Towards a Supply-Chain Instrument to Monitor an Information Technology Implementation

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Abstract

Based on improved information performance, agro-food companies and supply chains want to enhance their production processes. It creates the necessity to implement additional information technologies. The implementation of information technologies is, however, a complex task because of the interaction between technology, organization, and processes. Therefore, the aim of this paper is to present the development of a prototype of an "Implementation-monitoring Instrument" for project managers to help monitoring and managing an information-technology implementation towards required information performance. A design approach has been used to build the Instrument. The Instrument development is based on a literature review of a variety of theories explaining the mutual interaction between organization and technology. Keeping in mind the goal of the Instrument, the "information-quality literature" and "cost-benefit literature" is consulted as well. We aim to deliver a useful management Instrument, which is a step plan that helps chain actors to find the bottleneck of an information-performance failure. The Instrument allows for in-depth analysis of organizational and technical elements within processes that could be responsible for the information-performance failure. It is expected, in first instance, to be useful for the Dutch organic pork supply chain and other meat supply chains implementing new information technologies. In the future, the usage of this instrument will be prospectively tested and evaluated in a Dutch organic pork meat supply chain and retrospectively in two other agro-food supply chains.

Keywords: *information-technology implementation, supply-chain information exchange, monitoring instrument*

1 Introduction

Companies want to enhance their production processes to improve their competitiveness. To enhance production processes, improving information processes (with improved information performance) within companies and supply chain is a prerequisite (Gunasekaran and Ngai, 2004). It creates the necessity to implement additional information technologies. Research has showed that information technologies can create competitive advantages in the short run (Salin, 1998) and are essential for survival in the long run (Gunasekaran and Ngai, 2004). Within the last decades, many information technologies have popped up to improve information performance. An information technology can be defined as a set of interrelated components that collect, process, interpret, store, and distribute information to support decisions within and across partners (Laudon and Laudon, 2004).

The implementation of information technologies is a complex task (Bajaj and Nidumolu, 1998; Russell and Hoag, 2004; Stefanou, 1999). Incompatibility between old and new information technologies can lead to an implementation failure (Fawcett et al., 2009;

Wognum et al., 2004). Implementation is, however, more than just a technical challenge; the technology itself is not enough to improve the information performance within organization and supply chain. Importance of organizational and process change has been proven by many information-technology researchers. First, organizational change is indissolubly connected to information-technology implementation. Authors have stated that the interaction between technologies and organizations might lead to different outcomes than anticipated (Barley, 1986; Hall, 2002; Orlikowski and Hofman, 1997; Robey and Boudreau, 1999; Robey and Sahay, 1996). An often-mentioned explanation is the resistance of many employees to use technology as intended by the designers, although their performance could be enhanced (Bajaj and Nidumolu, 1998; Davis, 1989; Venkatesh and Davis, 2000). Those behavioural problems often lead to implementation failures. Second, process changes are linked to the information-technology implementation as well (Fawcett et al., 2009). Processes need to be redesigned as well as the accompanying tasks of people when decisions to implement information technologies are made (Fawcett et al., 2009).

Researchers have tried to cope with the complex character of implementing information technologies through delivering guidelines and critical success factors (Angeles, 2005; Ngai et al., 2007; Umble et al., 2003). Those factors and guidelines do, however, not help managers very much during implementation. Guidelines and critical success factors for implementation are often rather abstract (Wognum et al., 2004), making them difficult to use in a specific sector, like for instance the agro-food sector. For example, change management and monitoring change are critical success factors for information-technology implementations (Fawcett et al., 2007; Nah et al., 2001). It is, however, challenging how to monitor change or how to apply change management in a specific business environment.

This paper presents a research project in an organic pork supply chain within the Netherlands that wants to enhance its production and information processes through implementing innovative information technologies: RFID (Radio Frequency IDentity tags), DNA sampling and an inter-organizational information system. Inter-organizational information systems for the whole supply chain as well as RFID and DNA-profiling have not been widespread within the sector. This implementation is part of the TIPO project (Traceability of Individual Pigs in the Organic chain)[1]. The overall aim of this project is to give a full guarantee of the origin and the quality of organic pork throughout the Dutch organic pork supply chain till the shelf at the retailer. Such a guarantee, which is currently not possible, is important for the confidence in organic meat of the retail sector and consumers.

The main objective of this paper is to describe the development of a prototype of an “implementation-monitoring instrument” for project managers to help monitoring and managing an information-technology implementation towards required information performance in an agro-food supply chain. All supply chain actors require certain supply chain information in a certain format and within a certain time frame.

2 The Dutch organic pork meat supply chain

The organic food market is one of the fastest growing markets in Europe, although the growth has slowed down in recent years. Denmark, Austria and Switzerland are examples

[1] TIPO is made possible by a grant from the European Regional Development Fund and from the Province of Gelderland within the Netherlands.

where the market share is high when compared with the Netherlands, Belgium, France and Norway (Padel et al., 2009; Schaak, 2009) Within Denmark, organic food reached a market share of 7,2% in 2009, while in many European countries, the threshold of 2% market share has not been passed, including the Netherlands (Willer, 2009).

In the last years, the growth in the market share of organic pork meat has been lower than desired. The main barrier to buy organic food products has been the price (Hughner et al., 2007). An organic pork supply chain within the Netherlands wants, therefore, to improve its processes. Supply chain actors together produce fresh organic pork meat for the end consumer. The supply of organic pork meat is mainly governed and controlled by De Groene Weg (see figure 1). Figure 1 shows that De Groene Weg has two different roles: processor and chain director.

The supply chain wants to improve processes through implementation of innovative information technologies. Let's take the farmer as an example. First, innovative information technologies are expected to improve information processes and deliver more information to the farms, like, for instance, feed-conversion information and slaughter information. This information also contributes to improvement of processes, by supporting decision making, like the selection process of gilts and sperm, or farm management processes, like refining feed recipes for better pig quality.

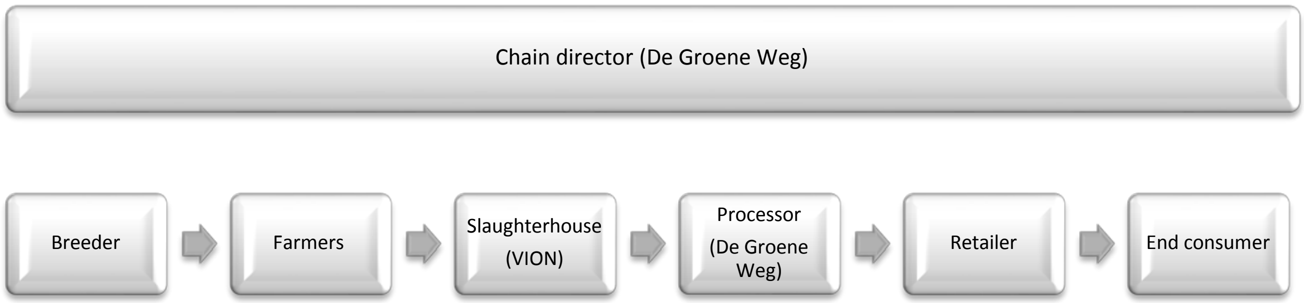

Figure 1.Key actors and main product flow in the Dutch organic pork meat supply chain

More information will be obtained through implementation of innovative information technologies: RFID (Radio Frequency Identification), DNA (Deoxyribonucleic acid) profiling, and a complementary "inter-organizational information system". RFID is a technology that uses radio waves to automatically and easily identify individual pigs, collect individual info and link different information files (Michael and McCathie, 2005). Genetic traceability using DNA is a technology that has the possibility to identify a pig based on one piece of it (Dalvit et al., 2007) to help to guarantee origin and improve meat quality through obtaining more genetic information. The "inter-organizational information system" is a web-based software application that connects different existing software systems for delivering the right information to the right chain actor. With the combination of those technologies, De Groene Weg supply chain aims to fulfil the following goals: improve traceability, obtain better meat quality through enhanced genetics and improve the effectiveness of processes.

The implementation starts when information technologies are introduced to the users. The implementation is finished when the information-performance objectives are met.

3 Research Objectives and Method

With the development process of the "Implementation-monitoring Instrument" we want to answer the question: "Which solution can be found for…?", which is called an engineering process (Sinclair et al., 2012). Such a process requires a design approach.

3.1 Research Objectives

The design approach consists of four major steps: define requirements, build the Instrument, use the Instrument, and evaluate the Instrument (see figure 2). The design process is a generally accepted method for developing instruments (Saraph et al., 1989). First, user requirements for the Instrument will be defined (Sinclair et al., 2012). Second, the "Implementation-monitoring Instrument" will be developed, which will be a prototype. Third, the prototype Instrument will be prospectively tested in a Dutch organic pork supply chain and retrospectively in two other agro-food supply chains. In a final step, the procedures and elements will be verified and validated (Saraph et al., 1989). The focus of this paper is limited to the first two steps of the development process:

1. Definition of the user requirements of the prototype "Implementation-monitoring Instrument".
2. Development of a prototype of an "Implementation-monitoring Instrument" to guide the implementation process of information technologies in the agro-food supply chain. Usage procedures and Instrument elements and relationships need to be defined.

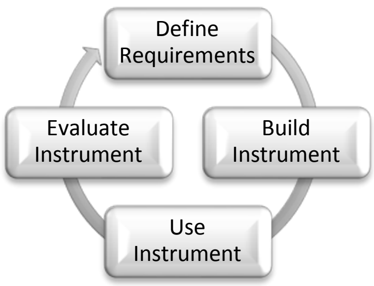

Figure 2. Development cycle of the "Implementation-monitoring Instrument"

3.2 Theoretical basis

First, defining the user requirements has been based on a literature review of designed instruments within various fields (Brooks and Tobias, 1996; Sinclair et al., 2012).

Second, building the Instrument has been based on constructs that are already known in the literature. First, constructs have been taken from "technology-mediated organizational change theories" (TOCT), which investigate the mutual impact of technology and organization (Leonardi and Barley, 2008); good examples of those theories have been developed by (DeSanctis and Poole, 1994; Orlikowski, 1992, 2000; Robey and Boudreau, 1999; Volkoff et al., 2007). Technology is created and adapted by people within an organization and has an impact on that organization. Therefore, a combined understanding of both organization and technology is necessary. Second, "Information-technology acceptance theories" (ITAT), which explain how and why individuals use and adapt technologies and more in particular information technologies (Venkatesh and Bala, 2008; Venkatesh and Davis, 2000; Venkatesh et al., 2003) have delivered additional constructs.

Relevant authors are: Venkatesh and Bala (2008); Venkatesh and Davis (2000) and Venkatesh et al. (2003). The most widespread model is the “technology-acceptance model” (TAM). This model has shown to explain 40% of the variance in the information-technology usage. “The Unified Theory of Acceptance and Use of Technology” (UTAUT) of Venkatesh et al. (Venkatesh et al., 2003) is able to explain more than 70% of the variance in information-technology usage. Third, supply chain management literature, in particular case studies of information-technology implementation to improve information exchange, has been consulted. Fourth, information-quality literature and cost-benefit literature has delivered constructs for information performance (Power and Simon, 2004; Wang and Strong, 1996).

ITAT and TOCT have limitations. First, TOCT and ITAT overlook the supply-chain level. All above-mentioned authors have investigated the implementation of information technologies in a single organization. Second, researchers dealing with both theories tend to neglect the material aspects of technology. The specific functions of the technology have been ignored. Third, information performance has never been included in those theories. Therefore, supply chain management literature, information-quality literature, and cost-benefit literature have been added to the theoretical basis of the Instrument

3.3 Method

User requirements are based on a literature review of designed instruments in various fields (Sinclair et al., 2012; Brooks & Tobias, 1996). The requirements are generic and can be easily used for our Instrument.

The Instrument is built in two steps: 1) The elements and their operationalization are identified based on a literature review of TOCT. Focus group discussions are held with the following members: one or two representatives of each organization within the Dutch organic pork supply chain (see figure 1) and one representative of the TIPO partners Nedap[2] and IPG[3] (Institute for Pig Genetics). Within a first discussion, information-performance requirements were defined. 2) The Instrument procedures are based on a literature review of designed Instruments (Brooks and Tobias, 1996; Sinclair et al., 2012). This build step will be finished through a second focus group discussion, which will be aimed at refining the prototype of the “Implementation-monitoring Instrument”. This will be done with the same people as in the first focus group discussion. Within the future, the Instrument will be used and regularly evaluated as well.

The Instrument will be used within three case studies, which is useful to achieve in-depth understanding of the research field (Miles and Huberman, 1994): 1) We will perform a single longitudinal case study in a Dutch organic pork supply chain during one year, which is the length of the practical part of the TIPO project. During the year of data collection, the Instrument will be applied with three months intervals; 2) The Instrument will be retrospectively tested in two other agro-food supply chains (Kumar, 2005). This will help to indicate that the Instrument is also relevant for other settings (Gibbbert et al., 2008).

The Instrument will be evaluated through two sequential focus group discussions (i.e. representatives of the three agro-food supply chains): 1) The Instrument will be evaluated

[2] An innovative world-player of electronic identification, data collection and processing.
[3] A service organization for the breeding sector with respect to information systems and genetics.

and, if necessary, elements and usage procedures, with their measurement methods, will be changed, deleted or added to come up with a final prototype Instrument; 2) The supportiveness of this final Instrument will be discussed during those focus group discussions and during complementary interviews with the project managers who made decisions.

4 Define Requirements

The literature review has revealed several requirements. Brooks and Tobias (2006) and Sinclair et al. (2012) have come up with two requirements.

First, the Instrument needs to be adequate (i.e. relevant) (Brooks and Tobias, 1996). Applied to our Instrument, all steps, observations, and questions need to be relevant to enhance information performance. This means that if information performance is not satisfactory, then the Instrument needs to help to find the bottleneck of the information-performance failure. Let's take an example from the Dutch organic pork supply chain. The farmer retrieves information about diseases of individual pigs. Currently, pigs with some diseases do not have an individual identification number when the farmer retrieves carcass information from the slaughterhouse. The tracing of the mother and father pig is, therefore, not possible. This could have been helpful for the selection process during breeding. The lack of information (i.e. information-performance failure) has a deeper organizational or technical cause within a part of the production or information process. It is critical to do the right observations and ask the right questions to the right limited amount of people. Those procedural steps need to be made clear through the user's manual of the Instrument. Only the procedural steps that can lead to find the bottleneck of this information-performance failure are necessary.

Second, the literature review has revealed that the Instrument with its user's manual has to be concise, because using this Instrument does usually not belong to the core business of the project manager (Sinclair et al., 2012). Besides, the interviewees do not want to spend so much time either.

In conclusion, the goal of the "Implementation-monitoring Instrument" is as follows. In general, the Instrument needs to help project managers during information-technology implementation to identify and achieve a satisfactory information performance for the whole supply chain as well as for all supply chain actors individually. Therefore, this Instrument needs to measure the information-performance for the supply chain as a whole as well as per supply chain actor. When this information performance is not satisfactory, then the bottleneck of the information-performance failure, which can be organizational or technical, within a certain process needs to be identified with help of the Instrument.

5 Build Instrument

The Instrument is based on the well-known Deming cycle (i.e. PDCA cycle – see figure 3). It is intended to help project managers with the implementation process of information technologies. Underneath a five-step cycle is given.

- Information within the supply chain is captured, transmitted, stored, manipulated, or delivered, though the use of information technologies within or between the different actors of a supply chain. Information technologies can refer to inter-organizational systems, information systems and, information and communication technologies (Pereira, 2009). The information performance of delivering information towards the different supply chain stakeholders needs to be checked.

- If the information performance is not satisfactory for one or all of the supply chain partners (i.e. information-performance failure), then the Instrument will help to find a list of production and information processes where the cause could have been appeared, which are called critical process points.
- The Instrument will help to discover the process bottleneck (i.e. one of the critical process points) and underlying organizational and/or technical bottlenecks of the information-performance failure.
- The bottleneck discovery might lead to redesign decisions of processes, organization, and technology.
- Redesign decisions might lead to adaptations of processes, organization, and technology.

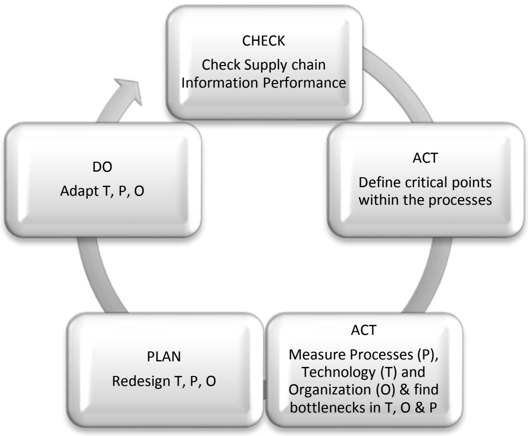

Figure 3. The process model of the “Implementation-monitoring Instrument”

5.1 Instrument elements

According to “technology-mediated organization change theories”, technology is created and adapted by people within an organization and has an impact on that organization. Therefore, a combined understanding of organization and technology is necessary. Those theories make a distinction between technology and organization. Technology is narrowly defined as: hardware and software in which their “…physical form and function remain fixed across time and contexts of use” (Orlikowski, 1992, p. 402). This is called the hardware view (Orlikowski, 1992). “Organizations are social entities […] that are designed as deliberately structured and coordinated activity systems” (Daft, 2004, p.11) Processes, namely production and information processes, are not included in those theories. Fawcett et al. (2007; 2009) claim, however, that processes need to be redesigned when implementing new technologies if we want to take advantage of information-technology capabilities.

The basis conceptual model consist of technology, organization and processes (see figure 4) as the interacting independent elements of the conceptual model. The dependent variable is information performance.

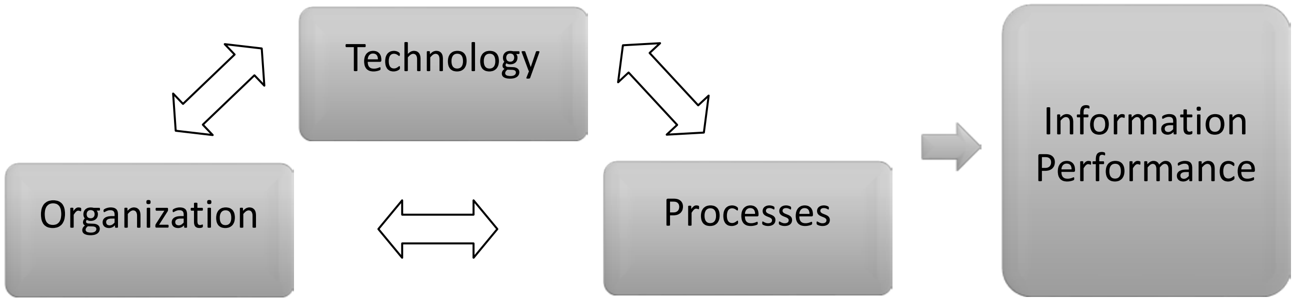

Figure 4. Basis conceptual model

Implementation of information technologies implies change decisions in the processes of the supply chain (Fawcett et al., 2007; 2009). Knowing the production and information processes is essential before any implementation starts. The processes that are relevant for achieving desired information performance need to be modelled and adapted together with technology implementation. These adapted processes are the basis for an application of the Implementation-monitoring Instrument.

Within our Dutch organic pork chain, an information process can be added by putting RFID readers[4] at the slaughterhouse. Further, implementation of those technologies may result in a modification of the production processes. Currently, within the slaughterhouse, pigs from different farms are mixed in the cooling storage line based on quality sorting. If we want to keep, for instance, individual farm identification in the cooling storage, carcasses have to be sorted in a different way.

Modelling gives a good overview of the production and information processes. During the years, a lot of modelling techniques have been invented. EPC (Event-driven Process Chain) will be used for modelling the supply chain processes because of two reasons. First, the technique is widely used. Second, the technique is user friendly and intuitive, which means that the modelling technique is easy to use for project managers.

With EPC, project managers are capable to model the processes with the following elements: function (active element), event (passive element), process paths and logical relationships. “Events represent the changing state of the world as a process proceeds” (Davis & Brabänder, 2007, p. 105). “Functions represent the activities or tasks carried out as part of a business process; ideally with each one adding some value to the business. Functions may be carried out by people or by IT systems. They have inputs, create outputs, and consume resources” (Davis & Brabänder, 2007, p. 107). Process paths and logical relationships (And, Or and Xor) connect the events and the functions. Those elements allow us to build the basic model for the production processes. The above-described elements are the basic elements of EPC. To model more than the basis process, extra elements have been developed. The outcome was called eEPC (extended Event-driven Process Chain) (Davis & Brabänder, 2007). This gives the possibility to model, for instance, the organizational units or persons, information, material or resource object and different flows like an information flow. For our instrument the following elements are used to model the processes: functions, events, process paths, logical relationships, organizational units, information, materials and information flows.

[4] Readers read and listens to the tags by sending signals to the tag

5.1.1 Information performance

Information performance is split into efficiency and effectiveness. “Effectiveness is defined as the ability to achieve stated goals or objectives”(Piccoli, 2008, p. 29). All supply chain actors require certain supply chain information in a certain format and within a certain time frame. Effectiveness of information performance is measured via multiple dimensions as found within the “information-quality literature” (Tayi and Ballou, 1998; Wand and Wang, 1996; Wang and Strong, 1996). Information-quality authors (Kahn et al., 2002; Lee et al., 2002; Wand and Wang, 1996; Wang and Strong, 1996) have come up with a range of dimensions – each with their own definition – for measuring information performance. A general agreement of dimensions and their definitions, however, has not been reached (Battini et al., 2008; Lee et al., 2002). Based on a literature review of the “information-quality literature”, a list of dimensions is proposed: accessibility, appropriate amount of data, believability, completeness, concise representation, consistent representation, ease of manipulation, free-of-error, interpretability, objectivity, relevancy, reputation, security, timeliness, understandability, and value-added. Based on the first focus group discussion (see section 3.3 – Method), this list is narrowed down to: accessibility, completeness, free-of-error, timeliness and understandability (see table 1). These five dimensions allow us to measure information performance in four different ways: intrinsic (free-of-error), contextual (completeness & timeliness), representational (understandability), and accessibility (accessibility) (Lee et al., 2002). The TIPO partners want identification information, origin information, performance information, and registration information of their pigs. They want this information: fast, free-of-error, unambiguous, online, everywhere, and every time available.

Table 1.
Constructs of the effectiveness of information performance (based on (Piccoli, 2008; Pipino et al., 2002))

Accessibility	The extent to which information is available, or easily and quickly retrievable.
Completeness	The extent to which information is not missing and is of sufficient breadth and depth for the task at hand.
Free-of-error	The extent to which information is correct and reliable.
Timeliness	The extent to which the information is sufficiently up-to-date for the task at hand.
Understandability	The extent to which the information is easily comprehended.

“Efficiency is defined as the ability to limit the waste and maximize the ratio of the output produced to the inputs consumed” (Piccoli, 2008, p. 29). The efficiency of information performance is measured through a cost-benefit analysis. Cost-benefit analyses are not new, but have rarely been used to evaluate the implementation of information technologies (Paris et al., 2009). It is, however, essential to take into account costs and benefits; information technologies are seldom implemented within budget (Gargeya and Brady, 2005). A cost-benefit analysis is a complex issue; various costs and benefits need to be taken into account. Costs can be measured relatively easily, but the benefits are less easy to transform into monetary values. Referring to our supply chain, on the one hand, certain costs are easy to quantify: labour costs and RFID’s. On the other hand, certain benefits, gained through improved information performance, are not easy to quantify: better quality of the delivered pigs to the slaughterhouse (i.e. better meat-fat proportion). In conclusion, cost and benefits are very specific per supply chain and many of them are difficult to quantify. It is, therefore, advisable to come up with two generic constructs (see table 2).

Table 2.
Constructs of efficiency of information performance (based on (Power and Simon, 2004))

Implementation costs	The estimated costs of implementation of information technologies.
Implementation benefits	The estimated benefits of implementation of information technologies.

5.1.2 Processes

Multiple processes (both changed and unchanged) that may form the bottleneck for information-performance failure are called critical process points. At one of those critical process points, one or more organizational and/or technical determinants may form the cause of information-performance failure.

Table 3.
Critical process construct

Critical process points	These are points in the production process or points where information is processed (i.e. captured, transmitted, stored, manipulated, or displayed), which may have led to information-performance failure.

At one of those critical process points, information-performance failure has two potential types of causes: technology that does not work as intended or the organisation, which we consider from the point of view the people that do not (fully) or correctly use the technology. The first type of cause is explained in the section on technology; the second type of cause is explained in the section on organization.

5.1.3 Organization

The organizational cause of the information-performance failure could be determined via information-technology usage (see table 4). Actual usage can be measured via objective and subjective measures (Straub et al., 1995; Turner et al., 2010). Objective measures can be generated via system logs incorporated in the technology itself (Dasgupta et al., 2002; Turner et al., 2010). Subjective measures are based on self-reported usage of the user (Turner et al., 2010). Most commonly used is the self-reported subjective usage of technology, mainly because such measurements are much easier to obtain (Legris et al., 2003; Turner et al., 2010).

Information technology usage is in first instance influenced by attitude towards use (Davis, 1989; Venkatesh and Bala, 2008; Venkatesh et al., 2003). A positive feeling for the information technology has a direct impact on the information-technology usage (Venkatesh et al., 2003). This positive feeling might increase job satisfaction, which influences commitment of employees (Hall, 2002). For instance, employees within our organic pork meat supply chain might use the information technology more when they find using the system a good idea and easy to use.

Table 4. Constructs of information-technology usage and attitude towards using information technology (based on (Straub et al., 1995; Venkatesh et al., 2003))

Information-technology usage	
Information-technology usage	The actual utilization of the information technology.
Attitude towards using information technology	
Attitude towards use	Positive feelings of joy or pleasure; negative feelings of depression, or disgust, or displeasure, or hate felt by an individual when using the information technology.

The "attitude towards using technology" is influenced by individual, company, and supply chain determinants. This attitude is influenced through users' perceptions, which impact the usage. Usage has impact on the users' work, the institutional properties of the company and the supply chain institutional properties (Orlikowski, 1992). The information-performance failure may have a cause on individual, company, or supply chain level. Underneath those three sections, a first paragraph describes the perceptions and a second paragraph describes the work or the institutional properties.

Individual level

Employees' expectations impact attitude towards information-technology usage. Information technology creates individual performance expectations and effort expectations (Venkatesh et al., 2003). First, performance expectations contain two constructs: perceived usefulness, and relative advantage (see table 5). For instance, at the farm an employee has to fill in a sheet of paper when medicine is administered. When using an RFID handheld reader, the employee believes that this registration is easier (perceived usefulness). In addition, registration will be done faster and more accurate than before (relative advantage). If the responsible employee perceives it as useful and better than an earlier way of working, then he or she is likely to be positive to use the information technology. Second, effort expectations contain two constructs: perceived ease of use, and complexity (see table 5). For instance, on the one hand, when the same employee at the farm finds it too complicated to use this handheld reader, because he or she does not understand some functionalities of the reader, then there is a chance that the employee is negative towards using the information technology (complexity). On the other hand, when this employee thinks that he or she will learn the functionalities very easily, then the employee is likely to be positive towards using this technology (perceived ease of use).

Using or partly using the information technology will change the experience and the work of the involved employees (see table 5), which will change the perceptions during implementation. A change of work means a change in workload, in responsibilities and in control. First, very often mentioned is the change in workload due to the implementation of information technologies (Boudreau and Robey, 2005; Orlikowski, 1992; Volkoff et al., 2007). Second, loss of control is another often-mentioned changed work characteristic (Boudreau and Robey, 2005; Orlikowski, 2000; Volkoff et al., 2007). Due to the implementation of an information technology and its embedded procedures, standardization increases, which might increase the loss of control (Volkoff et al., 2007). Third, information technologies can both limit and enhance responsibilities (Dhillon and Backhouse, 1996; Volkoff et al., 2007).

Table 5. Constructs of performance expectations, effort expectations, experience, and work (based on (Venkatesh et al., 2003; Wall et al., 1990))

Performance expectations	
Perceived usefulness	The degree to which a person believes that using a particular information technology would enhance his or her job performance.
Relative advantage	The degree to which using an innovative information technology is perceived as being better than using its precursor.
Effort expectations	
Perceived ease of use	The degree to which a person believes that using an information technology would be free of effort.
Complexity	The degree to which a person believes that using an information technology is difficult to understand and use.
Experience	
Experience	Positive or negative experience gained through the usage of information technology.
Work	
Workload	The amount of labour needed for executing a task.
Responsibilities	The degree to which a person is in charge of the information technology itself and the output.
Control	The degree to which an employee 1) can choose when to use the technology, 2) does not have to respond to the technology, and 3) does not restrict the employee how to perform the task.

Company level

Social expectations impact attitudes towards information-technology usage (see table 6). First, social expectations are expectations created through social influences from other employees within the company (Venkatesh et al., 2003). For instance, hair samples (example of a DNA sample) of certain pigs need to be taken at the farm. An employee might do it if the farmer supports this DNA sampling.

The implementation of information technologies and the additional process changes imply changes in company structure (see table 6). First, the change in processes require changes in procedural steps. For instance, the process of delivering store pigs to the slaughterhouse may change, because the procedural steps of this process imply the usage of an RFID handheld reader. Second, the division of labour may be redefined as well, because certain tasks may have been created while certain tasks may disappear due to the introduction of information technologies. A task is “a narrowly defined piece of work assigned to a person” (Daft, 2008, p. 30). For instance at the farm, an employee needs to take a DNA sample of some pigs, which was not the case before.

Table 6. Constructs of social influence expectations and structure
(based on (Daft, 2008; Lapointe and Rivard, 2007; Orlikowski, 1992; Venkatesh et al., 2003))

Social influence expectations	
Social factors	The individual's internalization of the reference group's subjective culture, and specific interpersonal agreements that the individual has made with others, in specific social situations.
Structure	
Division of labour	The division of tasks or labour.
Standard procedures	A sequence of steps that needs to be followed in order.

Supply chain level

On supply chain level, power-shift expectations, and trust impact attitude towards information-technology usage (see table 7). First, the availability of some specific information within an organization could shift the power within the supply chain (Premkumar, 2000; Spekman and Sweeney, 2006). Information is power and reluctance to exchange information within the supply chain can develop if the benefits of the exchanged information are not similar for all partners (Premkumar, 2000). Second, trust is an important enabler to exchange information in a supply chain (Ghosh and Fedorowicz, 2008; Provan and Kenis, 2008), and may impact the attitude towards information-technology usage.

On supply chain level, contracts need to be built (see table 7). Contracts are necessary for financial and risk-sharing arrangements, as well as for ownership and responsibilities alignments of information and information technologies (Ghosh and Fedorowicz, 2008; Provan and Kenis, 2008). For example, the farmer might remain owner of his farm information. In addition, De Groene Weg as chain director might be responsible for the "inter-organizational information system". Those contracts arrange ownership and responsibility issues and share risks among supply chain partners (Ghosh and Fedorowicz, 2008).

Table 7.
Organizational constructs on supply chain level (based on (Ghosh and Fedorowicz, 2008))

Power-shift expectations	The person's perception that the power shifts from one organization to one or multiple other organizations within the supply chain.
Trust	The person's perception that one party in a two-way relationship will not exploit its vulnerabilities.
Contracts	A mechanism that shares risks among supply chain partners and delineate ownerships and responsibilities.

5.1.4 Technology

If the information-performance failure is not organizational, then it is technical. More and more authors during the last decades have been advising to focus and take into account the material artefact of technology when doing research about information-technology implementations (Faulkner et al., 2010; Orlikowski and Iacono, 2001). It is clear that a huge amount of technical artefacts do play an important role when implementing information technologies towards information-performance improvements.

Within the "Implementation-monitoring Instrument", a split will be made between the material artefacts, namely software and hardware (Orlikowski, 1992). First, hardware is a much broader concept than just computer hardware. Like Orlikowski has stated, it can be seen as "a specific machine […], appliance, device, or gadget" (Orlikowski, 1992, p. 408). The non-computer hardware can contain pen and paper. Besides, the computer hardware contains first of all input and output devices (Laudon and Laudon, 2004). Keyboard, mouse, RFID reader and scanner are possible input devices and printer is a possible output device (Laudon and Laudon, 2004). Besides, the most important part of hardware consists of computers. Second, the software comprises information processing functions (DeSanctis and Poole, 1994; Orlikowski, 2000), which runs on the computer hardware. The software includes stored data, procedures and roles as well (DeSanctis and Poole, 1994; Volkoff et al., 2007). Roles are authorizations for technology users (Volkoff et al., 2007). Employees have the possibility to use certain functions within the software based on their role within the company, which is formally defined and restricted based in their ID code (Volkoff et al., 2007). Next, procedures embedded within the technology have been defined by Volkoff et al. (2007, p. 839) as embedded routines, which are "sets of explicitly defined steps that require specific data inputs to automatically generate specific outcomes".

Table 8.
Constructs of Technology (based on(DeSanctis and Poole, 1994; Orlikowski, 1992; Volkoff et al., 2007))

Hardware	It can be seen as a specific machine, appliance, device, or gadget.
Software	It comprises information processing functions, which runs on the computer hardware, and includes data, procedures and roles.

5.2 Instrument Procedures

The "Implementation-monitoring Instrument" is an instrument that guides project managers during the implementation of information technologies. The Instrument needs to be applied multiple times during implementation. Underneath the procedures are described with respect to how project managers need to act to achieve the required information performance within the whole supply chain. This is the basis for the users' manual.

- During step one, the production and information processes are modelled. During focus group discussions with all project managers, one information manager per organization and one general manger per organization, process change decisions, work decisions and institutional properties decisions will be taken (i.e. redesign decisions) (see 5.1.2 – Processes; 5.1.3 – Organization).
- The second step is to figure out the information-performance per supply chain actor. Focus group discussions with one financial manager and all managers who make (or want to make) decisions based on the (desired) new information within the supply chain need to be performed. This focus group discussion needs to be done per supply-chain actor. Additional clarifications during these discussions are necessary when there is an information-performance failure. For instance, when the information is not complete, it needs to be clear which information is lacking.
- During the third step, after modelling the processes, it needs to become clear at which processes the information-performance failure could have originated. Those processes (both production and information processes) are called critical process

points. They need to be discovered through open interviews with one information manager and one production manager per supply chain organization.

- During the fourth step, the organizational and/or technical cause of the information-performance failure needs to be detected. Observations need to be done together with the responsible of the critical process point. Second, at this identified critical point, interviews with an information manager need to be held. The hardware and software need to be checked with the responsible expert. Further, log files are consulted with one responsible expert, if it is expected that the information-performance failure has a technical cause. If this procedural step did not lead to find a technical cause of the information-performance failure, then the failure has an organizational cause. Direct observations and complementary focused interviews with the involved information-technology employees need to be executed.

6 Conclusions and future directions

The example implementation is part of the TIPO project. One of the aims of this project is to enhance the production processes. Enhancements can be achieved through better information performance, which creates the necessity to implement information technologies. The “inter-organizational information system” and the additional technologies RFID and DNA profiling will be used for more and better information exchange in the Dutch organic pork supply chain, which will support supply chain actors in improving and aligning their processes.

This implementation creates, however, technical or organizational complexities within certain processes. Therefore, we have defined an “Implementation-monitoring Instrument”, which is aimed to help project managers during implementation of information technologies within agro-food supply chain to achieve a satisfactory information performance for all supply chain partners. It allows to measure the information-performance per supply chain actor. If this performance is not satisfactory (i.e. information-performance failure), then the Instrument allows to measure organizational and technical determinants within critical process points. Critical process points are processes that could have led to information-performance failure. This extra supply chain dimension makes the instrument innovative. The Instrument is expected to be useful to monitor the implementation of information technologies in other supply chains as well.

Determining the causes of an information-performance failure is not enough. For instance, if information-technology usage is not satisfactory for the project managers and performance and effort expectations seem to be cause, then organizational intervention-decisions need to be taken (Venkatesh and Bala, 2008). Interventions should make the involved employees aware that the information technology is an opportunity to enhance their job performance. First, training is one of the major advises during information-technology implementations (Venkatesh and Bala, 2008). Second, the help of other employees (i.e. peer support) could help as well to increase information-technology usage (Venkatesh and Bala, 2008). Third, the job content of the employee can be changed, which means changing some tasks and workload.

The usage of this instrument will be prospectively used and evaluated in a Dutch organic pork meat supply chain and retrospectively in two other agro-food supply chains. During this usage, intervention decisions need to be discussed as well.

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References

Angeles, R., (2005). Rfid Technologies: Supply-Chain Applications and Implementation Issues. *Information Systems Management*, **22**: 51-65.

Bajaj, A., Nidumolu, S.R., (1998). A feedback model to understand information system usage. *Information and Management*, **33**: 213-224.

Barley, S.R., (1986). Technology as an Occasion for Structuring: Evidence from Observations of CT Scanners and the Social Order of Radiology Departments. Administrative Science Quarterly, **31**: 78-108.

Battini, D., Faccio, M., Persona, A., and Sgarbossa, F., (2008). A new methodological framework to implement an RFID project and its application. *International Journal of RF Technologies: Research and Applications*, **1**: 77-94.

Boudreau, M.C., Robey, D., (2005). Enacting Integrated Information Technology: A Human Agency Perspective. *Organization Science*, **16**: 3-18.

Brooks, R.J., Tobias, A.M., (1996). Choosing the best model: Level of detail, complexity, and model performance. *Mathematical and Computer Modelling*, **24**: 1-14.

Daft, R.L., (2008). Organization Theory and Design. South Western College Publishing, Stamford, Connecticut, U.S.

Dalvit, C., De Marchi, M., and Cassandro, M., (2007). Genetic traceability of livestock products: A review. *Meat Science*, **77**: 437-449.

Dasgupta, S., Granger, M., and McGarry, N., (2002). User Acceptance of E-Collaboration Technology: An Extension of the Technology Acceptance Model. *Group Decision and Negotiation*, 11: 87-100.

Davis, F.D., (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, **13**: 319-339.

DeSanctis, G., Poole, M.S., (1994). Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory. *Organization Science*, **5**: 121-147.

Dhillon, G., Backhouse, J., (1996). Risks in the use of information technology within organizations. *International Journal of Information Management,* **16**: 65-74.

Faulkner, P., Lawson, C., and Runde, J., (2010). Theorising technology. *Cambridge Journal of Economics,* **34**: 1-16.

Fawcett, S.E., Osterhaus, P., Magnan, G.M., Brau, J.C., and McCarter, M.W., (2007). Information sharing and supply chain performance: the role of connectivity and willingness. Supply Chain Management: *An International Journal,* **12**: 358-368.

Fawcett, S.E., Wallin, C., Allred, C., and Magnan, G., (2009). Supply chain information-sharing: benchmarking a proven path. Benchmarking: *An International Journal*, **16**: 222-246.

Gargeya, V.B., Brady, C., (2005). Success and failure factors of adopting SAP in ERP system implementation. *Business Process Management Journal*, **11**: 501-516.

Ghosh, A., Fedorowicz, J., (2008). The role of trust in supply chain governance. *Business Process Management Journal*, **14**: 453-470.

Gibbbert, M., Ruigrok, W.,and Wicki, B., (2008). Research notes and commentaries what passes as a rigorous case study? *Strategic Management Journal*, **29**: 1465-1474.

Gunasekaran, A., Ngai, E.W.T., (2004). Information systems in supply chain integration and management. *European Journal of Operational Research*, **159**: 269-295.

Hall, R., (2002). Enterprise resource planning systems and organizational change: transforming work organization? *Strategic Change*, **11**: 263-270.

Hughner, R.S., McDonagh, P., Prothero, A., Shultz, C.J., Stanton, J., (2007). Who are organic food consumers? A compilation and review of why people purchase organic food. *Journal of Consumer Behaviour*, **6**: 94-110.

Kahn, B.K., Strong, D.M., and Wang, R.Y., (2002). Information Quality Benchmarks: Product and Service Performance. *Communications of the ACM*, **45**: 184-192.

Kumar, R., (2005). Research methodology: a step-by-step for beginners. Sage, London.

Lapointe, L., Rivard, S., (2007). A triple take on information system implementation. *Organization Science*, **18**: 89-107.

Laudon, K.C., Laudon, J.P., (2004). Management Information Systems: Managing the Digital Firm. Prentice Hall, Upper Saddle River, New Jersey.

Lee, Y.W., Strong, D.M., Kahn, B.K., and Wang, R.Y., (2002). AIMQ: a methodology for information quality assessment. *Information and Management*, **40**: 133-146.

Legris, P., Ingham, J., and Collerette, P., (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information and Management,* **40**: 191-204.

Leonardi, P.M., Barley, S.R., (2008). Materiality and change: Challenges to building better theory about technology and organizing. *Information and Organization*, **18**: 159-176.

Michael, K., McCathie, L., (2005). The pros and cons of RFID in supply chain management, Mobile Business, 2005. ICMB 2005. International Conference: 623-629.

Miles, M.B., Huberman, A.M., (1994). Qualitative data analysis: an expanded sourcebook. Sage, London.

Nah, F.F.H., Lau, J.L.S.,and Kuang, J., (2001). Critical factors for successful implementation of enterprise systems. *Business Process Management Journal*, **7**: 285-296.

Ngai, E.W.T., Cheng, T.C.E., Lai, K.-h., Chai, P.Y.F., Choi, Y.S., and Sin, R.K.Y., (2007). Development of an RFID-based Traceability System: Experiences and Lessons Learned from an Aircraft Engineering Company. *Production and Operations Management*, **16**: 554-568.

Orlikowski, W.J., (1992). The Duality of Technology: Rethinking the Concept of Technology in Organizations. *Organization Science*, **3**: 398-427.

Orlikowski, W.J., (2000). Using Technology and Constituting Structures: A Practice Lens for Studying Technology in Organizations. *Organization Science*, **11**: 404-428.

Orlikowski, W.J., Hofman, J.D., (1997). An Improvisational Model of Change Management: The Case of Groupware Technologies *Sloan Management Review*, **Winter**: 11-21.

Orlikowski, W.J., Iacono, C.Z., (2001). Research Commentary : Desperately Seeking the "IT" in IT Research – A Call to Theorizing the IT Artifact. *Information System Research*, **12**: 121-134.

Padel, S., Schaak, D., and Willer, H., (2009). Development of the organic market in Europe, in: Willer, H., Kilcher, L. (Eds.), The World of Organic Agriculture. Statistics and Emerging Trends 2009. IFOAM - FiBL - ICT, Bonn - Frick - Geneva: 155-163.

Pereira, J.V., (2009). The new supply chain's frontier: Information management. *International Journal of Information Management,* **29**, 372-379.

Piccoli, (2008). Information Systems for Managers: Texts and Cases. John Wiley and Sons, Crawfordsville.

Pipino, L.L., Lee, Y.W., and Wang, R.Y., (2002). Data quality assessment. *Communications of the ACM,* **45**: 211-218.

Power, D., Simon, A., (2004). Adoption and diffusion in technology implementation: a supply chain study. *International Journal of Operations and Production Management*, **24**: 566-587.

Premkumar, G.P., (2000). Interorganization Systems and Supply Chain Management: An Information Processing Perspective. *Information Systems Management,* **17**: 1-14.

Provan, K.G., Kenis, P., (2008). Modes of network governance: Structure, management, and effectiveness. *Journal of public administration research and theory*, **18**: 229-252.

Robey, D., Boudreau, M.C., (1999). Accounting for the contradictory Organizational Consequences of Information Technology: Theoretical Directions and Methodological Implications. *Information System Research*, **10**: 167-185.

Robey, D., Sahay, S., (1996). Transforming Work Through Information Technology: A Comparative Case Study of Geographic Information Systems in County Government. *Information System Research*, **7**: 93-110.

Russell, D.M., Hoag, A.M., (2004). People and information technology in the supply chain: Social and organizational influences on adoption. I*nternational Journal of Physical Distribution and Logistics Management,* **34**: 102-122.

Salin, V., (1998). Information Technology in Agri-Food Supply Chains. *International Food and Agribusiness Management Review*, **1**: 329-334.

Saraph, J.V., Benson, P.G., and Schroeder, R.G., (1989). An Instrument for Measuring the Critical Factors of Quality Management. *Decision Sciences*, **20**: 810-829.

Schaak, D., (2009). Five Percent More Organic Land in the EU-27 - All Crops on the Increase, in: Willer, H., Kilcher, L. (Eds.), The World of Organic Agriculture. Statistics & Emerging Trends 2009. IFOAM - FiBL - ICT, Bonn - Frick - Geneva: 148-151.

Sinclair, M.A., Siemieniuch, C.E., Haslam, R.A., Henshaw, M.J.D.C., and Evans, L.,(2012). The development of a tool to predict team performance. *Applied Ergonomics*, **43**: 176-183.

Spekman, R.E., Sweeney, P.J., (2006). RFID: From concept to implementation. *International journal of physical distribution and logistics management*, **36**: 736-754.

Stefanou, C., (1999). Supply Chain Management (SCM) and Organizational Key Factors for Successful Implementation of Enterprise Resource Planning (ERP) Systems, AMCIS 1999 Proceedings, Paper 276.

Straub, D., Limayem, M.,and Karahanna-Evaristo, E., (1995). Measuring System Usage: Implications for IS Theory Testing. *Management Science*, **41**: 1328-1342.

Tayi, G.K., Ballou, D.P., (1998). Examing Data Quality. *Communications of the ACM*, **41**: 54-57.

Turner, M., Kitchenham, B., Brereton, P., Charters, S., and Budgen, D., (2010). Does the technology acceptance model predict actual use? A systematic literature review. *Information and Software Technology*, **52**: 463-479.

Umble, E.J., Haft, R.R., Umble, M.M., (2003). Enterprise resource planning: Implementation procedures and critical success factors. *European Journal of Operational Research*, **146**: 241-257.

Venkatesh, V., Bala, H., (2008). Technology Acceptance Model 3 and a Research Agenda on Interventions. *Decision Sciences*, **39**:273-315.

Venkatesh, V., Davis, F.D., (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science*, **46**: 186-204.

Venkatesh, V., Morris, M.G., Gordon, B.D., and Davis, F.D., (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, **27**: 425-478.

Volkoff, O., Strong, D.M., and Elmes, M.B., (2007). Technological embeddedness and organizational change. *Organization Science*, **18**: 832-848.

Wall, T.D., Martin, C.J., Clegg, C.W., Jackson, P.R., and Martin, R., (1990). Advanced Manufacturing Technology and Work Design: Towards a Theoretical Framework. *Journal of Organizational Behavior*, **11**: 201-219.

Wand, Y., Wang, R.Y., (1996). Anchoring data quality dimensions in ontological foundations. *Communications of the ACM*, **39**: 86-95.

Wang, R.Y., Strong, D.M., (1996). Beyond Accuracy: What Data Quality Means to Data Consumers *Journal of Management Information Systems*, **14**: 5-34.

Willer, H., (2009). Organic Agriculture in Europe: Overview, in: Willer, H., Kilcher, L. (Eds.), The World of Organic Agriculture. Statistics & Emerging Trends 2009. IFOAM - FiBL - ICT, Bonn - Frick - Geneva: 152-154.

Wognum, P.M., Krabbendam, J.J., Buhl, H., Ma, X.,and Kenett, R., (2004). Improving enterprise system support—a case-based approach. *Advanced Engineering Informatics*, **18**: 241-253.