New technologies and firm organization: The case of electronic traceability systems in French agribusiness

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Abstract
This paper considers the relationship between the adoption of electronic traceability systems (ETSs) and the organization of firms. More precisely, it analyzes the respective roles of a firm's organizational structure, and of organizational changes, in the process of ETS adoption in agribusiness. We use data from the French "Organizational Changes and Computerization" survey from 2006. We test a probit model to demonstrate the organizational structure and organizational changes underlying the firm's ETS adoption choice. Results show that ETS adoption is strongly favored by organizations with heavily hierarchical structures, standardized managerial practices and contractual mechanisms with external partners. This adoption process seems to co-evolve with the organization: firms that implemented an ETS during the observed period (2003-2006) have experienced the most important organizational changes in terms of managerial practices, information systems and contractual relations, as well as the strengthening of the intermediate levels in the hierarchy.

Keywords: Traceability systems, Firm organization, Technological change, Agribusiness

JEL codes: L22, 033, Q13

1. Introduction

Traceability, the capacity to trace a product through all of the stages of a supply chain, has become an important management instrument in organizations and an important tool for the codification and the transfer of information between firms. Advanced by the development of external constrains (both institutional and market related) and new information technologies, electronic traceability systems[1] (ETSs) have become a rapidly growing technology for industrial firms. This trend has been particularly present in the agro-food sector, given ETSs' capacity to reduce the cost of product recalls and food safety incidents. From the BSE (bovine spongiform encephalopathy, or mad cow disease) crisis and recent food incidents[2] have called for greater awareness, controls and coordination in supply chains. In this context, the need for traceability systems has become and important tool to reestablish consumers' trust[3] and has caught the attention of policy makers, food companies and mass media in most countries, even if specific practices and policies are usually adapted to national contexts.

ETSs are mainly characterized by their ability to intervene as a coordination mechanism between agents, allowing for increased information and knowledge transmission, storage and processing capacity (Lam, 2005), while reducing the costs of information acquisition and transmission (Garicano, 2010). However, as with other information and communication technologies (ICT), their adoption processes and impacts on organizations are complex. Several authors have shown that the characteristics of organizations are not only preconditions for the firm's technical and organizational pathways but also are also the way in which innovations and

[1] An ETS can be defined as a combination of technical codification supports (commonly associated to bar-codes and/or electronic tags such as RFID), coupled with ICT that enable firms to store, manage and transfer information on a rage of product attributes.
[2] Such as the *salmonella* scare on peanut products in the U.S. and Canada in 2009 or the recent detection of dioxins in eggs from Germany.
[3] Some authors show how traceability is an essential support and a complement of brands in the process of building consumer's trust. In addition, they are an effective tool for preventing potential recalls that could damage the firm's reputation that could result in the loss of clients (Kumar and Budin, 2006; Galliano and Orozco, 2011).

new practices, or technologies, will change the structure and the operations of an organization (Brousseau and Rallet, 1998; Teece, 1998).

The aim of this article is to explore the relationship between the adoption of ETSs and the organization of firms. More precisely, the objective is to analyze the respective roles of a firm's organizational structure and a firm's organizational changes in the process of ETS adoption in agribusiness. Our main hypothesis is that the adoption process is at the center of the firm's structural and strategic pathways and that it is also a part of a process of organizational changes, i.e., a co-evolutionary process with the entire organization. The overall objective is to test, first, the role played by a firm's structure (e.g., hierarchical, functional or informational) and, second, to test the roles played by changes at different levels of the organization.

To achieve these objectives, different theoretical frameworks ought to be considered, in order to explain both the structure of the firm and the internal and external coordination mechanisms that governs it, as well as the processes generated by dynamic changes. In this matter, the theoretical framework built for this research mobilizes two complementary approaches. The first, New Institutional Economics (NIE), is particularly useful to explain questions related to the firm's internal and external coordination processes, as well as the problem of information asymmetries and inter-firm relations. The second is the evolutionary approach, which allows for a better understanding of the dynamics in organizations. These two complementary approaches are at the base of our hypotheses and the explanatory factors.

Moreover, the empirical tests are based on 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 INSEE (National Institute for Statistics and Economic Studies) and the

Center for Employment Studies (CEE) with a representative sample of French industrial firms. Using this dataset, we use a probit model to discover, first, the organizational structure and, second, the organizational changes to firms given their decision to adopt an ETS.

The paper is organized as follows. Section 2 introduces the theoretical framework for technology adoption and organizational change, the explanatory factors and the research hypotheses. Section 3 describes the dataset, empirical model and variables employed. The empirical findings are presented in Section 4. The last section concludes the paper and discusses its contributions.

2. A theoretical framework of traceability and organizational change

As general purpose technologies (Bresnahan and Trajtenberg, 1995), ICT do not have identical adoption and diffusion characteristics and organizational determinants, and their interactions or impacts on organizations differ. In this context, this paper addresses the double question of the structural forms and organizational change associated with the adoption of ETSs. To address these two aspects (static and dynamic), we use two complementary theoretical backgrounds. The New Institutional Economics is used to explain the role and impacts of the firm's structure and its coordination mechanisms with the adoption of new technologies. The evolutionary approach is used to better understand and pose the questions of changes in organizations as well as the adaptation to their environment, notably when interactions exist between the diffusion of technologies and the dynamics of organizations (learning process, absorptive capacity and external technological opportunities, etc.).

This framework is particularly interesting in a way that the structure of the firm is regarded, in the first case, as an efficient response to its information costs (in Williamson's 1985 view) and, in the second case, as a precondition for both the firm's technical and organizational pathways (Malerba, 2005; Teece, 2010). These pathways result from the interplay between the environmental conditions that firms face and the internal conditions carried by organizations.

The theoretical literature on the relationship between information technologies and organizational design is first discussed with regard to traceability technologies (2.1), which allowed us then to identify a range of explicative factors and hypotheses (2.2) to be tested in our empirical study.

2.1. The adoption of information technologies and organizational design: the general framework of traceability adoption

Our aim is to consider works relating the adoption of ICT to the organizational transformation of firms to explain the determinants of ETS adoption. The relationship between organizations and technological innovation is addressed in the literature, first, by analyzing the structural characteristics of the innovative organization and, second, by focusing on organizational change and adaptation and the processes underlying the creation of new organizational forms (Lam, 2005).

In this context, New Institutional Economics (Williamson, 1985) characterizes firms by their organizational architecture, their degree of centralization (the distribution of authority among the network components) and the 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's structure is supposed to resolve the problems of information asymmetry and is conceived as a set of coordination mechanisms. ICT are tools designed to solve these coordination problems, mainly by modifying information management capabilities (Brousseau and Rallet, 1998). Traceability systems facilitate information about the histories and locations 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, independent of the "distance" between the decision-maker and the operators.

In addition, the NIE approach makes it possible to take into account inter-firm relations, i.e., the governance of contractual relations, the effectiveness of which varies with the institutional environment and the attributes of the economic actors. Incentive-based contractual mechanisms rely heavily on supervision and monitoring (transaction costs) and consequently have a positive influence on the adoption of ICT. Here, traceability systems are expected to reduce transaction costs and information asymmetry, especially with suppliers and customers. In agribusiness, monitoring costs will tend to rise if more information about the production methods is needed (Hobbs, 1996). Moreover, in this sector, information asymmetry is specially related to food safety, quality and origin of products (Ménard and Valceschini, 2005; Souza-Monteiro and Caswell, 2010).

Our analysis finds support, also, in evolutionary economics (Nelson and Winter, 1982), as this theory has developed analytical tools to address questions related to change, 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 of the necessary information about the set of opportunities (Dosi and Marengo, 1994). Economic behavior is defined more in terms of path dependency and the routinization of activity in an

organization constitutes the most important form of the 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, routines (problem-solving by nature) acquired by individuals serve as substitutes for managers in the coordination of decisions. In this sense, the move towards a "learning organization" is usually reflected in changes both within firms and in inter-firm relationships (Lundvall and Nielsen, 1999).

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 and coordination failures, among others. 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 economic activity (Rosenberg, 1982). However, the process of experimentation and discovery will progressively reveal how the technology can efficiently support coordination[4].

The two learning processes mentioned above are facilitated not by basic ICT but by technologies that help build an organizational memory, i.e., the acquisition, retention, maintenance, search for and retrieval of information (Stein and Zwass, 1995). In this regard, ETSs can be conceived as a vector of organizational learning. Forest (2000) provides a framework in which she considers both stages of the memorization process that is facilitated by traceability systems from an organizational perspective: the first consists of the memorization of data with a view to capitalize on these data in the future; the second aims to draw lessons from the capitalization stage (to promote learning). This process includes a reflection on and an

[4] Furthermore, finding solutions to these coordination problems may enhance the skills and know-how of employees (Jensen et al., 2007).

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 systems enable 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 found.

This general background can be applied to agribusinesses, which have been particularly exposed to the pressure of external constraints, both institutional and market related, to adopt and assure traceability systems, food safety and quality procedures. For the past fifteen years, the agro-food sector has seen the increasing adoption of food safety, quality control and just-in-time practices, which are designed to reduce delivery times, respond to sudden variations in demand and restore consumer confidence (Galliano and Roux, 2008b). A growing economic literature on traceability adoption in the agro-food sector has mainly focused on its drivers, the interoperability of systems along supply chains, and the economic implications (Hobbs, 2004; Souza-Monteiro and Caswell, 2010). However, to our knowledge, there has been no research on the relationship between electronic traceability adoption and the firm's organization.

2.2. ETS adoption and organizational change: Explanatory factors and hypotheses

This section analyzes the respective roles of a firm's organizational structure and that of a firm's organizational changes in the process of ETS adoption in agribusiness. Our primary hypothesis is that the adoption process is at the center of the firm's structural and strategic pathways, but at the same time, it is part of a process of organizational change, i.e., a co-evolutionary process with the entire organization. Therefore, our objective is first to examine the role of a firm's structure (e.g.,

hierarchical, functional or informational) and, second, to analyze the interactions with changes at different levels of the organization.

The adoption of ICT interacts with the governance structure (hierarchical and decisional structure), the managerial practices, and arrangements with external partners (Greenan, 2003; Benghozi, 2001; Frigant and Talbot, 2005). We use this approach to develop the set of factors related to the firm's structure and those related to organizational changes that could both explain the adoption of electronic traceability. The organizational structure relates to a static view, while organizational changes relate to a dynamic view; therefore, hypotheses are defined in terms of both statics and dynamics. In addition, we consider the possibility that the firm's external environments (sectoral, geographical and institutional) could also play a role in its adoption behavior.

2.2.1. The firm's hierarchical and decisional structure

From the ICT literature, on the one hand, we found that for a highly centralized organization, the use of advanced ICT leads to increased decentralization, while on the other, for a highly decentralized organization, the use of advanced ICT leads to increased centralization (Huber, 1990). This phenomenon is better explained by the trade-off between information acquisition costs and communication costs, depending on which hierarchical level decisions are made on (Garicano, 2010). A higher number of hierarchical levels imply the need to duplicate the information and the risk of losing some degree of control (Williamson, 1967), favoring, at the same time, the use of information management and communication tools. Relying more on the dictates of the hierarchy reduces the cognitive burden of lower managers and lowers the total information acquisition costs. This practice, however, comes at the price of increasing total

communication costs (Garicano, 2010). In a dynamic set, a decrease in communication costs is favorable to a reduction in intermediate hierarchical levels, the main function of which is to gather, process and transfer the information to the top management A decline in the middle management and a reduction in communication costs imply the flatness of the organization and a decrease in the number of hierarchical levels. For certain authors, at the operative level, this flatness entails an increase in the centralization of decisions (i.e., lower communication costs); hence production workers and plant managers can rely on decisions made by corporate managers. For others, however, this flatness means increased autonomy for the operators and thus a shift to a decentralization of decisions (Brynjolfsson and Hitt, 2000). This decentralization can be combined with the delegation of decision-making power to intermediate levels, whether individual or collective as in, for instance, autonomous working teams (Daft and Lewin, 1993).

The empirical evidence tends to show a higher delegation to and an increased autonomy at the individual level, i.e., for operators and specialists, but also to the collective level, which is supported by the development of collective organizational working practices (Brynjolfsson and Hitt, 2000). ICT have substituted the formal hierarchical structure to achieve coordination and manage relationships within and between organizations (Daft and Lewin, 1993). In the case of ETSs, formal authority can be delegated to lower hierarchical levels, while at the same time, the accumulated knowledge and information allows for an increase in the strategic decision-making capabilities (and tools) for the top management.

Hyp. 1a: The use of an ETS is generally associated with a high number of hierarchical levels.

Hyp. 1b: In dynamics, ETS adoption could translate into a decrease in hierarchical levels, which is sometimes associated with a delegation of formal authority to intermediate individual and collective levels.

Another aspect of the organizational structure is that the productive organization, and the functional structure that underlays it, could play key roles in a firm's information and traceability systems. The reason is that traceability systems influences the nature and the quantity of information exchanged within the organization, the group the firm belongs to or with external partners. The more a firm is functionally specialized, the more it will be interdependent and generate higher demands for coordination and information exchanges with other units of its group or network (Hwang, 1998). A low degree of functional complexity represents a specialization in certain functions and therefore a tendency to externalize other functions, either within the group it belongs to or to external partners; this process should favor the use of ICT. At the same time, a high degree of functional complexity will tend to show a higher productive integration and a higher internal complexity, favoring the use of ICT of an internal type (Intranet), and should generate fewer external links. In dynamics, several authors show that the use of ICT, while reducing the costs of communication, contributes to a decrease in the degree of vertical integration within the firm in favor of an increase in external relations (Brynjolfsson and Hitt, 2000). Traceability systems should play a role in this matter, given the fact that they are technical mechanisms that favor inter-firm coordination all along supply chains. However, these conclusions have yet to be validated empirically.

Hyp. 2a: The adoption and the use of an ETS will be greater if the functional complexity of the firm is high.

Hyp. 2b: In dynamics, an increase in the externalization of functions (i.e., a reduction in functional complexity) is expected to be positively associated with an ETS.

The conclusions of different studies are not unanimous and show a differentiated impact that depends on the level of specialization of a firm and the nature of its needs, in terms of coordination, that they have generated, either internally or externally.

2.2.2. The firm's managerial practices and information systems

The literature shows the interactions or complementarity (as in Milgrom and Roberts, 1990) between the use of information technologies and the adoption of new organizational practices. Empirically, these managerial practices mainly concern the management of quality (ISO norms), delays (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, 2003). The complementarity is also influenced by the speed at which new competencies and skills can be developed to match the demands of new technologies (Astebro, 2004) and the inertial forces linked to routines and the stock of know-how and tacit knowledge of the firm. The organization of production and the nature of information flow are strongly conditioned by the degree of formalization and codification of practices and knowledge (Brousseau and Rallet, 1998)[5]. If considered to be a precondition to the adoption of ICT and the implementation of an ETS, the codification of knowledge allows for its circulation within the firm's internal network and the development of standardized practices with external partners.

[5] These practices rationalize and formalize the coordination modes internally (mainly routines, e.g. Lazaric and Denis, 2005).

Hyp. 3a: The adoption of formalized managerial practices is expected to be positively related to the adoption of an ETS.

Hyp. 3b: In dynamics, an increase in these practices should play a positive role in the adoption.

From a theoretical point of view, ICT should reduce the information acquisition and communication costs (Garicano, 2000). As we mentioned earlier, this reduction will directly interact with the firm's decision-making process and will serve to support the management and transmission of traceability information. Enterprise resource planning (ERP) systems, for instance, will improve access to information for all managers across the organization, but these systems are also the main tools for the management of traceability data (ACTA-ACTIA, 2007). These systems allow for the organization and reorganization of the firm's information system in which ETSs will be supported.

In addition, information needs to be shared at different levels of the firm, and different tools will serve to reduce the accompanying communication costs. Intranet systems connect corporate headquarters with local managers, while reducing the costs of communication (Garicano, 2010). They can also be used to deliver and transfer traceability information. Traceability systems are assumed to have local specificities for each firm, especially in terms of internal information and knowledge management. However, an external coordination with partners upstream and downstream is needed to assure the correct transmission of information. Sending the necessary

information requires a data formatting process (following the receiver's specifications), such as EDI (electronic data interchange) formats[6].

Hyp. 4a: ETS adoption is expected to be positively related to the existence of other data management and communication tools.

Hyp. 4b: In dynamics, the adoption of an ETS is expected to be positively influenced by the development of the firm's information management systems.

2.2.3. Inter-firm relations

Benghozi (2001) underlines the role of ICT in shaping the firm's internal organization along with that of its supply chain, giving particular attention to the links between physical and informational exchanges. The supply chain literature has shown the limits of individual firms' abilities to implement traceability systems because this process cannot be done independent of the supply chain to which they belong.

The adoption of ETS at the inter-firm level, however, requires new organizational arrangements and procedures to assure the coordination of activities. The increased formalization of external relations into contractual forms has been highlighted as a corollary element to the traceability relations within supply chains (Banterle and Stranieri, 2008; Charlier and Valceschini, 2008). In this matter, Souza-Monteiro and Caswell (2010) show that vertical network effects occur when a decision made by a third-tier firm downstream impacts the first-tier firms upstream

[6] In the business-to-business context, EDI has been developed as a standard coordination tool, given its reliable means for achieving electronic, computer-to-computer information exchange (Bechini et al., 2008).

in the cascade (e.g., in the case of contracts between the producer of a multi-ingredient product and its intermediate processors). Therefore, partners have to adopt procedures to record the information established in the supply chain traceability system, implement quality production rules and assume the necessary investments and costs associated with the system[7].

Furthermore, outsourcing activities should also determine the adoption of traceability systems. Outsourcing is considered to be an organizational form that aims to profit from the knowledge and capabilities of providers (Mazzanti et al., 2009), which should encourage the adoption of new technologies and strengthen ties with such local providers (Holl et al., 2010).

Hyp. 5a: The adoption of an ETS will is going to be associated with the adoption of specific contracts both upstream and downstream.

Hyp. 5b: An increase in the use of contracts upstream and downstream should play a positive role in ETS adoption.

2.2.4. External environment

The evolutionary view emphasizes the ability of organizations to create new organizational forms (to overcome inertia) and adapt to environmental shifts and changes in technology. The sector of activity, the spatial externalities and the institutional context are expected to influence the firm's behavior.

[7] At stake is the consumer's trust, whether a product is being sold under a retailer's or a producer's brand. In the former, the reputation of the entire retailer's network is stake, whether in the latter, it might only be the trust in that particular firm that may drop.

The influence of the firm's sector of activity on its adoption behavior can be related to the technical characteristics of the industry and the nature of the product. The pace of traceability adoption has been different among the agro-food sectors, with the meat sector typically being the leader. This sector is characterized by long and complex supply chains with a tendency towards integration. This sector has also been particularly exposed to food safety scandals (such as BSE and food and mouth disease), which sparked consumer's pressure and demands concerning food safety[8].

With regard to the spatial environment, the general view is that firms are influenced by the environment in which they are located, as proximity and agglomeration economies are expected to foster innovation and the adoption of new technologies (Boschma and Frenken, 2006; Torre and Rallet, 2005; Malmberg et al., 2000). Urban agglomeration economies facilitate access to a variety of infrastructures and service activities, as well as to a qualified workforce, which favors the adoption of technologies by firms. In addition, the level of industrial specialization in the area in which the firm is located also plays a positive role (Antonelli, 1999) because it creates a dense network of relationships between firms (e.g., suppliers and associated services). However, even though proximity favors innovation, information technologies favor the use and the acquisition of external knowledge, as well as the development of global links (Bathelt et al. 2004) necessary to localized innovation.

Considering standards as institutions, Aust-Sterns and Reardon (2002) show how the agro-food sector is characterized by constant changes in standards (e.g., collective, public to individual and firm-specific) and regulations, which interact with technology, existing institutions and the market structure. These changes concern, among other things, the concept of food safety and

[8] Moreover, regulation also intervened early on in this sector, establishing a system for the identification of bovine animals and the labeling of beef products (c.f. Regulation EC 820/97).

quality, the guarantees required and the most efficient ways to achieve them (Ménard and Valceschini, 2005). Voluntary programs on food safety, sometimes promoted by public authorities (Fares and Rouvière, 2010), could be a response to these institutional constraints[9].

Hyp. 6: The nature of the environment in its different dimensions (sectoral, geographical and institutional) influences the probability of adopting an ETS.

3. Research method

3.1. The data

The main dataset is drawn from the 2006 COI-TIC survey conducted by the INSEE (National Institute for Statistics and Economic Studies) and the Center for Employment Studies (CEE). This survey combines the points of view of both firms and employees to describe a firm's 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 (approximately 2428 firms) with respect to size and sector; each firm in our final sample has 20 or more employees. Structural (e.g., size, sector and turnover) were

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

[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. Refer to Greenan et al. (2010) for further information.

taken from the Annual Enterprise Survey (EAE), also conducted by the French Institutes of Statistics[11].

A cut of the database by sector is presented in table 1. The meat and the fresh produce (fruits and vegetables) sectors have been the more responsive to ETS adoption (80.47% of meat firms, 75.30% before 2003, and 86.31% of fresh produce, 14.64% after 2003). The meat sector has a long history of identifying and tracking animals and has been particularly exposed to food safety scandals such as the BSE crisis, food-and-mouth disease, etc. (Vos, 2000). While, the fruits and vegetables sector is characterized by the development towards retail integration and branding, with coordinated chains, certified suppliers and contractual relations with retailers (Codron et al. 2007).

Table 1. Distribution of respondents by sector

	Number of firms	(%)	ETS adopters (%)	ETS adopters before 2003 (%)	ETS adopters after 2003 (%)
Meat sector	817	33.66	80.47	75.30	5.17
Prepared fruit and vegetables	106	4.35	86.31	71.64	14.67
Dairy products	207	8.53	76.10	61.80	14.30
Processed animal feed	128	5.25	74.67	64.10	16.00
Other food products	772	31.81	73.62	52.93	20.69
Beverages	398	16.40	74.04	51.56	22.48
Total	2 428	100	76.81	62.39	15.09

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

Additional statistics are provided in table A1 (in the appendix), which show the importance of managerial practices such as just-in-time (44.46% of firms adopting an ETS before 2003), quality certification (62.40%) and SCM (33.34%). We found, however, that a high percentage of firms that adopted an ETS after 2003 had also adopted EDI systems (71.74%). Similarly, the percentage of firms adopting an ETS after 2003 that had developed contractual relations with suppliers (67.49%) and customers (75.11%) is rather high and could suggest that ETSs are associated with the adoption of contracts both upstream and downstream.

[11] That includes INSEE and the Statistics and Forecasting Department (SSP) of the French Ministry of Agriculture.

3.2. Empirical model: the probit equation

The analysis of the organizational structure and organizational changes explaining ETS adoption is carried out in two parts. First we estimate a binary probit model in which the probability of adopting an electronic traceability system (*ETS* = 1) by a firm, *i*, is a function of the firm's organizational structure (hierarchical and decisional), its managerial practices and information systems, its inter-firm relations and the characteristics of its external environment. Then, we estimate ETS adoption as a function of organizational changes. Probit models are used to explain a dichotomous dependent variable with empirical specifications in terms of a latent regression (Greene, 2003). The probit equation is formally written as follows:

$$ETS_i = \beta_1 HD_i + \beta_2 MPI_i + \beta_3 IF_i + \beta_4 EE_i + \beta_4 x_i + \varepsilon_i \quad (1)$$

Where HD_i denotes the hierarchical and decisional structure of firm *i*, MPI_i denotes the managerial practices and other ICT, IF_i denotes the inter-firm relations, EE_i denotes the external environment, x_i denotes other control variables and ε_i, denotes the residual error, which is normally distributed. β is the vector of parameters. The observed dependent variable ETS indicates whether a firm (i = 1,…, n) has adopted an ETS. From the COI-TIC database, the binary variable *ETS* corresponds to whether the firm has an ETS or not. The variable *ETS* have the value 1 if the firm has an ETS and 0 otherwise.

We then test if the adoption of electronic traceability is a function of organizational changes. The probit equation is then:

$$ETS_i = \beta_1 cHD_i + \beta_2 cMPI_i + \beta_3 cIF_i + \beta_4 cEE_i + \beta_5 x_i + \varepsilon_i \quad (2)$$

Where cHD_i denotes the changes in the hierarchical and decisional structures, $cMPI_i$ denotes changes in the managerial practices and other ICT, cIF_i denotes the changes in the inter-firm relations, and cEE_i denotes the changes in the external environment.

3.3. Variables

Dependent variable. The dependent variable indicates whether or not a firm possesses an electronic traceability system (*ETS*). As shown in table A1, 76.81% of firms in the agro-food sector have adopted an ETS. This dichotomous variable equals 1 if the firm has adopted an ETS and 0 otherwise. This variable does not allow for the measurement of the intensity or degree of traceability, an argument commonly asserted in the literature[12]. Golan et al. (2004) establish a framework assuming that traceability depends on its breadth (amount of information recorded), depth (the different levels of the supply chain) and precision (detail to pinpoint a particular food product) and test it on several case studies. However, for the purposes of this section, the dichotomous dependent variable used makes distinguishing between two populations (adopters and non-adopters) and associating all of the variables possible. In both equations (1) and (2), we estimate two additional models with the dependent variables *ETS03* and *cETS*, which correspond to the adoption of an electronic traceability system before and after 2003, respectively. These models will allow us to differentiate between those firms adopting an ETS during the two time periods with respect to the entire population of adopters.

[12] See Souza-Monteiro and Caswell (2010) for a survey .

Table 2: Description of variables

Variables	Definition
Dependent variables	
ETS	= 1 if the firm has an Electronic traceability system, 0 otherwise
ETS03	= 1 if the firm has adopted electronic traceability before 2003, 0 otherwise
cETS	= 1 if the firm has adopted electronic traceability after 2003, 0 otherwise
Independent variables	
Hierarchical and decisional structure	
Hierarchical intensity	= 1 if high degree of hierarchical levels (using the 4th quartile of number of hierarchical levels/number of employees), 0 if low
Hierarchical levels	Qualitative variable of 3 modalities: Stable (reference), increase or decrease of the number of hierarchical levels in the firm during the 2003-2006 period
Functional complexity	= 1 if high degree of functions managed internally (using the 4th quartile of number of functions managed internally/number of employees, 0 if low
Externalization	Qualitative variable of 3 modalities: Stable (reference), increase or decrease of the number functions trusted to an external partner during the 2003-2006 period
Implication of hierarchy in tasks	= 1 if high implication of the hierarchy (in 4 or more tasks of the firm), 0 if low
Increase hierarchy's implication	= 1 if increase of the number of tasks the hierarchy is implicated, 0 if decrease or stable
Working teams	= 1 if the firm have working groups with autonomous durable organization, 0 otherwise
Managerial practices and ICT	
Just-in-time	= 1 if the firm has a just-in-time practice, 0 otherwise
Quality certification	= 1 if the firm possess a quality certification (ISO 9001), 0 otherwise
Supply chain management	= 1 if the firm implements the procedures of Supply chain management, 0 otherwise
Increase managerial practices	= 1 if the firm's number of managerial practices (JIT, quality certification, etc.) has increased during the 2003-06 period, 0 if stable or decrease
ERP	= 1 if the firm possess an Enterprise Resource Planning system, 0 otherwise
Intranet	= 1 if the firm has an Intranet, 0 otherwise
EDI	= 1 if the firm is equipped with an Electronic Data Interchange system, 0 otherwise
Increase num. of functions managed by an ERP	= 1 if the number of functions managed by an Enterprise Resource Planning system (conception, purchases, sales, production human resources, finance, etc.), 0 if stable or decrease
Inter-firm relations	
Upstream dependency	= 1 if the top three suppliers represent more than 50% of the firm's total purchases, 0 otherwise
Delivery contract with suppliers	= 1 if the firm use contracts with suppliers concerning delivery delays, 0 otherwise
Industrial outsourcing	Logarithm of total expenses dedicated to outsourcing/total revenue
Increase in contracts with suppliers	= 1 if the firms has increased its contractual practices with suppliers (long term contracts, delivery delays or specifications), 0 if stable or decrease
Downstream dependency	= 1 if the top three customers represent more than 50% of the firm's total revenue, 0 otherwise
Sells under another firm's brand	Logarithm of total sales under another firm's brand/total revenue
Sells under a retailer's brand	Logarithm of total sales under a retailer's brand/total revenue
Delivery contract with customers	= 1 if the firm use contracts with customers concerning delivery delays, 0 otherwise
Increase in contracts with customers	= 1 if the firm has increased its contractual practices with customers (certification, delivery delays or a customer service contract), 0 if stable or decrease
External environment	
Sector of activity	Qualitative variable with 6 modalities: Meat sector (reference), Prepared fruit and vegetables, Dairy products, Processed animal feed, Other food products, and Beverages
Head office location	Qualitative variable with 4 modalities for the location of the firm's head office: Urban area (reference), Peri-urban area, Rural pole and Rural isolated area
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
Market uncertainty	= 1 if the firm's activity has been strongly or very strongly affected by market uncertainty, 0 if little or no effect
Control variables	
Size	Qualitative variable with 4 modalities: 20 to 49 employees (reference), 50 to 249, 250 to 499 and more than 500
Group	= 1 if the firm is a subsidiary of a group, 0 if independent
Multi-unit	= 1 if the firm have two or more establishments, 0 if single unit
Exports (EU)	Logarithm of the firm's exports rate to the European Union: EU export/total revenue
Export (non EU)	Logarithm of the firm's exports rate outside the European Union: non-EU export/total revenue

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

[a] That is the ZAUER file (Zonage en aires Urbaines et en Aires d'Emploi de l'espace Rural) from 1999, also provided by INSEE.

Independent variables. The complete description of variables is shown in table 2. The variables in this table correspond to the organizational structure of the firm, organizational changes (hierarchy and decisional structure, managerial practices and information systems, and inter-firm

relations), as well as to the firm's external environment. Moreover, we introduce a series of controls necessary for this type of analysis.

4. Results: organizational structure and organizational changes supporting electronic traceability adoption in French agribusiness

In this section, we present and discuss the findings of our econometric estimations. Tables 3 and 4 report the marginal effects[13] of probit equations (1) and (2). For all estimations, we have used weighted data to correct for sampling bias (i.e., to ensure a better representation of the individual firm's distribution) and provide results for the entire population.

4.1. Organizational structure and electronic traceability adoption

The innovation literature underlines the importance of a firm's internal characteristics and its external environment in the technology adoption process. These are important constraints to be considered during the adoption, but they could also constitute the starting conditions for the co-evolutionary process between technology and organization. In this matter, we consider that the organizational structure of the firm include both its characteristics and its external coordination modes.

The results (table 3) emphasize the importance of the firm's organizational structure to the agro-food firms' probability of adoption. Model 1 explains the average behavior of the entire population (with a *pseudo* $R2 = 0.175$). However, the models offer less clear explanations of the

[13] The marginal effect of an explanatory variable can be interpreted as the impact of a 1% variation of a continuous variable (the passage from 0 to 1 for a binary variable) on the probability of possessing an ETS. Example, in table 3, the fact of having a high hierarchical intensity increases by 8.66% the probability of possessing an ETS, all other things being equal.

behavior of new adopters (adoption after 2003, model 3, *pseudo* $R2$ = 0.129). Moreover, the explanatory factors of these new adopters are very different from model 1.

Thus, as showed in the general model (model 1), the profile most favorable to adoption is that of a middle-sized firm (between 250 and 499 employees). Belonging to this size class increases the probability of possessing an ETS by 17.2%. Their governance profile is characteristic of a hierarchical multi-level organization (hypothesis 1), with a low level of participation by the higher levels of the hierarchy in the company's tasks and the presence of collective work organization mechanisms such as autonomous working teams. The formalization of work practices is also supported by the application of managerial practices such as just-in-time, quality certification and supply chain management, which are key elements of ETS adoption. Results from model 1, consistent with our hypotheses, demonstrate this relationship, to the point that these elements increase the probability of adopting an ETS by 10.6% (JIT), 11.8% (quality certification) and 5.85% (SCM). These results suggest that these managerial practices go together and are adopted at approximately the same time. Moreover, no conclusion can be drawn from the firm's functional complexity (hypothesis 2) because the models show no significant evidence; thus, electronic traceability seems to be independent of the number of functions managed within the firm.

Table 3: Electronic traceability adoption and organizational structure

Dependent variable:	Model 1 Total adopters (ETS=1)		Model 2 Adopters before 2003 (ETS03=1)		Model 3 Adopters after 2003 (cETS=1)	
	M.E.	S.E.	M.E.	S.E.	M.E.	S.E.
Hierarchical and decisional structure						
Hierarchical intensity	0.087***	(0.017)	0.159***	(0.021)	-0.061***	(0.018)
Functional complexity	0.018	(0.022)	-0.012	(0.032)	0.045	(0.032)
Hierarchy implication in tasks	-0.035*	(0.014)	-0.048**	(0.019)	0.008	(0.016)
Working teams	0.052***	(0.016)	0.041*	(0.020)	0.021	(0.016)
Managerial practices and ICT						
Just-in-time	0.106***	(0.014)	0.130***	(0.019)	-0.019	(0.015)
Quality Certification	0.118***	(0.018)	0.196***	(0.021)	-0.071***	(0.018)
SCM	0.058**	(0.018)	0.083***	(0.023)	-0.004	(0.018)
ERP	0.081***	(0.016)	0.057**	(0.020)	0.018	(0.016)
Intranet	0.004	(0.015)	-0.040*	(0.019)	0.058***	(0.014)
EDI	0.016	(0.016)	-0.017	(0.019)	0.064***	(0.014)
Inter-firm relations						
Upstream dependency	-0.023	(0.015)	-0.048*	(0.019)	0.014	(0.016)
Delivery contract with suppliers	-0.017	(0.015)	-0.025	(0.020)	0.017	(0.016)
Industrial outsourcing	0.566*	(0.285)	1.513***	(0.371)	-0.565	(0.335)
Downstream dependency	-0.072***	(0.015)	-0.070***	(0.019)	-0.012	(0.015)
Delivery contract with customers	0.082***	(0.017)	0.047*	(0.020)	0.056***	(0.015)
Retailer's brand	0.079	(0.045)	-0.055	(0.053)	0.138***	(0.042)
Other firm's brand	-0.013	(0.089)	0.312*	(0.123)	-0.208*	(0.101)
External environment						
Sector: Meat sector	Ref.		Ref.		Ref.	
Prepared fruits and vegetables	-0.000	(0.039)	-0.106*	(0.049)	0.130*	(0.052)
Dairy products	-0.083**	(0.031)	-0.175***	(0.036)	0.104**	(0.036)
Processed animal feed	-0.205***	(0.044)	-0.262***	(0.044)	0.141**	(0.051)
Other food products	-0.098***	(0.020)	-0.255***	(0.023)	0.183***	(0.025)
Beverages	-0.037	(0.026)	-0.235***	(0.033)	0.248***	(0.039)
Location: Urban zone	Ref.		Ref.		Ref.	
Peri-Urban	-0.073***	(0.021)	-0.167***	(0.027)	0.096***	(0.024)
Rural pole	-0.007	(0.022)	-0.063*	(0.029)	0.079**	(0.029)
Rural isolated area	0.071***	(0.016)	0.019	(0.022)	0.096***	(0.023)
Other control variables						
Size: 20 – 49 employees	Ref.		Ref.		Ref.	
50 – 249	0.058*	(0.026)	0.102**	(0.034)	-0.042	(0.029)
250 – 499	0.172***	(0.023)	0.188***	(0.041)	-0.027	(0.037)
500 or more	0.067	(0.039)	0.095	(0.052)	-0.024	(0.044)
Group	-0.019	(0.015)	0.010	(0.020)	-0.021	(0.017)
Multi unit	0.009	(0.014)	0.056**	(0.019)	-0.060***	(0.016)
Exports (EU)	-0.083	(0.066)	0.239**	(0.087)	-0.425***	(0.087)
Export (non EU)	0.044	(0.086)	-0.071	(0.096)	0.131	(0.070)
Observations	596		596		596	
(Weighted data)	(2428)		(2428)		(2428)	
% of correct predictions	83.89		73.15		84.56	
Log likelihood	-1084.46		-1331.03		-897.52	
Pseudo R^2 (McFadden's)	0.175		0.172		0.129	
BIC	2373.41		2866.55		1999.52	

M.E.: Marginal effects. S.E.: Standard errors (in parentheses). Significance levels $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$
Source: COI-TIC and EAE (2006), French National Institutes of Statistics and CEE.

With only a few variables presenting different results, in terms of their organizational structures, the early adopters (adoption before 2003, model 2) follow an adoption profile similar

to that of the entire population. However, as shown in model 3, the overall profile of late adopters is quite different and are generally integrated firms (negative effect of Multi unit). Contrary to early adopters, they have low hierarchical intensity, with few collaborative links and interactions (non-significant effects for the hierarchy's involvement tasks and working teams). The importance of organizational practices such as just-in-time or SCM does not have any effect; quality certification schemes actually reduce the probability of adopting an ETS.

In model 1, ERP has a positive and significant effect on possessing an ETS. However, internal communication networks (Intranet) and standard external communication formats (EDI) show no effect. The opposite is true for new adopters (model 3), for which communication tools have a positive effect while ERP does not. Thus, the correlation between information management and communication technologies with electronic traceability tends to depend on the time of adoption; early adopters are more associated with ERP, given the more complex (and costly) nature of such tools, while the Intranet and EDI communication tools tend to be more generic and less costly.

Regarding inter-firm relations, crucial to the New Institutional and traceability literature, we also found contrasting results between all adopters and new adopters (models 1 and 3). First, in model 1, we observe that upstream dependency (the primary suppliers representing more than 50% of a firm's total purchases) has no effect and that downstream dependency (the primary customers representing more than 50% of total revenues) actually reduces the probability of adopting an ETS. Conversely, industrial outsourcing positively influences ETS adoption. In fact, this type of relationship is characterized by a contract with a set of specifications that are favorable to the implementation of an ETS. Delivery contracts also demonstrate a positive effect

when established with customers (even for new adopters). This result shows that traceability is mainly based on formal and contractual practices, not on dependency relations.

For new adopters (model 3), the (non-significant) effect of industrial outsourcing is replaced by a strong interaction with customers and retailers. Delivery contracts with customers play a positive role, and this trend is supported by the positive sign of the sales under a retailer's brand, which as mentioned earlier, represents a relationship based on the vertical coordination (enforcement of specifications and monitoring) of the production process, in which traceability is expected to reduce transaction costs. This relationship seems to be deeply oriented towards mass distribution (retailers) and not towards other industrial customers (negative role of sales under another firm's brand).

Concerning environmental factors, particularly the sector of activity, we found that the meat sector firms implemented traceability systems, in many cases, very early and before 2003. This result is essentially due to the large number of traceability adopters after the BSE sanitary crisis (Vos, 2000). Conversely, firms in other sectors such as fruits and vegetables, dairy and beverages have been "catching up" and adopting ETSs later than the meat sector (see the positive effect of these sectors relative to meat in model 3). This result reflects a process of recovery, as compared to those sectors strongly affected by food safety problems.

Concerning the geographical environment, the location of the firm's main office in urban agglomerations is detrimental to ETS adoption in peri-urban and rural poles (model 1). The positive effects of urban externalities are traditionally emphasized in the empirical literature regarding the innovation and adoption process of ICT. A positive effect of the location is only observed in isolated rural areas because they moderate the agglomeration effects and reveal the

need for more extensive coordination and communication for firms in isolated locations. The results also highlight that the location of the firm's market, in the EU or the rest of the world, has no effect on ETS adoption. The negative effect of EU exports for an adoption after 2003 could suggest that firms exporting to the EU adopted an ETS before 2003.

In terms of location, contrary to early adopters, firms adopting ETS after 2003 are settled in outlying areas; thus, the location in urban areas reduces the probability of adoption. This effect could also reflect a recovery process by peripheral firms compared to urban firms that had earlier access to urban and technological externalities[14].

4.2. Electronic traceability adoption and its organizational changes

The 2006 COI-TIC survey provides information on the changes experienced by French industrial firms between 2003 and 2006. The results from equation (2) (table 4), show how changes in the firm's organization at three levels (hierarchical and decisional structure, managerial practices and ICT, and inter-firm relations) can explain the possession of an ETS. In addition, we test the effect of changes in the firm's external environment (mainly changes in regulations and norms and the expected market uncertainty of firms) on the firm's ETS adoption probability. Again, the models test the dependent variables *ETS*=1 (all adopters, model 4), *ETS03*=1 (adopters before 2003, model 5), and *cETS*=1 (adopters after 2003, model 6). Model 6 is better explained by the organizational change variables (*pseudo* $R2 = 0.224$), which could suggest that other changes in the firm's structure influence the adoption of ETSs.

[14] The relative scarcity of infrastructures, service activities and a qualified workforce in rural areas, together with a low technological level, could explain the delay in the adoption process of rural firms (Gale, 1998; Galliano and Roux, 2008a).

For the entire population (model 4), the adoption of electronic traceability seems to be associated with different governance trends. The results show that adoption is associated with changes in the hierarchical structure of the firm (both an increase and a decrease) with a clear tendency towards a decrease in the number of hierarchical levels (the marginal effect of a decrease, 9.24%, is greater than that of an increase, 5.51%). At the same time, there is a greater involvement of the hierarchy in the definition of employee tasks. For new adopters (model 6), the adoption after 2003 is correlated with the stability or the increase in the number of hierarchical levels (a decrease being associated with negative effects). Therefore, this result demonstrates that to promote the adoption process, it is necessary to strengthen intermediary hierarchical levels, and once the traceability system is installed, the process will tend to reduce the firm's hierarchical weight. This process is, however, accompanied by an increase in the hierarchy's implication in tasks, which may reinforce the view that ETSs can provide the necessary information to facilitate the decision-making (and coordination) processes, regardless of the distance between the decision-maker and the operators.

This tendency concerning the firm's hierarchical structure is combined with the significant role of the internalization of the functions regarding the different networks that the firm belongs to (e.g., franchises, subsidiaries and groups). Similarly, for the new adopters, we found a very significant co-evolution between the internalization of functions and ETS adoption. Therefore, for the new adopters, the profile of co-evolution between traceability and changes in governance modes is that those firms that have increased their hierarchical levels have increased their participation in private networks and decreased participation in external networks.

Table 4: Electronic traceability adoption and organizational changes

Dependent variable:	Model 4 Total adopters (ETS=1)		Model 5 Adopters before 2003 (ETS03=1)		Model 6 Adopters after 2003 (cETS=1)	
	M.E.	S.E.	M.E.	S.E.	M.E.	S.E.
Hierarchical and decisional structure						
Hierarchical levels: Stable	Ref.		Ref.		Ref.	
Increase	0.055*	(0.023)	-0.027	(0.034)	0.071*	(0.029)
Decrease	0.092***	(0.026)	0.228***	(0.029)	-0.132***	(0.015)
Increase hierarchy's implication	0.147***	(0.022)	0.071	(0.048)	0.086	(0.048)
Externalization: Stable	Ref.		Ref.		Ref.	
Increase	-0.264***	(0.064)	-0.139*	(0.066)	-0.075**	(0.026)
Decrease	0.019	(0.035)	-0.310***	(0.052)	0.319***	(0.051)
Managerial practices and ICT						
Increase managerial practices	0.094***	(0.017)	-0.023	(0.025)	0.149***	(0.022)
Increase of ERP functions	0.109***	(0.021)	-0.001	(0.032)	0.082**	(0.026)
Inter-firm relations						
Increase in contracts with customers	-0.047	(0.040)	-0.188***	(0.048)	0.117**	(0.041)
Increase in contracts with suppliers	0.125***	(0.025)	-0.170***	(0.048)	0.205***	(0.044)
External environment						
Changes in regulation and norms	0.054***	(0.016)	0.019	(0.019)	0.050***	(0.014)
Market uncertainty	0.072***	(0.017)	0.081***	(0.020)	-0.021	(0.015)
Sector: Meat sector	Ref.		Ref.		Ref.	
Prepared fruits and vegetables	0.014	(0.040)	-0.071	(0.050)	0.084	(0.047)
Dairy products	-0.064*	(0.030)	-0.156***	(0.036)	0.107**	(0.034)
Processed animal feed	-0.077*	(0.038)	-0.121**	(0.045)	0.080	(0.045)
Other food products	-0.034	(0.018)	-0.192***	(0.023)	0.166***	(0.022)
Beverages	-0.037	(0.024)	-0.207***	(0.031)	0.205***	(0.033)
Location: Urban zone	Ref.		Ref.		Ref.	
Peri-Urban	-0.079***	(0.022)	-0.146***	(0.027)	0.063**	(0.021)
Rural pole	0.017	(0.022)	0.024	(0.028)	-0.014	(0.021)
Rural isolated area	0.063***	(0.016)	0.027	(0.022)	0.037*	(0.019)
Other control variables						
Size: 20 – 49 employees	Ref.		Ref.		Ref.	
50 – 249	0.038**	(0.015)	0.062***	(0.019)	-0.018	(0.015)
250 – 499	0.175***	(0.018)	0.184***	(0.031)	-0.011	(0.027)
500 or more	0.100***	(0.028)	0.108**	(0.041)	0.019	(0.038)
Group	0.001	(0.015)	0.017	(0.019)	0.004	(0.014)
Multi unit	0.006	(0.015)	0.047*	(0.019)	-0.049***	(0.015)
Exports (EU)	0.028	(0.067)	0.347***	(0.087)	-0.387***	(0.079)
Export (non EU)	0.139	(0.087)	0.147	(0.100)	0.036	(0.066)
Log likelihood	-1161.87		-1412.86		-799.05	
Observations	596		596		596	
(Weighted data)	(2428)		(2428)		(2428)	
% of correct predictions	82.72		72.15		86.58	
Pseudo R^2 (McFadden's)	0.116		0.121		0.224	
BIC	2489.88		2991.87		1764.24	

M.E.: Marginal effects. S.E.: Standard errors (in parentheses). Significance levels $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$
Source: COI-TIC and EAE (2006), French National Institutes of Statistics and CEE.

As for changes in the formalization of managerial practices and the firm's information systems, we found that for the entire population of adopters (model 4) and the new adopters (model 6), both an increase in managerial practices and the number of functions managed by the company's ERP is positively associated with ETS adoption. An increase in managerial practices

mainly concerns just-in-time, quality certification, supply chain management and working teams. This result reaffirms the view that changes are, for the most part, co-evolutive: the adoption and implementation of traceability systems necessitates organizational changes and vice versa. Furthermore, we show the central organizational role of enterprise resource planning systems and their close relationship with electronic traceability. An increase in the number of functions using a firm's ERP can be seen as a desire on the part of firms to computerize their functions, and we can suppose that traceability could be part of these functions.

As for inter-firm relations, the adoption process for new adopters, in terms of changes in coordination modes with external partners of the same supply chain, is strongly influenced by the existence and strengthening of contractual practices with customers, and especially suppliers. Contractual relations downstream distinguish, to an even greater extent, new adopters from the whole population. These relationships have a positive effect on new adopters; however, this trend does not correspond to those of the early adopters and all adopters, in which contractual relations downstream have negative (early adopters) and non-significant effects (all adopters).

With regard to the external environment, the survey provides information on whether the enterprise's activities have been affected by changes related to the firm's institutional and market environments. The results from model 4 show that these two factors have a positive effect on having implemented an ETS. Being an adopter is significantly influenced by the existence of institutional changes in terms of the regulations and standards for the company's activities and by the effects of market uncertainty. New adopters are particularly affected by institutional changes that occurred during their adoption period; however, they seem to be unconcerned by market uncertainty. The opposite is observed for early adopters, i.e., market uncertainty seems to characterize firms that adopted an ETS prior to 2003.

5. Conclusion

The objective of this paper was to analyze the two-part question of organizational structure and organizational changes associated with the adoption of electronic traceability systems. From a theoretical point of view, it was necessary to mobilize the New Institutionalists' and Evolutionists' respective contributions to understand the relationship between the firm's organization and the adoption of electronic traceability. The first approach is particularly suitable to answer questions related to coordination and transaction costs associated with the flow and management of information. The second approach, however, is more appropriate to addressing questions related to organization dynamics and individual and collective learning mechanisms, which are generated by the interaction between the organization and its environment.

The econometric study is based on a representative sample of French agribusinesses with more than 20 employees found in the Organizational Changes and Computerization Survey from 2006. The empirical models first tested the role of the firm's structure in the ETS adoption process and, second, tested the organizational changes associated with the adoption of electronic traceability.

Regarding traceability-related organizational forms, two important aspects became apparent in the results: their role as organizational governance tools (intra-firm) and their role in the firm's modes of coordination with their environment (inter-firm). The adoption of an ETS is strongly favored by organizations with heavy hierarchical structures and standardized managerial practices (especially just-in-time and quality certification practices). At the inter-firm level, it is the existence of formal practices and contractual mechanisms with external partners that promotes the adoption of electronic traceability, rather than a dependency on upstream or

downstream actors. Upstream, the use of industrial outsourcing requires the implementation of traceability systems, which are likely a part of specifications and monitoring mechanisms designed to enforce contracts. A similar contract/specifications/monitoring scheme is observed for downstream relationships, especially when the production is destined for retailers. Here, the guarantee of delivering the goods on specific schedules (enforced by contracts) favors the use of an ETS.

These various points highlight and summarize the relationship, already mentioned in literature, between a firm's informational and decision-making structures (Brynjolfsson and Hitt, 2000). The more (less) information-intensive the nature of intra- and inter-firm coordination mechanisms are and the more (less) information is standardized, the more (less) that coordination and management procedures will influence the firm's governance methods and be a major determinant of ETS adoption.

In dynamics, the results clearly show a co-evolutionary process between ETSs and managerial practices, as well as between ETS adoption and organizational changes. In terms of managerial practices, knowledge management systems and contractual relationships, it is precisely those firms that implemented an ETS during the observed period (2003-2006) that have experienced the most important organizational changes. In addition, governance modes have evolved with the adoption of an ETS. The results confirm that ETS adoption is made more likely by a strengthening of the intermediate levels in the hierarchical structures and that, once implemented, traceability systems tend to reduce the firms' hierarchical weights.

The analysis of traceability systems underlines, perhaps more than other coordination systems, the respective contributions of the authority principle discussed in the transaction cost

theory, as well as the concept of routines proposed by the evolutionists. It also shows that technology is not neutral in the process of organizational change. From a managerial but also a policy-making perspective, our results suggest that the adoption of traceability technologies make the organization more efficient and able to adapt to its environment.

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Appendix

Table A1. Characteristics of French agribusiness

	Total agro-food	Total ETS adopters	ETS adopters before 2003	ETS adopters after 2003
Number of firms	2 428	1 865	1 515	366
%	100	76.81	62.39	15.09
Hierarchical intensity	50.27	49.65	49.72	51.30
Functional intensity	49.02	47.17	45.08	55.62
Hierarchy implication in tasks	72.67	71.84	70.56	76.12
Working teams	32.28	35.87	35.94	36.13
Just-in-time	38.63	43.28	44.46	36.75
Quality certification	54.95	60.68	62.40	53.08
Supply chain management	24.06	27.96	29.53	24.67
ERP	30.10	33.98	33.34	35.39
Intranet	46.55	48.39	46.68	55.51
EDI	62.07	65.43	64.30	71.64
Upstream dependency	28.47	27.67	26.99	29.25
Delivery contract with suppliers	57.67	60.20	58.86	67.49
Downstream dependency	39.49	38.39	37.56	42.66
Delivery contract with customers	65.64	69.63	68.64	75.11
Size: 20 – 49 employees	55.52	58.18	50.71	60.10
50 – 249	33.22	34.05	34.71	29.85
250 – 499	6.68	8.39	8.79	6.36
500 or more	4.58	5.38	5.80	3.69

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