Intensity of organizational change and traceability adoption: Evidences from French agribusiness

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Abstract

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Keywords: Organizational change, Traceability systems, Agribusiness, Firm Behavior

JEL: Q13, O33, L22

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Abstract

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1. Introduction

It is now widely accepted in the literature that industrial firms have undergone major transformations in the past decades: from the mass production model characterized by the old Fordist-Taylorist organization, to more flexible multi-product firms focusing on quality and faster responses to market conditions (Aoki, 1986; Milgrom and Roberts, 1990). Particularly, agro-food systems have been characterized by a diversity of organizational patterns, concentrating on food safety, quality control and reduction of delivery times, in order to meet downstream contractual commitments and comply with regulations, and consumers' demands. In this context, traceability has been the source of major transformation in firms, affecting their information systems (especially when based on electronic supports (Galliano and Orozco, 2011)), the organization of production and the mechanisms of coordination with external partners. Traceability systems are an effective risk management tool for reducing the impact of product recalls and food safety incidents, and are used together with a host of other management, marketing, and safety/quality control tools (Golan et al., 2004)[1].

This paper explores the recent organizational changes in agro-food firms, and their relation with the adoption of traceability systems. Organizational changes refer to firm-level modifications of structures, work interactions and human resource practices, affecting internal business processes as well as relationships with external partners (Murphy, 2002). Our

[1] While in the U.S., traceability systems have been promoted through private incentives (Golan et al., 2004), in Europe, agribusinesses must comply with EU regulations on the control and assurance of food quality and safety, which include traceability requirements The General Food Law of January 1st 2005 (Regulation EC 178/2002) requires the implementation of basic "step-by-step" traceability systems (Charlier and Valceschini, 2008).

hypothesis is that the intensity of these changes is affected by the adoption of traceability systems. The objective is to test the respective role of the adoption of traceability systems and the other factors related to the firm's internal characteristics (structure, strategy, etc.) and its external environment (supply chain effects, market characteristics and spatial externalities). The main questions underlying our research are: to what extent the intensity of a firm's organizational changes can be explained by the adoption of a traceability system? What are the roles played by the firm's internal characteristics and external environment (sector, market, institutions and spatial externalities)? Is there a co-evolution process between organizational changes and traceability adoption?

After describing the characteristics of these processes and the factors likely to influence them, we empirically test our predictions using recent data from a thematic survey, i.e. the Organizational Changes and Computerization Survey (COI-TIC, for its initials in French) conducted in 2006 by the main French statistical institutes[2]. The main goal of this survey was to assess what changes had occurred between 2003 and 2006 in terms of production and internal organization, of labor practices, and in terms of adoption of information technologies. This survey gives us exhaustive information on the firms' activities, structural characteristics, ICT and electronic traceability use, as well as the location of their main office. Using this dataset, we first test a general model of organizational change intensity in order to assess the role of traceability system adoption in the intensity of change. We then test the determinants of the intensity of organizational change by distinguishing firms according to their type of traceability behavior (early adopter, new adopter and non adopter).

The paper is organized as follows. Section 2 introduces the theoretical framework on organizational changes, the relation to ICT and traceability adoption, the explanatory factors, and the research hypothesis. Section 3 describes the dataset, the variables and the empirical model used. Findings are presented in Section 4. The last section concludes the paper and discusses the contributions.

2. Theoretical background

Several authors have shown that the characteristics of an organization determine both the initial conditions on which the firm's technical and organizational trajectory is based, and the framework in which an innovation, a new practice or a new technology will modify the

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structure and functioning of the organization (Brousseau and Rallet, 1998; Teece, 1998). At the same time, because all organizations operate in a competitive world where substitutes for their products are available, they have to reach for the efficacy that will enable them to adapt (Ménard, 2004). The aim of this section is to review the theoretical and empirical literature on organizational changes, especially when there is a relation with ICT adoption (2.1), and then to explore the implications of the adoption of electronic traceability systems and other factors that are likely to influence the intensity of a firm's organizational changes (2.2)

2.1. Organizational changes and information technologies

2.1.1. Understanding organizational changes

The general view is that any change in the distribution of power, skills, information management and in the lines of communication (Greenan, 2003), as well as in arrangements with external partners (Benghozi, 2001) constitutes an organizational change. Following these authors, as well as Murphy (2002), we could consider that firm-level organizational changes include three groups of factors: i) changes in the firm's hierarchical and decisional structure; ii) the firm's managerial practices and information systems; and iii) the inter-firm relations.

Concerning the *hierarchical and decisional structure*, organizational changes involve decentralizing management responsibility and empowering employees in order to enhance flexibility (Murphy, 2002). A higher number of hierarchical levels imply the need to duplicate the information, and the risk of loosing some degree of control (Williamson, 1967). Flatter hierarchies and decentralization can also be combined with the delegation of decision-making to intermediate levels, whether individual or collective (for instance autonomous working teams) (Daft and Lewin, 1993). The empirical evidence tends to show a higher degree of delegation to and autonomy of individuals i.e. operators and specialists, and also to collective bodies, where collective organizational working practices exist (Brynjolfsson and Hitt, 2000; Greenan and Guellec, 1994).

The organization of production and the nature of information flows are strongly conditioned by the degree of formalization and codification of practices and knowledge (Brousseau and Rallet, 1998; Galliano and Roux, 2008a). In this respect, the adoptions of *new managerial and work practices*, as well as the adoption of new *information technologies*, are organizational changes. Managerial practices mainly concern the management of quality (ISO norms), delivery times (Just-in-time), and logistics (Supply chain management), which

contribute to the coordination of tasks, limiting the intervention of the hierarchy, and increasing the responsibility of operators (Greenan and Walkowiak, 2010). These practices rationalize and formalize the modes of internal coordination, mainly routines (Lazaric and Denis, 2005) and of coordination with the firm's external partners. Similarly, the firm's information system is determined by the ICT adopted by firms. From a theoretical point of view ICT should reduce the costs of information acquisition and communication (Garicano, 2000; Bloom et al., 2009)[3].

Finally, the relations with external partners (*inter-firm relations*), such as suppliers and customers, have been considered a key dimension of organizational change. In particular, firms can outsource certain activities while focusing on their specificities and areas of strength. Similarly, intense competition can lead to declining customer – and brand – loyalty, and is a major reason for paying more attention to customer relations (Murphy, 2002). Other forms of organizational changes (in the relations with external partners), such as inter-firm networks can provide access to resources such as information or technology; economies of scale and scope in production or services; skills and knowledge, etc. These types of coordination mechanisms are sometimes referred to as "hybrid" forms of organization; they are gaining ground in the food industry (Ménard and Valceschini, 2005), and rest on the use of contracts.

However, measuring organizational changes is not an easy task. Previous works have focused only on specific aspects such as hierarchical inertia (Colombo and Delmastro, 2002), or have aggregated different "forms" of changes (hierarchy, managerial practices, etc.) into models (or classes) of organizational changes[4]. Similarly, Mazzanti et al. (2006) constructed an index of organizational change for a sample of agro-food firms in Italy. From the COI-TIC survey, and using a similar approach to that of Mazzanti et al. (2006), we build a dependent variable, by aggregating changes in the firm's hierarchical and decisional structure, managerial and work practices, information systems, and arrangements with external partners (mainly contractual).

2.1.2. Organizational change and ICT adoption

[3] For instance, the more functions are managed by a firm's Enterprise Resource Planning (ERP) systems, the better the access to the information by managers across an organization. At the same time, information needs to be shared at different levels of the firm, and different tools reduce the communication costs. Intranet systems connect corporate headquarters with local managers, while reducing the costs of communication (Bloom et al., 2009), while EDI (Electronic Data Interchange) formats, ensure the external coordination and transmission of information, with partners upstream and downstream the supply chain.

[4] See Greenan (2003) for all French industrial firms, and Galliano and Roux (2008b) for the agro-food sector.

First, we need to consider the relation between ICT adoption and organizational change. We then apply this approach to the analysis of the relations between the adoption of an ETS and organizational change. As Garicano (2010) stated, if organizations are all about information processing, then it is expected that exogenous changes in the cost of acquiring and communicating information must affect organizational design. Information and communication technologies are generic technologies that mostly serve as tools of coordination between individuals and between organizations, allowing for an increased information and knowledge transmission, storing and processing capacity (Lam, 2002) and reducing the costs of information acquisition and transmission (Garicano, 2010). In general, the main effects of information technologies in organizations include changes to the communication modes and the creation of an electronic environment for cooperative work teams (Wang, 1997). More specifically, the adoption of ICT interacts with the governance structure (hierarchic and decisional structure), the managerial practices (Greenan, 2003), and arrangements with external partners (Benghozi, 2001; Vaccaro et al., 2010).

The adoption of new ICT results from a more general process of organizational change that affects the organizational and technological structures of the firm in the context of an overall planned strategy (Milgrom and Roberts, 1990; 1995). These changes could also be the result of the search for new practices, of adaptation and learning process, and determine the internal structure of organizations and the relations between the actors (Greenan, 2003; Bocquet et al., 2007). These changes are the result of the search for new practices, of adaptation and learning process, and determine the internal structure of organizations and the relations between the actors (Nelson and Winter, 1982; Garicano, 2000; Ménard, 2004). This double view[5] has been analyzed by several authors, by combining the New Institutional approach with that of Evolutionary Economics (Brousseau and Rallet, 1998; Hodgson and Knudsen, 2007; Cayla, 2008). More specifically, Brousseau and Rallet (1998), have used this approach to understand the relation between ICT adoption and firm-level organizational change.

In this context, New Institutional Economics (NIE) (North, 1990; Williamson, 1985) characterize firms by their organizational architecture, their degree of centralization (the distribution of authority among the network components) and interdependence between the different components of the organization (referring to the autonomy of the activity of various organizational components) (Brousseau and Rallet, 1998). The organization structure is

[5] Organizational changes being the result of a planned strategy vs. the result of an adaptation process.

supposed to resolve the problems of information asymmetry (Williamson, 1985), and is conceived as a set of coordination mechanisms. Information and communication technologies are tools designed to solve these coordination problems, mainly by modifying the information management capabilities (Brousseau and Rallet, 1998). In addition, the NIE approach makes it possible to take into account the inter-firm relations, i.e. the governance of contractual relations whose effectiveness varies with the institutional environment and the attributes of the economic actors. Incentive-based contractual mechanisms rely heavily on supervision and monitoring (transaction costs[6]), and consequently have a positive influence on the adoption of ICT.

As in Brousseau and Rallet (1998), our analysis also finds support in Evolutionary Economics (Nelson and Winter, 1982), given that this theory has developed analytical tools to help address questions related to change, to the process of innovation diffusion and to technological evolutions. The firm's internal governance structure co-evolves with the environment in which they are embedded; the decision makers do not possess all the necessary information about the set of opportunities (Dosi and Marengo, 1994). Williamson's view in this sense is static in nature, that is to say that it does not take into account the dynamics of change. The evolutionary approach regards organizational changes as a product of the search for new practices in the neighborhood of an organization's existing practices, that is a "local search", and thus organizational routines and skills change only slowly and incrementally (Lam, 2005). Economic behavior is defined more in terms of path dependency, and the routinization of activity in an organization constitutes the most important form of storage of the organization's specific operational knowledge (Nelson and Winter, 1982). Evolutionary theorists reject the hypothesis of a manager capable of coordinating all decisions. Instead, they believe that the routines (problem-solving by nature) acquired by individuals serve as substitutes for managers in the coordination of decisions.

Brousseau and Rallet (1998) identify two types of organizational learning processes in which ICT act as revealing devices. First the adoption of ICT leads to a systematic normalization of existing coordination and information management processes, allowing for the identification of information gaps, process duplication, coordination failures, etc. Second, according to Rosenberg's "learning-by-using" approach, users do not know all the potentialities of the technology when it is used to coordinate the economic activity (Rosenberg, 1982). However, the process of experimentation and discovery will progressively

[6] Transaction costs are the costs of exchange involved in the elaboration and implementation of contracts (i.e. the costs of acquiring information, the costs of processing it (bounded rationality), asymmetric information, etc. (Morroni, 2006).

reveal how the technology can efficiently support coordination.

2.2. Explanatory factors

In this section we attempt to determine the factors that are likely to influence the intensity of firm-level organizational change, using the approach described above. The first aim is to consider and test the role of the adoption of electronic traceability systems in the intensity of organizational change. Then, more specifically, and in compliance with the literature, we seek to identify the role of the factors related to the internal characteristics of the firm – sometimes associated to planned changes that are part of a larger strategy – and that of the external factors related to the firm's environments (market, geographical and institutional), which are often associated with changes resulting from an adaptation process.

2.2.1. Adoption of an electronic traceability system (ETS)

Our main objective is to explain the role of traceability systems in the intensity of organizational changes in agro-food. An ETS can be defined as a complex combination of technical codification support systems (commonly associated with bar-codes and electronic RFID[7] tags) which, when coupled with ICT, enable firms to collect, track, store, and transfer information on a range of product attributes (Galliano and Orozco, 2011). Such systems have been rapidly adopted by agribusiness in recent years in response to market and institutional demands. By 2006, 76.91% of agribusinesses had adopted ETS (compared with 62.39% in 2003[8]).

Overall, traceability systems facilitate access to information about the history and geographic origin of products, as well as all transformations made. This information can rapidly be retrieved via the firms' information systems and be used in the decision making process regardless of the "distance" between the decision-maker and the operators. Moreover, traceability systems are expected to play a role in reducing transaction costs (notably with suppliers and costumers), especially when they are supported by information technologies. For instance monitoring costs will tend to rise if more information about the production methods is needed; these costs depend on the ability of traceability systems to trace the origin of a product (Hobbs, 1996). The voluntary introduction of traceability systems improves

[7] Radio-frequency identification tags.
[8] See table A1 in appendix.

vertical coordination through the implementation of specific contracts, which reduce the uncertainty about transactions (Banterle and Stranieri, 2008).

The two learning processes mentioned above (normalization of existing processes and "learning-by-using") are facilitated not by basic ICT, but by technologies that help build an organizational memory; i.e. the acquisition, retention, maintenance, search and retrieval of information (Stein and Zwass, 1995). In this regard, electronic traceability systems can be conceived as a vector of organizational learning. Forest (2000) provides a framework, in which she considers both stages of the memorization process facilitated by the traceability systems from an organizational perspective: the first consists in the memorization of data with a view to capitalize on the latter; the second aims to draw the lessons from the capitalization stage (to promote learning). This includes a reflection on and an exploitation of data, a process through which an organization is able to learn, making it possible to explain, for instance, the causes of a success or a failure. Traceability enables the firm to build a memory, learn from others and from the past, compensate for the loss of knowledge caused by the departure of an individual, re-use past knowledge, and avoid wasting time looking for a solution when one has already been tested (Forest, 2000) .

H1. Therefore we expect the adoption of electronic traceability systems to be positively related to the intensity of firm-level organizational change.

2.2.2. The internal characteristics of the firm

In addition to electronic traceability systems, we seek to explain the intensity of organizational change using variables related to the firm's structure and strategy. According to the literature on the determinants of innovation, the firm's internal characteristics, whether technical or organizational, play a significant role. The hypothesis made is that firms have different characteristics (related to their size, their organizational form, their financial resources or the characteristics of their technology) that influence their capacity to innovate and the benefits from the adoption of new technologies (cf. ranks effects as in Karshenas and Stoneman, 1993))[9]. Some authors also highlight the fact that the firms that have large internal resources face fewer innovation problems or failures (Lhuillery and Pfister, 2009).

[9] The term "rank" is used because in these models the net benefits can be classified according to the type of firm. The firms positioned in the higher ranks will be the first to adopt a new technology.

Thus, in theory, *large* firms have better access to financial resources, to both economies of scale and scope, to a relatively diverse workforce in terms of skills and also to information about new technologies (Greenan and Mairesse, 2006). Similarly, belonging to a group can have a positive effect on the firm's innovation capacity, and above all, can increase its absorption capacity and help it overcome the difficulties experienced during the innovation process (Lhuillery and Pfister, 2009). Belonging to a *group* seems to give firms greater access to different resources, even though the benefits of this depend on the functional division and on the degree of centralization/decentralization of decision making within the group. A *multi unit* form of organization is believed to facilitate organizational learning both by improving information transfer across units and by increasing the likelihood that the knowledge generated in one plant applies to another, although it depends on the firm's external environment (Audia et al., 2000).

H2. Being a large firm, belonging to a group and having several production units are characteristics that are expected to have a positive effect on the intensity of firm-level organizational change.

Overall, the intensity of a firm's organizational change is driven by its strategy. Shorter product life cycles, strong competition and a need to constantly renew products have caused firms to change their model from mass production and standardization, to "mass customization", that is, a focus on product differentiation and quality (Murphy, 2002). These changes imply that a greater number of objectives be reconciled. On the one hand, firms need to improve productivity so as to be able to set competitive prices, but on the other they also need to increase flexibility and to produce quality products (Greenan, 2003).

H3. The firm's strategy of both competitive prices and product quality is expected to be positively related to the intensity of firm-level organizational change.

2.2.3. The firm's external environment

The evolutionary view emphasizes the ability of organizations to create new organizational forms (in order to overcome inertia) and to adapt to environmental shifts and changes in technology. Over the past 40 years, firms have been exposed to external factors related to the

global economy: liberalization of trade, worldwide financial integration, deregulation and privatization at the national level, and major advances in information and communication technologies (Magun, 1998). More precisely, we will consider four aspects of firms' external environments: the coordination modes related to their supply chain and sector of activity; and their geographic, commercial and institutional environments.

A firm's modes of coordination with outside partners determine the intensity of the organizational change it undertakes. The influence of the firm's *sector of activity* can be related to the technical characteristics of the industry and the nature of the product. For instance, the meat sector has been less flexible and decentralized than others (Galliano and Roux, 2008b), however it has been the leading sector in ETS adoption (Galliano and Orozco, 2011). Furthermore, as firm's strategies have become more geared towards customers' needs, new changes in the organization are needed (Murphy, 2002). In general, the weight of the downstream partners, especially retailers, in the firm's activity is expected to have an influence on the intensity of its organizational change. The demand for food safety and quality is compelling retailers to project consumers' demands upstream of the supply chain by imposing strict specifications. Retailers implement mechanisms to monitor their suppliers, which require the latter to undertake firm level organizational changes. In the specific case of ETS adopters, the influence of retailers in the firm's sales should translate into internal organizational adjustments by partners in the supply chain, as well as into mechanisms of coordination between them (Banterle and Stranieri, 2008; Banterle et al., 2009).

H4. A firm's strong dependence – in terms of sales – on retailers positively influences the intensity of its organizational changes, all the more so as the firm has adopted an ETS.

The intensity of organizational change can also be influenced by the firm's geographic environment, as proximity and agglomeration economies are expected to foster innovation and influence the firm's decision to adapt and change (Boschma and Frenken, 2006; Malmberg et al., 2000). The nature of the environment where a firm is located is generally believed to have an influence on the firm's strategic choices and capacity to innovate (Antonelli, 1999). The hypothesis, often found in the literature, is that urban agglomeration economies facilitate access to a variety of infrastructures and service activities (information technology services, technology suppliers etc.), as well as to a qualified workforce, which favors the adoption of technologies by firms. Urban externalities refer to an environment that

is oriented towards the use of local public resources and is highly conducive to the transfer of information, knowledge and technologies. More generally, the recent literature about agglomeration and proximity mostly emphasizes the crucial role of knowledge externalities and of strategic interactions (co-location of head offices, science/industry interactions, etc) in innovation (Autant-Bernard et al., 2007).

H5. Agglomeration economies are expected to foster innovation and influence the firm's decision to adapt and change.

Organizational changes are believed to be prompted by the market environment. The firm's capacity to innovate and its pace of innovation depend on its position on the market (a firm that already has a large market share is more likely to innovate) but also on the nature of the innovation and the type of market structure (see Reinganum (1989) for a survey). Magun (1998) shows that market pressure and national and global competition were considered major reasons for Canadian firms to embark into an organizational change program. Moreover, the internationalization of the firm's activity beyond their home region, requires a certain level of adaptation to local markets (Filippaios and Rama, 2008). Furthermore, Magun (1998) explains that when faced with market uncertainty, firms tend to rely more on knowledge and information "to redesign their structures, production processes, technologies and even products in order to make them compatible with new environments" (Magun, 1998). In order to protect themselves from competition pressure, firms are encouraged to develop breakthrough innovations or reduce their costs by implementing more efficient production methods (Majumdar and Venkataraman, 1993).

H6. Market pressure and uncertainty are expected to be positively related to the intensity of firm-level organizational change.

Finally, the institutional environment – which includes norms, routines, established practices, rules, laws, standards, etc – is supposed to shape the agents' interactions (Malerba and Montobbio, 2004). Two complementary views are often considered, that of North (1990) who considers institutions to be "the rules of the game", designed to "reduce uncertainty by establishing a stable structure to human interaction", and that of Aoki (2001), where institutions are a "self-sustaining system of shared beliefs", created endogenously through the

strategic interactions of agents Considering standards as institutions, Aust Stearn and Reardon (2002)show how the agro-food sector is characterized by constant changes in standards (collective, public to individual, firm-specific, etc.), which might imply changes in the firm's organization, quality assurance schemes, and new forms of coordination between partners.

H7. Changes in norms and regulations are expected to be positively related to the intensity of organizational change.

3. Data and methods

3.1. The data

The main dataset is drawn from the Organizational Changes and Computerization survey (COI-TIC 2006 for its initials in French) carried out by the INSEE (National Institute for Statistics and Economic Studies), the French Institute of Statistics of the Ministry of Industry (SESSI) and the Ministry of Agriculture (SCEES). This survey combines the points of view of both firms and employees in order to describe its internal organization, its labor practices and the diffusion of ICT. The survey selected 2005 (or January 2006) as the year of observation, with an overall response rate of 85%[10]. The final sample used in this paper is composed of 596 firms that are representative of the firms in the entire French agro-food industry (around 2428 firms) with respect to size and sector; each firm in our final sample has 20 or more employees. Structural variables (size, sector, turnover, etc.) were drawn from the Annual Enterprise Survey (EAE) also carried by the French Institutes of Statistics. Descriptive statistics are provided in table 1.

3.2 Variables

Dependent variable: We construct an indicator of organizational change during the 2003-2006 period, by taking into consideration four groups of variables[11]. The first group is related to whether there have been changes in the firms' hierarchical and decisional structures (variation

[10] This rather high response rate is due to the fact that all French national surveys, carried by the different statistical services of French ministries, and under the surveillance of the CNIS (*Centre National de l'Information Statistique*) are mandatory. Firms are obliged by law to respond to the survey, otherwise be subjected to an administrative fine. Access to this data, however, is restricted to researchers having agreed to secrecy agreements.

[11] These information comes from the COI-TIC 2006 survey

in the number of hierarchical levels, variations in the functions managed at group level or by external partners, an increase in the number of tasks performed by the hierarchy; and a change in the firm's organization chart). The second group of variables is related to whether or not the firm has adopted new managerial (Just-in-time, Quality certification, Supply chain management) or work practices (Autonomous working teams, Groupware applications, and workflow). The third group is related to whether the firm has upgraded its information systems (an increase in functions managed by an ERP[12], the adoption of a Document management system, Intranet, Electronic data interchange, or an increase in the number of ICT shared with its main customer). Finally, we look at changes in the contractual mechanism with external partners (an increase in long term, delivery times, or specifications contracts) with both customers and suppliers. The obtained variable *SCORE* has 10 modalities, as defined below, and is distributed as shown in figure 1.

$$\begin{cases} y_i = 0 & \text{if no changes} \\ y_i = 1 & \text{if one type of change} \\ \quad = 2 & \text{if two type of changes} \\ \quad : & \\ y_i = 9 & \text{if nine or more types of changes} \end{cases}$$

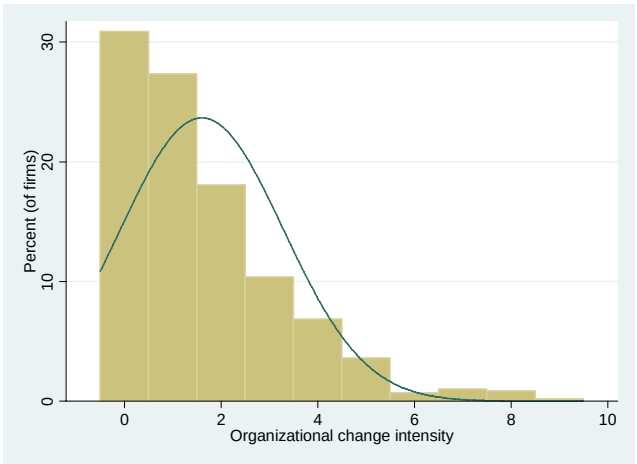

Fig. 1 Distribution of dependent variable

[12] Enterprise Resource Planning.

Independent variables: The complete list of independent variables is defined in the appendix (Table A2). The *size* of the firm is measured using the number of workers employed (Hollenstein, 2004; Galliano and Roux, 2008a). Belonging to a *group* provides the firm with greater access to resources, even though the benefits of belonging to a group depend on the functional division and the level of centralization of decision-making within the group. The firm is considered to have a *multi unit* structure if it has two or more establishments performing part of its activity. Furthermore two binary variables provide an indicator of the importance given by the firm to a *quality* or *competitive prices* strategy.

The external coordination modes are determined by the sector. The firm's main activity is used to distinguish between six *sectors of activity* (Meat, Prepared fruit and vegetables, Dairy, Processed animal feed, Other food products, and Beverages). Using firm-level data has the drawback of not illustrating the links between the firms in the sample, or their positions along the supply chain. However, two variables related to the firm's downstream activities are used: the firm's sales under a *retailer's brand* and the sales under *another firm's brand*. The former could indicate a greater dependency on retailers while the latter, a greater role of other downstream processors. In both cases, the assumption is made that the firm follows a set of specifications, quality requirements, etc.

Two types of variables are used in order to capture the spatial effects. The *proximity* relations and coordination with upstream partners are captured by a binary variable that indicates whether or not the firm's biggest client (in terms of turnover) is located in proximity (i.e. within 30km of one of the firm's units). A similar binary variable is used for the largest supplier. Second, to capture agglomeration effects, the *location* of the head office is used in order to distinguish between four types of locations. The ZAUER zoning database[13] is used to characterize the nature of the firms' geographic location (urban or rural). The obtained typology allows for the categorization of all French cities into seven spatial categories, which are then aggregated into four levels: urban zones, peri-urban zones, rural poles and rural isolated areas. We used a Glaeser et al. (1992) indicator to capture the *industrial agglomeration* effects, i.e. the ratio of the share of a sector's workforce in the « *département* »'s total workforce to the share of the same sector's workforce in the country's total workforce. If this ratio is above 1, we consider that the region specializes in this sector of activity more than does the country as a whole.

[13] That is the 1999 ZAUER file (*Zonage en Aires Urbaines et en Aires d'emploi de l'Espace Rural*), also provided by INSEE.

We use a C4 indicator of *market concentration*, which enables us to test the influence of a search for market power in the firm's organizational choices. Furthermore, the location of the firm's markets is captured by two binary variables which indicate whether the firm is present in the *local or regional* market and whether it is present in the *national* market. In addition, we use the firm's rate of *exports*, a proxy of the firm's degree of openness to foreign markets, distinguishing exports to the EU from exports towards countries outside the EU. Finally we have used an indicator of the effect of *market uncertainty* on the firm during the 2003-2006 period. The effect of the institutional environment is considered using a binary variable that equals one if the firm's activity has been strongly affected by *changes in regulation and norms*.

3.2. Descriptive statistics

Table 1 shows the characteristics of the entire French agro-food sector. By 2003, 62.39% of French agribusinesses had adopted an electronic traceability system. This percentage rose to 76.81% in 2006.

Figure 2 shows the number of changes in firms according to their size. At first sight we note that 38% of small firms (between 20 to 49 employees) did not experience any type of changes during the 2003-2006 period. It may be important to note that 46% of all firms have experienced at least one or two types of changes. From these statistics, we can infer that, to some degree, the size of the firm is related to the intensity of the organizational change – larger firms having experienced a greater number of changes.

Table 1. Characteristics of the French agribusiness

	Total agro-food	ETS adopters before 2003	ETS adopters after 2003	Firms without ETS
No. of firms	2,428	1,515	366	563
	%	%	%	%
Total ETS adopters	76.81			
ETS adopters before 2003	62.39			
ETS after 2003	15.09			
Total of non adopters	23.19			
Size: 20 – 49 employees	55.52	50.71	60.10	66.56
50 – 249	33.22	34.71	29.85	30.46
250 – 499	6.68	8.79	6.36	1.04
500 or more	4.58	5.80	3.69	1.93
Group	51.01	55.07	43.80	44.95
Multi unit	40.92	44.62	33.92	35.75
Quality strategy	95.92	96.11	99.72	93.06
Competitive prices strategy	83.46	86.84	81.48	76.14
Sector: Meat sector	33.66	40.63	14.07	28.36
Prepared fruit and vegetables	4.35	4.99	4.22	2.57
Dairy products	8.53	8.45	8.09	8.79
Beverages	16.40	13.55	24.43	18.36
Other food products	37.06	32.38	49.18	41.92
Proximity of largest customer	17.97	16.32	23.79	20.77
Proximity of largest supplier	23.77	23.49	17.24	28.06
Location: Urban zone	44.16	45.03	34.50	48.31
Peri-Urban	17.85	13.68	25.80	23.38
Rural pole	12.46	13.65	11.34	9.79
Rural isolated area	25.53	27.64	28.36	18.53
Effect of changes in reg. and norms	68.20	68.83	76.36	61.95
Effect of market uncertainty	70.27	73.96	71.96	58.63

Source: COI-TIC and EAE (2006), French National Institutes of Statistics. Weighted data.

In figure 3, we show firms' organizational changes in terms of ETS adoption (mainly the date of adoption). The figure shows that 37% of the firms that have never adopted an ETS, have not experienced either type of organizational change, while 47.47% have only had one or two types of changes. The great majority of firms that adopted an ETS before 2003 (75.55%) underwent zero to two types of changes between 2003 and 2006. In parallel to this, there is a high correlation between the fact that a firm adopted an ETS after 2003 and the intensity of its organizational changes: 30% of the firms that adopted an ETS after 2003 underwent 5 or more types of changes, and 48.50% underwent between 2 to 4 types of changes).

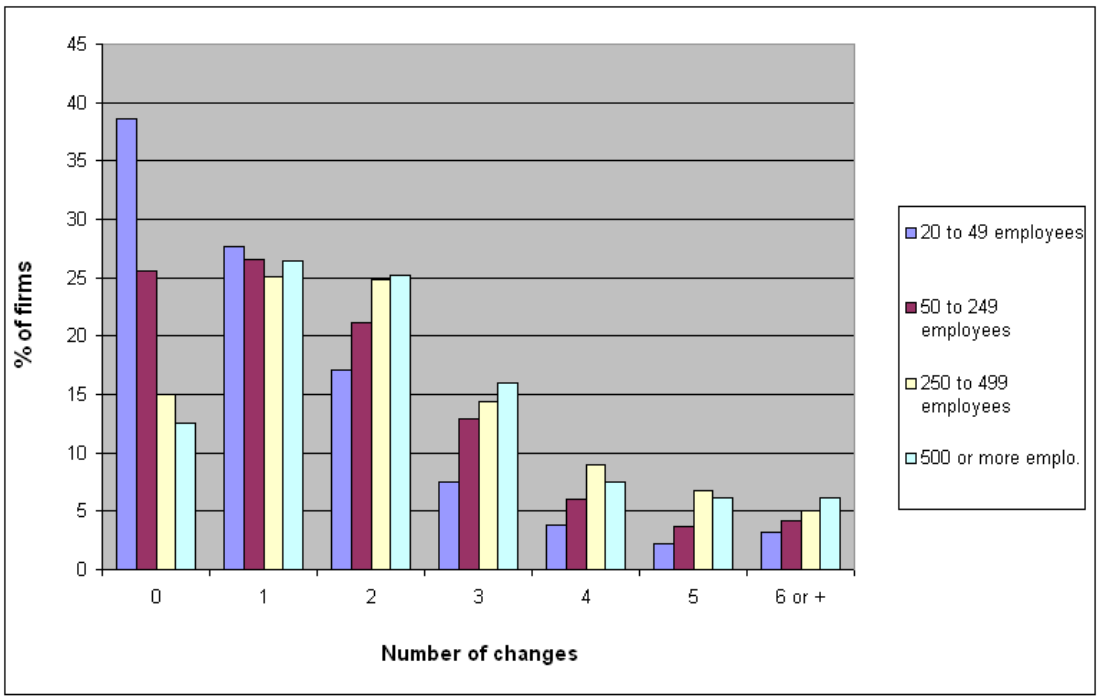

Fig. 2 Organizational changes according to the size of the firms

3.3. Empirical model: an ordered probit

In this section we present the methodology used to test the determinants of the intensity of a firm's organizational change, and the role of ETS adoption and of non adoption respectively. In the first step (models 1 and 2), we test the *SCORE* variable for the entire population of agro-food firms with and without the ETS variable, in order to test the role of ETS adoption in the intensity of organizational change. In the second step (models 3, 4, 5 and 6), the *SCORE* variable is tested for the population of firms that adopted ETS (model 3) and according to the period when the adoption took place (model 4 before 2003 and model 5 after 2003 i.e. during the period of observation of organizational changes) and for firms that have not adopted ETS (model 6). Results are the econometric estimation of an ordered probit model. First, we describe the method used to estimate this type of model, before presenting the estimation results.

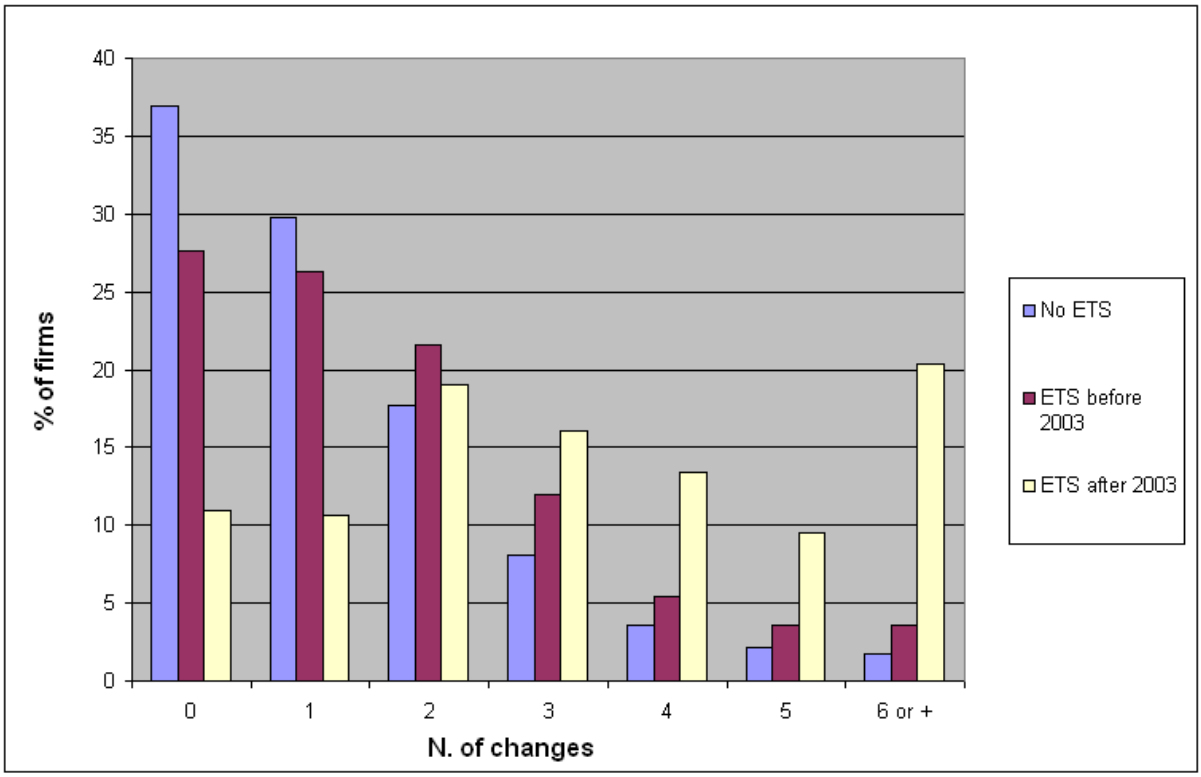

Fig. 3. Organizational changes according to the period when the ETS was adopted

Ordered probit models are used in the case of ordered and exclusive multinomial qualitative variables (Greene, 2003). The outcome of our dependent variable are coded 0, 1,…, 9, for which a linear regression would treat the difference between a 3 and a 2 the same as that between a 2 and a 1, whereas in fact they are only a ranking. The dependent variable measuring the intensity of organizational change is explained by the measurable factors x_i (the firm's ETS adoption, and its internal and external characteristics) and certain unobservable factors ε_i. The model is built around a latent regression in the same manner as a binomial probit:

$$y^*_i = x'_i \beta + \varepsilon_i$$

Then, y^* is unobserved. What we observe is y, which provides incomplete information about y^* according to:

$$
\begin{aligned}
y_i &= 0 \quad if \quad y^* \leq 0 \\
&= 1 \quad if \quad 0 < y^* \leq \mu_1 \\
&= 2 \quad if \quad \mu_1 < y^* \leq \mu_2 \\
&\quad : \\
&= J \quad if \quad \mu_{J-1} \leq y^*
\end{aligned}
$$

where $j = 0, 1, \ldots, J$ represent the different modalities of the endogenous variable. The μ are unknown parameters (cut points between scores) to be estimated along with the parameter vector β. As in binomial probit models, the term ε_i is normally distributed across observations, the following probabilities are obtained:

$$\text{Prob}(y_i = j|x_i) = \Phi(\mu_j - x'_i \beta) - \Phi(\mu_{j-1} - x'_i \beta)$$

where Φ is the cumulative distribution function of the standard normal distribution.

As in probit models, ordered probits are estimated using a maximum likelihood procedure, and coefficients cannot be directly interpreted, only their sign indicate in which direction the probability change.

4. Results

Tables 2 and 4 report the results of the Ordered Probit model. For all estimates we used weighted data, in order to correct for sampling bias (i.e. for ensuring a better representation of the distribution of individual firms) and provide results for the entire population.

4.1. Organizational changes in the agro-food sector

Estimated coefficients are shown for the explanatory variables along with the estimated cut points (μ) between scores. These points provide the essential input for measuring the probabilities of scores (i.e., on the scale from 0 to 9) attached to the entire French agro-food firms.

In model 1 (table 2), we test the intensity of organizational change for the entire sample of agro-food firms, without taking into account the adoption of ETS. In model 2, we introduce

ETS adoption variables, before and after 2003. The first result is that traceability adoption has a positive and significant impact on organizational change intensity. This impact is greater for the firms which adopted ETS after 2003, i.e. during the period of observation of organizational change (see table 3 of marginal effects). This result could suggest that there is a co-evolution between the adoption of traceability systems and the adoption of other organizational practices in the firm. One notes that the pseudo R-squared (McFadden's) measure of fit is higher for model 2, i.e. the adoption of electronic traceability has a significant and positive influence on a firm's organizational change intensity. This result tends to highlight the strong influence of the adoption of electronic traceability systems on the organizational changes which the agribusiness sector underwent during the 2003-2006 period. It is backed up by the fact that firms that adopted ETS before 2003 are not the ones that underwent the most changes between 2003 and 2006. The changes are therefore mostly co-evolutive: the adoption and implementation of traceability systems necessitates organizational changes, or vice versa (Milgrom and Roberts, 1995).

The other results reveal the role of the other factors – i.e. the firms' internal characteristics and those related to their external environment – in their organizational change scores. The size, being a multi unit firm (Audia et al., 2000) and belonging to a group are factors which overall increase the probability of organizational change. The modes of coordination with external partners also play an important role in the firm's dynamics. Thus, the results show that strong sales under the retailer's brand as well as the geographic proximity of its main client play an incentive role. On the other hand, the proximity of the main supplier has a negative effect. These results tend to show the particular influence of the downstream dynamics and actors in the processes of change in agribusinesses.

Table 2. Determinants of organizational change intensity in French agribusiness: an ordered Probit model

Dependent variable: SCORE	(1)		(2)	
Electronic Traceability				
No ETS			Ref.	
ETS before 2003	-		0.148**	(0.0573)
ETS after 2003	-		1.082***	(0.0764)
Internal characteristics				
Structure				
Size: 20 – 49 employees	Ref.		Ref.	
50 – 249	0.164**	(0.0534)	0.177***	(0.0536)
250 – 499	0.305**	(0.0963)	0.251**	(0.0971)
500 or more	0.277*	(0.114)	0.222	(0.114)
Group	0.148**	(0.0485)	0.183***	(0.0487)
Multi unit	0.185***	(0.0481)	0.231***	(0.0484)

Strategy				
Quality	0.820***	(0.134)	0.718***	(0.135)
Competitive prices	0.183**	(0.0656)	0.231***	(0.0660)
External environment				
Coordination modes				
Sector: Meat sector	Ref.		Ref.	
Prepared fruit and vegetables	0.445***	(0.118)	0.376**	(0.118)
Dairy products	-0.134	(0.0945)	-0.199*	(0.0949)
Other food products	0.219***	(0.0579)	0.0967	(0.0591)
Beverages	0.189*	(0.0822)	0.00910	(0.0837)
Sales under another firm's brand	0.122	(0.267)	0.234	(0.267)
Sales under a retailer's brand	0.588***	(0.135)	0.488***	(0.135)
Spatial externalities				
Proximity of largest customer	0.301***	(0.0635)	0.222***	(0.0639)
Proximity of largest supplier	-0.265***	(0.0553)	-0.187***	(0.0558)
Location: Urban zone	Ref.		Ref.	
Peri-Urban	0.335***	(0.0636)	0.288***	(0.0640)
Rural pole	0.253***	(0.0722)	0.194**	(0.0725)
Rural isolated area	0.162**	(0.0594)	0.0696	(0.0599)
Industrial agglomeration effects	0.0841***	(0.0241)	0.0982***	(0.0242)
Market effects				
Market concentration	0.169**	(0.0515)	0.143**	(0.0516)
Local-regional market	-0.159*	(0.0761)	-0.242**	(0.0765)
National market	0.196**	(0.0614)	0.194**	(0.0616)
Exports (EU)	-0.547*	(0.225)	-0.288	(0.227)
Exports (Non-EU)	-0.143	(0.262)	-0.371	(0.265)
Effect of market uncertainty	0.175***	(0.0501)	0.156**	(0.0504)
Institutional environment				
Effect changes in reg. & norms	-0.0899	(0.0494)	-0.139**	(0.0497)
Cut point: μ_1	1.621***	(0.231)	1.512***	(0.234)
μ_2	2.397***	(0.233)	2.314***	(0.236)
μ_3	2.958***	(0.234)	2.910***	(0.238)
μ_4	3.386***	(0.236)	3.375***	(0.239)
μ_5	3.819***	(0.237)	3.867***	(0.241)
μ_6	4.236***	(0.241)	4.353***	(0.245)
μ_7	4.360***	(0.242)	4.497***	(0.247)
μ_8	4.635***	(0.247)	4.812***	(0.252)
μ_9	5.213***	(0.277)	5.453***	(0.287)
Observations	596		596	
Weighted data	*2428*		*2428*	
Pseudo R^2	0.045		0.074	

Standard errors in parentheses; * p < 0.05, ** p < 0.01, *** p < 0.001
Source: COI-TIC (2006), French National Institutes of Statistics

With regard to the commercial environment, competitive pressure and uncertainty on the markets are factors that are conducive to organizational changes within the firm. Being active in local or regional markets has a negative effect on the intensity of change, whereas being active in national markets has a positive influence on organizational innovation. Let us note finally, that the firms', whose activities are highly affected by changes in their institutional environment, and particularly by changes in regulation and standards, innovated less during

the observation period. On the other hand, market uncertainty appears to stimulate organizational change.

Lastly, and contrary to what studies in the field of the geography of innovation show, the firms that have had the highest organizational change scores are those that are located outside urban areas; and firms located in peri-urban areas are particularly dynamic in this respect. Furthermore, we observe a location effect (Antonelli, 1999) i.e. an effect of industrial specialization of the areas – that is favorable to organizational changes within agribusinesses.

As previously shown, we can estimate the expected probabilities for a firm to undergo the different levels of organizational change, using the estimated threshold values. This enables us then to interpret the effects of the *ETS* variable, by calculating its marginal effects on the probability for an average firm to undergo an organizational change. For binary variables such as *ETS*, the marginal effects are obtained by comparing the probabilities that result when the variable takes its two different values (0 and 1) with those that occur with the other variables held at their sample means (Greene, 2003). Table 3 reports the marginal effects that the *ETS* variables, both before and after 2003, have on the intensity of organizational change.

Table 3. Marginal effects of ETS adoption on the intensity of organizational change

Values of dependent variable y_i (organizational change intensity)	ETS before 2003	ETS after 2003
0	-05.03%	-27.03%
1	-00.71%	-13.64%
2	01.57%	02.92%
3	01.63%	09.26%
4	01.36%	11.44%
5	00.75%	08.78%
6	00.13%	01.87%
7	00.18%	02.98%
8	00.12%	02.70%
9	00.02%	00.72%

For a discrete change of a binary variable from 0 to 1

Therefore, table 3 indicates that as a firm adopts an electronic traceability system after 2003, the probabilities of obtaining a *SCORE* of 3, 4 and 5 (of organizational change intensity) are expected to increase by 9.25%, 11.44% and 8.78% respectively for an average firm. On the contrary, probabilities of getting a score equal to 0 and 1 are expected to decrease by 27.03% and 13.64%.

4.2. Organizational changes by ETS adoption profiles

Before looking closer at the relation between traceability and organizational changes, we aim

to test three models of change intensity for each of the two types of firms – those that have adopted an electronic traceability system (model 3) and those have not – by distinguishing those that adopted ETS before the period of observation of organizational changes in France ("early adopters" model 4) from those that adopted them after 2003, i.e. during the period of observation of changes (Model 5).

For the firms that have adopted ETS[14], the intensity of their organizational changes is positively influenced by specific internal and external variables and that are often opposed depending on the date of adoption. The firms that adopted ETS during the observation period have a specific structural and sectoral profile: they are small firms, more independent from industrial groups and belonging to sectors that innovated little in terms of traceability in the past (it is the case of the fruit and vegetable sector for example). The intensity of their organizational changes is positively influenced by a price competitiveness strategy, whereas in the case of early adopters it is favored by a product quality strategy. The organizational change *SCORE* of the latter increases when they are large firms and belong to a group.

From the point of view of the geographic environment, the new adopters are firms whose organizational change is favored by their being located far from urban centers – i.e. in rural centers, or better, in isolated rural areas. The spatial variables have more influence in the case of new adopters than in the case of other types of firms: the need for change is particularly important for firms located in low density areas, far from urban areas. Rural firms, and mostly those located the furthest away from urban centers, are those that have the highest intensity of organizational change. In keeping with the literature, we find that for the early adopters and those that have not adopted ETS, the rural effect has less influence, or even becomes negative. Being located in an area that is more specialized in agribusiness has a stimulating role on change intensity whatever the type of firm. This result concerning the effect of location economies is in keeping with that of the literature, and above all, reveals that inter-firm relations are more intense within specialized productive systems.

For the new adopters, we note that their being affected or not by changes in regulation and standards, or high market uncertainty, has no influence on the intensity of their organizational changes. On the other hand, this institutional effect is negative for the early adopters that underwent changes in regulation during the previous period. Let us note, finally that from a commercial perspective, the intensity of the organizational changes undertaken by new adopters increases if they are active in national markets, and sharply decreases when they are

[14] See table 4.

open to international markets outside the EU.

In short, the internal structure of the "new adopters" as well as their relations with their external partners and environment has a strong influence on the intensity with which they undertake change. The various results (effects of a small size, of being located in an isolated rural area, etc.) point to a situation whereby the firms which, in the past, undertook little innovation in organizational practices and particularly in traceability systems, are now catching up with other firms. As observed above, the early adopters carried out their main organizational changes before 2003, a priori during their ETS adoption phase. Thus, the adoption of a traceability system has quite clearly contributed to – and has even been a major vehicle of – the organizational changes that the agro-food sector underwent during the observation period. The new adopters with the highest rate of organizational change have profiles that are often in contradiction with the typical standards of innovating firms (small firm, located in a rural area, does not export, driven by price competitiveness). However, they are those that contributed the most to organizational changes in the agribusiness sector during the observation period (cf. table 2, model 2, and adoption after 2003).

Table 4. The determinants of organizational change intensity per type of ETS adopters

Type of ETS adopters	All adopters		Before 2003		After 2003		No ETS	
Dependent variable: SCORE	(3)		(4)		(5)		(5)	
Internal characteristics								
Structure								
Size: 20 – 49 employees	Ref.		Ref.		Ref.		Ref.	
50 – 249	0.137*	(0.0621)	0.255***	(0.0687)	-0.499*	(0.209)	0.576***	(0.129)
250 – 499	0.292**	(0.102)	0.397***	(0.111)	-0.866*	(0.350)	0.282	(0.454)
500 or more	0.233	(0.123)	0.187	(0.132)	-0.0637	(0.389)	0.565	(0.372)
Group	0.0407	(0.0554)	0.264***	(0.0625)	-0.177	(0.174)	0.864***	(0.130)
Multi unit	0.153**	(0.0546)	0.171**	(0.0598)	0.849***	(0.189)	0.537***	(0.118)
Strategy								
Quality	0.609***	(0.166)	0.837***	(0.173)	1.173	(1.159)	1.671***	(0.271)
Competitive prices	0.271***	(0.0792)	-0.00654	(0.0934)	1.117***	(0.179)	-0.257	(0.136)
External environment								
Coordination modes								
Sector: Meat sector	Ref.		Ref.		Ref.		Ref.	
Prepared fruit and vegetables	0.257*	(0.129)	-0.0460	(0.147)	1.391***	(0.410)	0.927**	(0.331)
Dairy products	-0.167	(0.108)	-0.139	(0.121)	-0.143	(0.314)	-0.217	(0.220)
Other food products	0.262***	(0.0665)	0.0581	(0.0758)	-0.0262	(0.210)	0.113	(0.141)
Beverages	0.130	(0.0948)	-0.0856	(0.108)	-0.134	(0.261)	0.820***	(0.225)
Sales under another firm's brand	0.198	(0.299)	0.379	(0.307)	-0.161	(1.656)	0.934	(0.666)
Sales under a retailer's brand	0.506***	(0.146)	0.386*	(0.168)	0.648	(0.428)	2.153***	(0.401)
Spatial externalities								
Proximity of largest customer	0.354***	(0.0743)	0.132	(0.0869)	0.135	(0.183)	0.119	(0.145)
Proximity of largest supplier	-0.351***	(0.0654)	-0.297***	(0.0709)	-0.876***	(0.235)	-0.00128	(0.130)
Location: Urban zone	Ref.		Ref.		Ref.		Ref.	
Peri-Urban	0.466***	(0.0752)	0.501***	(0.0876)	0.363*	(0.183)	-0.156	(0.158)
Rural pole	0.340***	(0.0813)	0.201*	(0.0902)	0.946***	(0.221)	0.218	(0.186)
Rural isolated area	0.285***	(0.0675)	-0.0948	(0.0765)	1.429***	(0.214)	-0.411*	(0.173)
Industrial agglomeration effects	0.0739**	(0.0271)	0.0887**	(0.0309)	0.213**	(0.0801)	0.137*	(0.0622)
Market effects								
Market concentration	0.172**	(0.0579)	0.128	(0.0684)	0.0413	(0.136)	0.195	(0.126)
Local-regional market	-0.178*	(0.0878)	-0.272**	(0.0944)	-0.530	(0.346)	-0.369	(0.191)
National market	0.160*	(0.0725)	-0.108	(0.0814)	0.896***	(0.203)	-0.0251	(0.134)
Exports (EU)	-0.360	(0.252)	-0.0998	(0.273)	0.617	(0.921)	-1.561*	(0.633)
Exports (Non-EU)	-0.214	(0.283)	-0.692*	(0.331)	-2.508**	(0.881)	1.668	(1.073)
Effect of market uncertainty	0.279***	(0.0592)	0.154*	(0.0681)	0.152	(0.150)	-0.220	(0.119)
Institutional environment								
Effect changes in reg. & norms	-0.166**	(0.0571)	-0.297***	(0.0639)	-0.243	(0.152)	0.0483	(0.115)
Cut point: μ_1	1.400***	(0.264)	0.751*	(0.295)	1.672	(1.259)	2.309***	(0.599)
μ_2	2.137***	(0.265)	1.580***	(0.296)	2.196	(1.260)	3.406***	(0.607)
μ_3	2.702***	(0.267)	2.207***	(0.298)	3.041*	(1.264)	4.154***	(0.613)
μ_4	3.139***	(0.268)	2.751***	(0.299)	3.558**	(1.266)	4.687***	(0.617)
μ_5	3.554***	(0.270)	3.411***	(0.304)	3.953**	(1.268)	5.573***	(0.635)
μ_6	3.980***	(0.273)	3.851***	(0.312)	4.657***	(1.272)	6.257***	(0.678)
μ_7	4.118***	(0.275)	4.180***	(0.327)	4.781***	(1.273)	6.468***	(0.704)
μ_8	4.405***	(0.279)	4.241***	(0.332)	5.278***	(1.278)		
μ_9	5.049***	(0.313)			5.941***	(1.286)		
Observations	490		403		90		106	
Weighted data	*1865*		*1515*		*366*		*563*	
Pseudo R^2	0.042		0.052		0.149		0.143	

Standard errors in parentheses; * p < 0.05, ** p < 0.01, *** p < 0.001
Source: COI-TIC (2006) and EAE, French National Institutes of Statistics

5. Conclusion

The aim of this paper has been to explore the relation between the adoption of traceability systems and the intensity of organizational changes in industrial firms. It aimed to test if this adoption increases the intensity of firm-level organizational changes and to highlight the existence of a process of co-evolution between technology adoption and organizational changes. For this purpose, we constructed an indicator of the intensity of firm-level organizational change, based on a definition discussed in the literature, including changes in the firm's hierarchical and decisional structure, managerial practices and information systems, and inter-firm relations (Greenan, 2003; Benghozi, 2001; Murphy, 2002). Our hypothesis was that the intensity of these changes was affected by the adoption of traceability systems. Moreover, the objective was to test the respective role of the adoption of traceability systems and other factors related to the firm's internal characteristics (structures, strategy, etc.) and its external environment (supply chain effects, market characteristics and spatial externalities). Our aim was to investigate the "double view" approach whereby changes can be the result of a planned strategy or of an adaptation process.

The empirical test is based on the French Organizational Changes and Computerization survey which gave us substantial information to carry out this research. Empirically, two stages are tested, which enables us to analyze the influence of electronic traceability adoption on the intensity of organizational change, first for the entire agro-food industry and, second, for different populations of firms, distinguished by their period of adoption.

The results provide new empirical evidence on the relationship between organizational changes and traceability adoption. The first stage provides support for the hypothesis of the positive influence of electronic traceability adoption in the intensity of organizational change in French agribusiness. Moreover, the results show that organizational changes are coherent with the firm's strategy, but they are also an adaptation process to their external environment. Thus, beyond the influence of the firm's internal characteristics, we show the particular influence of downstream actors, and especially retailers, in the processes of organizational change in agribusiness. Similarly, the presence of local networks effect generated by industrial agglomeration of agro-food firms and the effect of market uncertainty seems to stimulate organizational changes.

Furthermore, by dividing the population of firms according to when they adopted their ETS, we highlight the process of co-evolution between the adoption and the organizational

changes. The results show a clear correlation between the period of adoption and implementation of traceability systems and the period and the intensity of organizational changes at firm-level. Moreover, we found that, depending on the adoption period, the factors that positively influence the intensity of organizational changes are different and often contrary. Early adopters are influenced by a product quality strategy, a large size, belonging to a group and location in urban and peri-urban areas, whereas new adopters are influenced by the opposite factors (price competitiveness, small size, rural location, etc.), which reflects, for a large part, the fact that they are situated at the end of the process of diffusion of the first traceability technologies.

In conclusion, whatever the factors of adoption and their diversity, this study demonstrates that the adoption of electronic traceability systems has been a major vector of the organizational changes that the agro-food sector underwent during the observed period. The findings open new perspectives for managers and policy makers. Electronic traceability systems, influenced by regulation, and demanded more and more by downstream customers, are not implemented independently of the other components of an organization, both internally and externally. For managers, this first wave of traceability technologies – backed up by regulation – has created strategic opportunities for firms to enhance their identity and product specificity (e.g. organic foods, GMO's, etc.). These processes will reinforce the co-evolution between technologies and organizational changes. Further empirical research should explore these new strategies and the diversity of technological systems which can vary among sectors, supply chains and products, and influence the intensity of firms' organizational changes.

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Appendix

Table A1. ETS adoption by French industrial firms

Sector of activity	No. of firms	% of firms	% of firms with ETS in 2003	% of firms with ETS in 2006
Agro-food	2,428	11.43	62.39	76.81
Consumption goods	4,210	19.82	24.18	28.83
Automobile	547	2.58	44.57	51.71
Equipment goods	4,803	22.62	37.09	41.58
Intermediate goods	9,248	43.55	44.28	49.89
Total	21,236	100.00	40.77	46.96

Source: COI-TIC (2006), French National Institutes of Statistics

Table A2. Definition of variables

Variables	Definition	Source
Dependent variables		
SCORE	An ordered variable of 10 modalities representing a number of firm-level organizational changes (from 0 to 9)	COI-TIC
Independent variables		
Size	Qualitative variable with 4 modalities: 20 to 49 employees (ref.); 50 to 249; 250 to 499; and more than 500	EAE
Group	= 1 if the firm is a subsidiary of a group, 0 if independent	COI-TIC
Multi unit	= 1 if the firm has 2 or more establishments, 0 if single unit	EAE
Quality strategy	= 1 if a quality strategy is important or very important, 0 if little or no importance	COI-TIC
Competitive prices strategy	= 1 if a competitive price strategy is important or very important, 0 if it has little or no importance	COI-TIC
Quality strategy	= 1 if quality is considered important or very important in firm's strategy, 0 otherwise	COI-TIC
Competitive prices strategy	= 1 if having competitive prices is considered important or very important in the firm's strategy, 0 otherwise	COI-TIC
Sector of activity	Qualitative variable with 6 modalities: Meat sector (ref.), Prepared fruit and vegetables; Dairy products; Processed animal feed; Other food products; and Beverages	EAE
Sells under another firm's brand	Logarithm of total sales under another firm's brand/total revenue	EAE
Sells under a retailer's brand	Logarithm of total sales under a retailer's brand/total revenue	EAE
Proximity of largest customer	= 1 if the firm's largest customer is located in proximity to one of its production sites (within a 30km radius), 0 otherwise	COI-TIC
Proximity of largest supplier	= 1 if the firm's largest supplier is located within proximity of one of its production sites (within a 30km radius), 0 otherwise	COI-TIC
Head office location	Qualitative variable with 4 modalities for the location of the firm's head office: Urban area (ref.); Peri-urban area; Rural pole; and Rural isolated area	EAE/Zonage
Industrial agglomeration effects	Logarithm of the ratio of the share of a sector's workforce in the « *département* »'s total workforce to the share of the same sector's workforce in the country's total workforce.	EAE
Market concentration	Logarithm of the C4 concentration ratio : cumulated market shares of the first four firms in the sector (at the NAF 700 level)	EAE
Active in the local/regional market	= 1 if the firm is active in the local or regional market, 0 otherwise	COI-TIC
Active in national market	= 1 if the firm is active in the national market, 0 otherwise	COI-TIC
Exports (EU)	Logarithm of the exports rate to the European Union: EU export/ total revenue of the firm	EAE
Export (non EU)	Logarithm of the exports rate outside the European Union: non-EU export/ total revenue of the firm	EAE
Market uncertainty	= 1 if the firm's activity has been strongly or very strongly affected by market uncertainty, 0 if little or no effect	COI-TIC
Changes in regulation and norms	= 1 if the firm's activity has been strongly or very strongly affected by a change in regulations and norms, 0 if little or no effect	COI-TIC

Source: EAE and COI-TIC (2006), French National Institutes of Statistics