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What determines the acceptance and use of electronic traceability systems in agri-food supply chains?

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ABSTRACT

The paper is investigating the electronic-based traceability systems (ETsystems) that are considered as a valuable tool for the assurance of food safety and quality, for guaranteeing value added to products and ultimately, for serving the transparency and sustainability of agri-food chains. The objective of this research is to investigate the factors influencing the acceptance and use of ETsystems in agri-food chains.

A model that identifies the most significant factors influencing farmers' and processors' behavior regarding the installation and operation of an ETsystem is proposed. The theoretical approach is based on a combination of the Technology Acceptance Model 2 (TAM2) and the Theory of Planned Behavior (TPB). The theoretical concept and related hypotheses are tested by means of PLS-SEM analysis of data from the dairy supply chain in Greece.

'Perceived Control' and most importantly, the 'perceived costs' over the installation and operation of the ETsystem, is the most important factor with the strongest direct effect influencing the intention to install and operate such a system. This effect is stronger in the case of dairy farmers than in the case of dairy processors. Stronger for dairy farmers is also the identification mechanism thus, their need to comply with their social/business group expectations.

Useful findings offered for policy makers and regulators interested in the way traceability systems could be successfully integrated within an agri-food sector to guarantee its added value. The limitation of voluntariness and the enforcement of certain mandatory requirements is one tool to exploit and, based on our study, would be more effective at the processors' level.

1. Introduction

A traceability system is an increasingly important tool within the agri-food sector. The development of traceability systems throughout the food supply chains reflects a dynamic balancing of associated costs and benefits. Although many firms operate traceability systems for different objectives, these have played varying roles in driving the development of traceability systems in the food supply system (Golan et al., 2004).

Electronic Traceability Systems - ETsystems are considered by scholars and policy makers a necessity or, at least, a valuable tool for the assurance of food safety and quality (Regattieri et al., 2007; Hobbs, 2006; Pouliot and Sumner, 2008a, 2013; Trienekens and Zuurbier, 2008; Valeeva et al., 2004; Menard and Valceschini, 2005). Traceability for food safety is a field extensively covered in the literature (Trautman et al., 2008; Barker et al., 2009) and incorporated in legislation like the EU General Food Law (Reg. (EC) 178/2002). According to this EU law, traceability is mandatory in the form of 'one step forward and one step back' reporting of the whereabouts of a food due to possible safety issues and recall needs.

Beyond the mandatory requirements of the EU General Food Law, ETsystems in the European and global dairy sector are adopted on a voluntary basis with different levels of integration (Henson et al., 2005; Golan et al., 2004; Augustin et al., 2013; Banterle and Stranieri, 2008). In this paper, the term 'ETsystem' refers to an electronic-based, as opposed to a document-based, system of tracking and tracing food, which enables supply chain participants to react effectively to possible food recall incidents that go beyond the obligatory one step forward and one step back concept and include detailed 'information gathering and transmitting' about quality and credence attributes.

Credence attributes are the extrinsic quality attributes in added value products that include "country of origin", "fair trade", "organic production", etc. that cannot be detected by consumers without some form of quality signal, such as a label (Hobbs, 2002). The non-observable credence attributes of traditional products, that compose their quality and authenticity, have to be certified along the entire supply

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chain in order to allow capitalizing on their reputation (Pascucci, 2010). If there is no effective traceability system along the entire supply chain of an agri-food the trust of the consumers in relation to the anticipated credence attributes will be lost and consequently the competitive advantage of the agri-food will be deprived (Young and Hobbs, 2002).

However, full traceability systems, that presuppose the compatibility of systems and close, strategic cooperation between the different actors along the supply chain, could only be voluntary (Bosona and Gebresenbet, 2013). This voluntariness provokes different reactions from these actors, regarding the installation and operation of traceability systems (Stranieri and Banterle, 2006). Such reactions depend on factors that are necessary to investigate in order to be able to understand and subsequently to elaborate at the various policy levels. The already widespread voluntary use of traceability complicates the application of a centralized system because actors have developed so many different approaches and systems of tracking and tracing (Golan et al., 2004).

Although, drivers such as, food safety and quality, regulatory, social, economic, and technological concerns (Hobbs, 2003; Roth and Doluschitz, 2007; Goldsmith, 2004; Theuvsen and Hollmann-Hespos, 2005), barriers such as, resource/capacity, information, standard and awareness limitations (Resende-Filho and Buhr, 2007; Gellynck et al., 2007; Holleran et al., 1999) and benefits such as, market and consumer satisfaction, regulatory fulfilment, improved recall and risk management, transparency of supply chain etc. (Sparling et al., 2006; Pouliot and Sumner, 2008b; Chryssochoidis et al., 2009), of the ETsystems have been identified in the literature, which factors influence the actual installation and operation of an ETsystem and their correlation, still remains an open question.

The value of investment in a traceability system constitutes a matter of considerable concern and debate for both practitioners and academics alike (Chryssochoidis et al., 2009). Fritz and Schiefer (2009) summarize the decision situation for enterprises and their sector in a cost–benefit decision table for a tracking and tracing system but based on safety issues and product recalls. Heyder et al. (2012) were the first to attempt an in-depth analysis of the determinants of investments based on a comprehensive model that allows the derivation of testable hypotheses as a basis for large-scale empirical research.

Yet, these studies do not incorporate and combine insights gained from technical and socio-economic analyses of ETsystems. This research fills this knowledge gap. More specifically, the objective of this study is to investigate the factors influencing the installation and operation of ETsystems by the actors of the dairy chain (milk farmers and processors) combining technology acceptance with behavioral analyses. The results of this research are expected to provide policy makers with insight into the psychological factors that influence the installation and operation of ETsystems. These insights can be used to develop policy initiatives to promote the adoption and use of ETsystems in agri-food chains. We analyze empirical data from the Greek dairy sector, using a Partial Least Squares - SEM (PLS-SEM) analysis approach. The theoretical model developed and tested can serve as a predictive model.

Data collection through a questionnaire was conducted in the main milk producing regions of Greece. This country represents an interesting case because although the importance of tracing and certifying the credence attributes, such as geographical indication of origin or organic production, has been widely recognized, it is unclear why the application of such systems is rather the exception than the rule.

Greece has a long tradition of high quality dairy products, some well-known worldwide, like Feta Cheese, a white cheese in brine from sheep and goat milk of Protected Designation of Origin (PDO) in the EU. The size of the dairy sector, as measured by both the number of producers and the quantity of milk produced, has declined during the last decade and the current financial crisis has worsened the conditions even further. Exports are considered a promising marketing option but in order to compete on the international market against similar, lower-cost products, being able to promote and guarantee the differentiating quality attributes of these products is vital. ETsystems function as a tool to support and implement the aforementioned strategy (Theuvsen and Plumeyer, 2007; Barjolle and Sylvander, 2002; Becket and Staus, 2008; Giacomini et al., 2010).

2. Theoretical framework

In order to achieve the objective of this study and investigate the factors influencing the installation and use of ETsystems by milk farmers and processors of the dairy chain we combine technology acceptance with behavioral analyses.

Research in the information systems (IS) literature explaining user acceptance of new technology has resulted in several theoretical models, with roots in information systems, psychology, and sociology, that routinely explain over 40 percent of the variance in individual intention to use technology (Venkatesh et al., 2003). Among the most influential theories in the IS field is the Technology Acceptance Model – TAM. For the investigation of psychological factors influencing actors' decisions and behaviors the Theory of Planned Behavior - TPB has been widely used.

2.1. Technology acceptance models in agricultural studies

Regarding the acceptance and use of technology in a business environment, especially information and communication technology (ICT), there is substantial theoretical and empirical support toward the Technology Acceptance Model (TAM). The TAM, adapted from the Theory of Reasoned Action (Ajzen and Fishbein, 1980) and originally proposed by Davis (1986), is considered the most influential and commonly employed theory for describing an individual's acceptance of information systems (Lee et al., 2003). TAM theorizes that an individual's behavioral intention to use a system is determined by two beliefs: perceived usefulness, the extent to which a person believes that using the system will enhance his or her job performance, and perceived ease of use, the extent to which a person believes that using the system will be free of effort (Venkatesh and Davis, 2000).

According to TAM, perceived usefulness (PU) is also influenced by perceived ease of use (PEOU) because, other things being equal, the easier the system is to use, the more useful it can be. TAM 2 (Fig. 1), which is an extension of the technology acceptance model by Venkatesh and Davis (2000), explains perceived usefulness and usage intentions by introducing two additional theoretical constructs: social influence processes (subjective norm, experience, voluntariness, image) and cognitive instrumental processes (job relevance, output quality, result demonstrability).

Although TAM 2 has been broadly used in various disciplines it appears at a lesser extent in agricultural studies. Some examples, using mostly the earlier TAM, are: the examination of technology adoption in dairy farming (Flett et al., 2004), the investigations into the perception and attitudinal characteristics of farmers who plan to adopt precision agriculture (Adrian et al., 2005), the research about the applicability of TAM to agriculturist's acceptance of a knowledge management system in agricultural extension services (Folorunso and Ogunseye, 2008), the prediction of factors affecting intention to adopt precision agriculture technologies among agricultural specialists (Rezaei-Moghaddam and Salehi, 2010), the study of the major factors influencing the investment behavior of agribusiness firms concerning tracking and tracing schemes (Heyder et al., 2010), experimental evaluation of a decision-support system for monitoring crops using technologies such as wireless sensor networks with a group of potential users (Cardenas Tamayo et al., 2010), explaining the difficulties of precision agriculture technology adoption (Aubert et al., 2012) or measuring the volitional aspect of the ICT adoption behavior of young entrepreneurs in a rural community (Zaremohzzabieh et al., 2015).

As stated before, although TAM is a powerful and robust predictive