly debated at the European level (Tille et al., 2012).

- Demand-side uncertainty: Estimating the demand for non-GM products is a challenging task as there are no relevant evidences regarding the consumer's willingness to pay. Moreover, existing figures regarding the awareness of European consumers towards both biotech crops and food derived from GM varieties are largely inconsistent across member states (Tille et al., 2012). This uncertainty affects the incentive of upstream actors to switch to GM since the monetary and organizational costs to maintain segregation might become no longer sustainable in the long run. In this uncertain scenario, the decision to switch to GM could be the best. The availability of non-GM soybean can be considered an endogenous variable when used as a predictor for the demand of non-GM products.
- Price uncertainty: it results from demand-side and supply-side uncertainty. Hand in hand with the attitude of European customers towards genetically modified organisms, the retailers play a central role on the pricing mechanisms: it is unlikely that retailers fully transmit the price differential between GM and non GM raw materials downstream, as the WTP will unlikely cover this gap. Therefore, the price differential must be borne by some other actors along the supply chain; these with less market power will probably gain lower profits (i.e. livestock breeders). To date, we are not able to figure out to what extent the premium paid for non-GM raw material could increase without being an excessive burden for the supply chain and how it affects the retailer's marketing strategies concerning non-GM food. The contract between the international trader and the Brazilian provider of non-GM soybean meal provides for a premium price corresponded for the non-GM status itself. Since there is not a reference market for such premium it results from a negotiation process s. The negotiation is based on several factors: the international price for soybean, the availability of non-GM soybean at the world level, the costs associated to the segregation techniques and the determinants of the demand for such goods. The outcome of the negotiations is uncertain, although its main predictors provide an estimate of the final premium. Clearly, price premiums have been increasing over

the last few years as the global supply for non-GM soybean has been steadily shrinking; that is, besides the pure market effect of this contraction, one shall also account for the drop in logistic efficiency when moving such products throughout the globe. However, although the structure of the supply for non-GM soybeans provides some insightful information regarding the trend of this premium price, the demand-side effects are less clear, as the willingness to pay for non-GM food is a topic that still needs to be further addressed. Moreover, estimates of the demand price elasticity for non-GM food are also missing. That is, the derived demand at the trader level is less predictable with respect to the supply and the gap between the two may generate price uncertainty for non-GM goods.

The international price of conventional soybean meal represents the basis for non-GM soybean price calculation. The demand for GM product from emerging countries is one of the key drivers of the opportunity costs that Brazilian producers face when they choose to produce non-GM soybean meal. The combined effect of the non-GM soybean meal price components may have an impact on the demand price elasticity, thus on the market served by the international trader.

Consistently with our methodological approach, we predict the appearance of hybrid forms ofgovernance for a non-trivial level of environmental uncertainty. Nonetheless, as uncertainty moves from a non-trivial to a high level, hierarchical and hybrid governance forms are less adaptive to the uncertain market conditions. Therefore, in this case, a more market-oriented governance form would be preferable.

6. Organizational and managerial implications

Despite the core of TCE identifies the most appropriate hybrid governance forms depending on both asset specificity and the combined effect with uncertainty, our work takes into consideration and place emphasis on the role played by uncertainty. As we expected, the actual structure of the exchange between the upstream and downstream agents results from the combined effect of both environmental and quality-related uncertainty. A high degree of environmental uncertainty is related with a market-oriented governance form. In fact, transactors adopt a flexible framework based upon yearly contracts with the price premium for the non-GM status re-negotiated on an annual basis. On the other hand, the exchange is framed such that the uncertainty related to product quality is counterbalanced through a set of downstream-driven technical requirements supported with process certification schemes. Buyer's process control over the supplier is therefore achieved through formalized contracts and process certification, the two main features of vertical integration. Contracts between the international trader and Brazilian producers are renewed yearly and transactors have been using them for many years, building upon trust and enduring personal relationships. In accordance with the literature on trust (Wei, Wong and Lai, 2012; Whan and Kwon, 2004) and transaction's long-term orientation (Ashwin et al., 1999), we observe that the long-lasting trust-based relationships between crushers and the trader may serve as a flexible vertical coordination mechanism to reduce uncertainty, and transaction costs consequently. The main effects of the long lasting trust relationship between Brazilian crushers and the international trading company are:

- a stabilization of the price premium that the international trader recognizes to Brazilian producers for non-GM soybean: this is of particular relevance, as there is no reference market for this premium;
- a secure market channel for Brazilian producers, i.e. a lower incentive to switch to GM crops;
- a stable and reliable supply of non-GM crops to the international trader.

Furthermore, the frequency of transactions between the international trading company and Brazilian crushers seems to play a key role in building trust.

The exchange between the international trader and feedstuff manufacturers, is mainly managed through spot contracts. However, if we take into consideration the relationship between the trader and the main Italian customer, we cannot classify this transaction as pure market governance, where the identity of the transacting parties is irrelevant and no mutual dependency exists. What we notice is that parties to the transaction maintain their autonomy but are bilaterally dependent in a nontrivial way: their identity matters and each of them cannot be replaced in a costless way by the other. The degree of uncertainty affects heavily the structure of the transaction in this case too: the volatility of demand and supply conditions may thin out the gains from the the advantages of buyer's control over the supplier. However, at this point of the supply chain, other economic determinants play a crucial role in shaping the transaction's governance form. The volume of non-GM soybean meal handled at the Italian level is such that the economies of scale may be exploited by one international trader only, with a relatively large size if compared to feed manufacturers. In this context, a buyer's tight control over the supplier is achievable only through bilateral consent on product technical specifications and information/product management.

Additionally, the feed manufacturer aims to establish a trust-based and long-term oriented relationship with the international trader in order to curb the transaction costs arising from uncertainty. In our case study, the feed manufacturer has been doing business with one particular trading company, mainly because of the reputation of its upstream suppliers and the trust relationship between the two companies' managements. This implies that both hybrid form and trust between the trader and Brazilian producers, also affect the governance between the international trader and feedstuff manufacturers.

References

Ashwin, W.J. and L.S. Rodney "Transaction Cost Analysis: Integration of Recent Refinements and an Empirical Test". *Journal of Business-to-Business Marketing*, 5, 4 (1999): 37-71.

Boccaletti, S., G. Leoni, A. Varacca, C. Soregaroli "Coexistence implications within the EU and international supply chain". Deliverable prepared for PRICE Project, project n° FP7-KBBE-2011-5 (2012).

Co-Extra, GM and non-GM supply chains: their CO-Existence and TRAceability "Final activity Report – Publishable Executive Summary". Prepared for CO-EXTRA Project (November 2009).

David, R.J., and S. Han "A systematic assessment of the empirical support for transaction cost economics." *Strategic Management Journal* 25 (2004):39-58.

Ding, Y., M.M. Veeman, and W.L. Adamowicz "The Impact of Generalized Trust and Trust in the Food System on Choices of a Functional GM Food." *Agribusiness* 28 (2012):54-66.

Geyskens, I., J.E. Steenkamp, and N. Kumar "Make, buy, or ally: A transaction cost theory meta-analysis." *Academy of management journal* 49 (2006):519-43.

Jap, S. D. "Pie-expansion efforts: collaboration processes in buyer-supplier relationships." *Journal of Marketing Research* (1999): 461-475.

Johnston, D.A., D.M. McCutcheon, F.I. Stuart, and H. Kerwood "Effects of supplier trust on performance of cooperative supplier relationships." *Journal of Operations Management* 22 (2004):23-38.

Klein, Saul, Gary L. Frazier, and Victor J. Roth. "A transaction cost analysis model of channel integration in international markets." *Journal of Marketing research* (1990): 196-208.

Kwon, I.G., and T. Suh "Factors affecting the level of trust and commitment in supply chain relationships." *Journal of Supply Chain Management* 40 (2004):4-14.

Lee, P.K.C., A.C.L. Yeung, and T.C. Edwin Cheng "Supplier alliances and environmental uncertainty: An empirical study." *International Journal of Production Economics* 120 (2009):190-204.

Loader, R. "Assessing transaction costs to describe supply chain relationships in agri-food systems." *Supply Chain Management: An International Journal* 2 (1997):23-35.

Ménard, C. "On clusters, Hybrids, and Other Strage Forms: The Case of the French Poultry Industry" *Journal of Institutional and Theoretical Economics (JITE)/Zeitschrift für die gesamte Staatswissenschaft* (1996):154-183.

Ménard, C. "The economics of hybrid organizations." *Journal of Institutional and Theoretical Economics (JITE)/Zeitschrift für die gesamte Staatswissenschaft* (2004):345-76.

Ménard, C., and E. Valceschini "New institutions for governing the agri-food industry." *European Review of Agricultural Economics* 32 (2005):421-40.

Pelaez, V., D. Aquino, R. Hofmann, and M. Melo "Implementation of a Traceability and Certification System for Non-genetically Modified Soybeans: The Experience of Imcopa Co. in Brazil." *International Food and Agribusiness Management Review* 13 (2010):27-44.

Reviron, S. “La Diversité Des Systémes De Marché, Proposition d'une représentation du cadre des négociations commerciales pour les marchés de biens; le cas des marchés agro-alimentaires”. *Travaux Universitaires - Thèse nouveau doctorat* (2000)

Réviron, S., and J. Chappuis "Effects of the Swiss retailers' strategy on the governance structure of the fresh food products supply chains." *Agribusiness* 21 (2005):237-52.

Riordan, M.H., and O.E. Williamson "Asset specificity and economic organization." *International Journal of Industrial Organization* 3 (1985):365-78.

Smyth, S., and P.W. Phillips "Competitors co-operating: Establishing a supply chain to manage genetically modified canola." *The International Food and Agribusiness Management Review* 4 (2001):51-66.

C. Soregaroli, F. Passuello and S. Boccaletti, Managing GM-free food supply chains in Italy: insights from a case study, paper accepted for presentation at the 17th ICABR Conference - Ravello (Italy), June 18-21, 2013.

Tille, P., M. Vigani, K. Dillen, E.R. Cerezo “Proceedings of a workshop on “ Market for non-Genetically Modified Identity Preserved crops and derived products””, European Union, 2012, http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=5779.

USDA, Foreign agricultural Service (2012). “Canada, Agricultural Biotechnology Annual”. Global Agricultural Information Network (GAIN) Report, number CA12029.

USDA, Foreign agricultural Service (2012). “EU 27, Agricultural Biotechnology Annual - 2012”. Global Agricultural Information Network (GAIN) Report, number FR9105.

USDA, Foreign agricultural Service (7/18/2012). “Argentina, Agricultural Biotechnology Annual Report”. Global Agricultural Information Network (GAIN).

USDA, Foreign agricultural Service (7/18/2012). “Brazil, Agricultural Biotechnology Annual, Biotech Annual 2012”. Global Agricultural Information Network (GAIN) Report, number BR0813.

Wei, H., C.W.Y. Wong, and K. Lai "Linking inter-organizational trust with logistics information integration and partner cooperation under environmental uncertainty." *International Journal of Production Economics* 139 (2012):642-53.

Walker, G., and D. Weber "A transaction cost approach to make-or-buy decisions." *Administrative Science Quarterly* (1984):373-91.

Williamson, O.E. "Transaction-cost economics: the governance of contractual relations." *Journal of Law and Economics* 22 (1979):233-61.

Williamson, O.E. "The economics of organization: the transaction cost approach." *American journal of sociology* (1981):548-77.

Williamson, O.E. "Transaction cost economics: The comparative contracting perspective." *Journal of economic behaviour & organization* 8 (1987):617-25.

Williamson, O.E. "Comparative Economic Organization: The Analysis of Discrete Structural Alternatives." *Administrative Science Quarterly* 36 (1991):269-96.