How a BI-wise Responsible Integrated Management System May Support Food Traceability

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ABSTRACT

Food manufacturers are required to meet certain traceability specifications. This research aims at underscoring the relevant needs and expectations of various stakeholders across the entire food supply chain. In this context, firms' decisions on resource allocation and risk mitigation overlap several domains, such as quality, safety, environment, social responsibility and information. Business Intelligence (BI) platforms are specifically conceived to support analytical decision making by providing a centralised view on multiple distributed data sources. However, BI solutions are usually deployed within a single organization, whilst traceability involves multiple actors with potentially divergent interests and diverse levels of willingness to participate. Along this line of thought, integration of management systems within a company and throughout the overall supply chain is suggested to meet the emerging managerial challenges. After a detailed survey of integrated management systems (IMSs) in food traceability contexts, this research proposes a BI-wise solution using the IMS overarching approach and investigates its success conditions.

KEYWORDS

Business Intelligence, Food Traceability, Integrated Management System, Social Responsibility

INTRODUCTION

Food traceability (FT) refers to "all stages in the food supply chain so that the product can be checked for safety and quality control, traced upward, and tracked downward at any time required" (Bosona and Gebresenbet, 2013). Regulatory frameworks have been developed to enforce traceability measures in order to assure prevention of food contamination and to track any causes of compromising the pathway of the food commodities from farm to plate. Furthermore, voluntary schemes, such as the Hazard Analysis of Critical Control Points (HACCP) and the ISO 22000:2005 standard have been released and spread to support the efficient and effective establishment of the processes and procedures to facilitate traceability.

Traceability is anticipated to address sustainable development concerns about animal welfare, ethical production methods and environmental issues, including herbicides used in farming, animal feed and water, providing a fast and efficient support to decision making in the management of any identified quality incident in the food supply chain. Food incidents, such as "mad cow disease", dioxins in chicken feed and genetically modified crops (Aung & Chang, 2014), can provide illustrative

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examples of the transparency and inter-operational weaknesses in traceability systems that may endanger health and question consumers' trust.

Therefore, traceability is a highly significant issue that isolated practices and stand-alone management systems (MSs) have yet failed to adequately address. It requires the joint management of several domains, such as quality, safety, supply chain, environment, social responsibility, information management and decision support. Moreover, the lack of a theoretical framework to embrace all aspects and foster synergies is acknowledged (Karlsen et al., 2013). To this end, integration of MSs seems to be the most suitable approach. An Integrated Management System (IMS) builds upon the individual management sub-systems aligning strategic objectives with business processes, allocating resources and meeting stakeholders' needs and expectations.

Information-wise, food traceability demands for multiple sourced data that needs to be uniquely codified and recorded. Next, data has to be interpreted within a regulatory and managerial framework from a strategic perspective, since critical decision making is involved. In this context, key challenges are the availability, content uniformity and sufficiency of information, the access velocity, and the strategic perspective of information use. Information availability and uniformity are addressed by regulations (Aiello et al., 2015). However, the degree of direct access to information depends on the stakeholders' communication, which is yet quite limited (Bevilacqua et al., 2009). Finally, the question of speed and accuracy is not at all under control. Indeed, a great amount of information is paper trailed, i.e. collected by hand and stored on sheets of paper (Bosona & Gebresenbet, 2013; Manos & Manikas, 2010). Consequently, data capture entails time-consuming and error-prone human interactions.

These observations advocate for a centralised and formalized access to information to meet the analytical needs that arise in a food chain. Stakeholders, including institutions, regulatory authorities, non-governmental organizations (NGOs), retailers, and consumers, raise their own needs and requirements in terms of food safety, quality and traceability. In this context, farmers and food manufacturers need support towards making decisions on the allocation of resources based on economic, social, and environmental criteria via metrics, such as the optimal information value and the economic traceability lot. In addition, given the lack of a common and centralized data base to capture food and feed processing data, the lack of a dedicated holistic ontology and the overlapping and non-harmonized regulations and standards, business intelligence (BI) platforms offer a typical architecture and framework to address these needs. As a prelude to the design of a BI system for food traceability, this paper explores how a BI-wise responsible IMS may support food traceability. In this context, extant research on FT management is discussed. Additional research topics are traceability's relationship with social responsibility, information management embeddedness in an IMS and the critical success factors. This paper concludes with the identification of the challenges and the expected benefits from the implementation of a BI platform for FT management.

The remainder of this paper is structured as follows. Next section provides a detailed overview of traceability and IMSs. Then BI concepts are introduced and two sections are respectively dedicated to the identification of critical success factors and challenges of the development of a BI platform for FT management. This paper ends with conclusions and future research directions.

TRACEABILITY

Traceability is an interdisciplinary concept with a variety of definitions and perspectives. According to ISO, traceability is defined as the "ability to trace the history, application and location of that which is under consideration", including the origin of materials and parts, the processing and the distribution. Karlsen et al. (2013) contend lack of a common understanding and a common theoretical framework with respect to FT implementation. Moreover, traceability is a critical issue that MSs alone have failed to adequately address, so far. It requires the simultaneous and efficient alignment of several domains, i.e. quality, safety, supply chain, environment and information. The respective standards that interact are the ISO 9001 for quality, ISO 22000 for food safety, ISO 14001 for the environment, ISO 26000 for corporate social responsibility, ISO 28001 for supply chain security, ISO 27001 for information security and ISO 20000 for information service management (Gianni & Gotzamani, 2016).

Despite the world-wide efforts for institutionalization and standardization in a holistic sense, FT solutions remain contingent and custom-made for specific parts of the food supply chain, within country- and industry-specific contexts, like for example the Cattle tracking system in the UK. Barge et al. (2014) examine the information flow at a dairy plant and identify factors affecting successful traceability beyond the RFID devices. Benefits accrued by the traceability system, such as labour and risk reduction, automation, transparency, improved logistics and increased data availability, are intertwined within the production process and the supply chain, as a whole, and, therefore, difficult to quantify (Barge et al., 2014). Ringsberg (2015) understands FT requirements overlapping across food safety, quality and sustainability domains among supply chain partners. In a similar vein, traceability is identified as a potential link of management sub-systems in order to achieve sustainable integrated management (Gianni et al., 2014). In the following table (Table 1.) there is a summary of the most recent and relevant research in the field where traceability challenges, such as requirements elicitation, cost, and speed, are addressed.

Traceability in global food supply chains can only be fully accomplished if organizations abide by regulations and agreements and apply standardized approaches that enable interoperability and coordinate buyers and suppliers (Aung & Chang, 2014; Pizzuti & Mirabelli, 2015). FT links intra- and inter-organizational logistics and recordkeeping systems used for business, food safety and quality control (Bosona & Gebresenbet, 2013; Bourlakis & Bourlakis, 2006; Ringsberg, 2015). Thus, FT contributes to the timely withdrawal of unsafe goods from markets and mitigates product liability and control transaction costs (Bevilacqua et al., 2009).

Information Asymmetry and Traceability Economics

In a principal-agent relationship, information asymmetry refers to a situation when one party in the relationship has more or better information than the other (Zu & Kaynak, 2012). Zu and Kaynak (2012) emphasize that quality management is "management by fact" and it requires the systematic collection and analysis of timely and correct quality-related data and information so that quality problems can be identified early and actions can be taken to rectify them. More specifically, since supply chain transactions are becoming increasingly distant and international, it is made more difficult for buyers to observe the qualifications of supplier raising problems of information asymmetry (Terlaak & King, 2006). In this context, Ringsberg (2015) highlights the perspective of transparency in the management of traceability information.

Resende-Filho and Hurley (2012) "define traceability by its precision, i.e. the probability of finding the source of the problem" and deepen into positive and normative issues via the economics of traceability. In this context, an organization's decision on the accuracy level of a traceability system depends primarily on the cost vs benefit ratio and not on technical implementation shortcomings. Resende-Filho and Buhr (2008) used the case of injection-site lesions in beef as an example to numerically simulate the economic value that can be attained through a reduction in information asymmetry. Aiello et al. (2015) underline the optimal value of information (granularity level) compared to the operational cost of automatic data collection via a stochastic mathematical approach (first and second type errors) and introduce the "Economic Traceability Lot".

Traceability and Social Responsibility

Since the Single European Market was launched and the mad cow disease scandal burst a debate was triggered over shared responsibility across all actors in the food supply chain encompassing institutional, ethical and societal aspects. In this context, a farm to table policy was introduced guided by five key principles: "Clear definitions of the roles and responsibilities of stakeholders in the food chain; traceability of feed and food and their ingredients; transparency of food policy; risk analysis as

Table 1. Traceability as a decision support vehicle in food industry – literature review

Header	Year	Authors	Main topics
The Global Track&Trace System for food: General framework and functioning principles	2015	Pizzuti & Mirabelli	Information access, delivery speed, loss risk
Development and evaluation of an intelligent traceability system for frozen tilapia fillet processing	2015	Xiao, Fu, Qi, Mira, & Zhang	Intelligent traceability system with SPC & FTA
Food Track & Trace ontology for helping the food traceability control	2014	Pizzuti, Mirabelli, Sanz-Bobi, & Goméz-Gonzaléz	Ontology based on actor, food product, service product and process
Item-level Radio-Frequency IDentification for the traceability of food products: Application on a dairy product	2014	Barge, Gay, Merlino & Tortia	Success factors – costs and benefits
Critical factors for sub-supplier management: A sustainable food supply chains perspective	2014	Grimm, Hofstetter & Sarkis	Difficulties, regulations
Quality control in food supply chain management: An analytical model and case study of the adulterated milk incident in China	2014	Chen, Zhang & Delaurentis	Transparency, information visibility
Integration of management systems: Insights from a dairy plant	2014	Gianni, Gotzamani & Vouzas	Traceability as a linking factor for the integration of MSs
Food traceability as an integral part of logistics management in food and agricultural supply chain	2013	Bosona & Gebresenbet	Size of companies as a traceability barrier
The TraceFood Framework – Principles and guidelines for implementing traceability in food value chains	2013	Storøy, Thakur & Olsen	Organizational obstacles – costs and benefits
Biotracing: a novel concept in food safety integrating microbiology knowledge, complex systems approaches and probabilistic modelling	2011	Hoorfar, Wagner, Jordan & Barker	Mathematical modelling decision support approach
Food traceability systems: Performance evaluation and optimization	2011	Dabbene & Gay	Performance criteria – worst-case recall scenario
Applying evolutionary prototyping model for eliciting system requirement of meat traceability at agribusiness level	2010	Zhang, Lv, Xu & Mu	Requirements eliciting model for meat traceability
Framework for implementing traceability system in the bulk grain supply chain	2009	Thakur & Hurburgh	IDEF0 model: traceability performance in food safety incident response
Business process reengineering of a supply chain and a traceability system: a case study	2009	Bevilacqua, Ciarapica & Giacchetta	Stakeholder equality - traceability as a communication tool.

the foundation on which food safety policy is based; and the application of the precautionary principle in risk management decisions" (Halkier & Holm, 2006). With regard to consumer perceptions, Chrysochou et al. (2009) stress that the volume and the credibility of information provided, the perceived levels of convenience, the impact on product quality and safety, the impact on consumers' health and the environment, and the potential consequences on ethical and privacy liberties impact the opinion of consumers on technologies that provide traceability.

Many researchers (see e.g. Barnett et al., 2016; Jin & Zhou, 2014) understand traceability systems as an important means to provide food safety and quality information to consumers and, thus, (re) gain their confidence. In a similar vein, increasing the confidence of consumers in their food, the changing lifestyles, the increasing awareness of society about their health are some of social issues that motivate food companies to implement traceability systems (Bosona & Gebresenbet, 2013). Furthermore, Bourlakis et al. (2014) shed more light on the social perspective of traceability when the claim that by providing information on product flows consumer/stakeholder attention shifts away from product price and appearance towards its origin (place and people).

On the other side, the reluctance to share information and the lack of transparency raise ethical issues in terms of social responsibility principles. Traceability is linked to information visibility (transparency) and the need to preserve an enterprise's integrity. However, transparency increases the difficulties of protecting the integrity of a food commodities enterprise due to similarities in competitive interests (Trienekens et al., 2012). According to Pizzuti and Mirabelli (2015) the "information recorded on food labels refers to the last actor involved in the transformation process" usually missing the link with its predecessors in the supply chain. Beekman (2008) understands ethical traceability as both a management and governance tool and emphasizes how the intermediate actors overpower the primary producers and the end-consumers in the food supply chain. Vasiliou et al. (2008) researched ethical traceability in the Greek olive oil chain and found that quality, trust, human health and origin were top concerns for all stakeholders. Consumers are concerned about the transparency of the olive oil production. However, traceability and mostly ethical traceability is compromised due to the blending/mixing of different batches of oil during packing and whole selling (Vasiliou et al., 2008).

INTEGRATED MANAGEMENT SYSTEMS IN THE FOOD SECTOR

IMSs address the complexities that emerge when more than one management system (MS) standards are adopted by an organization. In this context, requirements of different stakeholders have to be managed concurrently, efficiently and effectively. To date, the majority of IMS research is limited to the integration of quality and environmental MSs in manufacturing firms irrespective of sector. Particularly in the food industry, Renzi and Capelli (2000) and Satolo et al. (2013) have analysed the implementation, the level, the motives, the difficulties and the benefits of IMSs. Aggelogiannopoulos et al. (2007) highlight the performance yield when integrating Hazard Analysis of Critical Control Points (HACCP) principles into the ISO 9001-based quality MS. In the same vein, Efstratiadis and Arvanitoyannis (2000) stress that HACCP as a part of a quality system not only manages to provide safety to the products, but also assures a better and more effective implementation of the "whole quality system". Fresner and Engelhardt (2004) pinpointed IMS in a brewery as a step towards corporate sustainability. In a similar vein, Weyandt et al. (2012) studied corporate social responsibility (CSR) integration in fisheries IMS. Proto et al. (2013) proposed a model for the integration of MSs and product standards in the agri-food sector.

Information Domain Within Integrated Management Systems

To date, information systems have been found to support IMS in terms of documentation and procedures, such as corrective and preventive actions and complaints (Karapetrovic & Casadesús, 2009; Ivanova et al., 2014). In this vein, Ivanova et al. (2014) contend that "the integration and information technology pathways overlap". Gianni and Gotzamani (2016) extend the integration discussion to the internalization of multiple MSs into the fabric of an organization elevating information to knowledge - both explicit and tacit. Savino and Batbaatar (2015) underscore information technology systems and artificial intelligence as a means for continuous improvement within IMSs. Barata and da Cunha (2014) composed a framework for the integration of information systems with quality MSs. Martins et al. (2011) understand the "merger" of information security management and business excellence within a total quality management framework. In a similar vein, Mesquida and Mas (2015) address the commonalities of the ISO 20000 standard for information service management and the ISO 9001 quality management standard and highlight their integration synergies. Hoy and Foley (2015) emphasize the benefits of joint quality and information management audits towards process improvement. Extant research on IMS incorporating information management is summarized in Table 2.

Generic and Food Sector-Specific Standards and Guidelines

Certain standards, like the quality assurance norm ISO 9001 (see ISO 9001:2015 in Table 3), are well known even by a general public, but most of them are only known by domain experts. Due to its transdisciplinary nature, FT is addressed by many different norms (see Table 3). A management norm or standard is "a set of conditions or requirements, prescribed and either formally adopted or widely recognized and accepted, whether promulgated by government agencies or merely established by custom or agreement, among buyers, sellers, or other governmental or commercial units" (Ivanova et al., 2014). It is stressed that FT in global supply chains can be fully accomplished only when food enterprises apply standardized approaches that enable interoperability (Aung & Chang, 2014). Furthermore, Terlaak and King (2006) suggest that standardized management systems might provide for buyers, regulators, and other institutional agents a viable way of reducing problems of asymmetric information; the main traceability barrier. Thus, the complex and demanding nature of traceability is approached via standards covering several domains (see Table 3.) As mentioned above, both the ISO 9001 and the ISO 22000 standards include requirements for traceability from a generic (quality) and a sector-specific (food safety) perspective. Moreover, ethical issues are raised from stakeholders, other than end-consumers, that call for social responsibility principles to be co-managed. With regard to social responsibility, the SA8000 standard's scope is limited to human resources while the ISO 26000 guidance embraces all core subjects and practices for integrating social responsibility, including the environment, consumer issues and community involvement and development (ISO, 2010). The AccountAbility AA1000 standards series addresses stakeholder engagement embedded within governance and decision-making processes based on the principle of inclusivity, i.e. the participation of stakeholders in developing and achieving an accountable and strategic response to sustainability (AccountAbility, 2015).

European Union (EU) established a centralized management structure for food safety to be overseen by the European Food Safety Authority and supported by decision and policy-making bodies, such as the Consumers, Health, and Food Executive Agency of the European Commission and the Food and Veterinary Office. Furthermore, EU released a set of regulations for food safety and hygiene under the General Food Law led by EC Regulation 178/2002 (Tang et al., 2015). In the U.S.A. food security legislation includes the Food Safety Modernization Act, the Food Safety

Table 2. Research on multiple management systems embedding information

Authors (publication year)	*Research topic*
Barata & da Cunha (2014)	Information systems and quality MSs
Martins, Bulkan & Klempt (2011)	ISO/IEC 17799 (Information technology – security techniques – Code of practice for information security management) and EFQM
Hoy & Foley (2015)	ISO 9001 and ISO 27001 integrated audits
Mesquida & Mas (2015)	IT service management (ISO/IEC 20000-1) and quality MSs
Crowder (2013)	Integration of QMS, EMS and Information Security MS

Table 3. Food supply chain related standards and guidelines

Standard/Guideline	*Title / content description*
Generic	
ISO 9001:2015	Quality management systems – Requirements
ISO 9004:2009	Managing the sustained success of an organization – A quality management approach
ISO 14001:2015	Environmental management systems – Requirements with guidance for use
ISO 14031:2013	Environmental management – Environmental performance evaluation – Guidelines
ISO 14044:2006	Environmental management – Life cycle assessment – Requirements and guidelines
ISO 28001:2007	Security management systems for the supply chain – Best practices for implementing supply chain security assessments and plans – Requirements and guidance
ISO/IEC 27001:2013	Information security management
ISO/IEC 20000-1:2011	Information technology - service management – Part 1: Service management system requirements
ISO 26000:2010	Guidance on social responsibility
SA 8000:2014	Social Accountability 8000 International Standard
AA1000AS (2008)	AccountAbility Assurance Standard
Sector-specific	
ISO 22000:2005	Food safety MSs – Requirements for any organization in the food chain
ISO 22005:2007	Traceability in the feed and food chain – General principles and basic requirements for system design and implementation.
ISO 22006:2009	Quality MSs – Guidelines for the application of ISO 9001:2008 to crop production
ISO/TS 22002-1:2009	Prerequisite programmes on food safety – Part 1: Food manufacturing
ISO/TS 22002-2:2013	Prerequisite programmes on food safety – Part 2: Catering
ISO/TS 22002-3:2011	Prerequisite programmes on food safety – Part 3: Farming
ISO/TS 22002-4:2013	Prerequisite programmes on food safety – Part 4: Food packaging manufacturing
ISO/TS 22002-6:2011	Prerequisite programmes on food safety – Part 6: Feed and animal food production
ISO/TS 22004:2014	Food safety management systems – Guidance on the application of ISO 22000
GS1 Global Traceability Standard	Business process and system requirements for full supply chain traceability
ISO 12875:2011	Traceability of finfish products - specification on the information to be recorded in captured finfish distribution chains
ISO 12877:2011	Traceability of finfish products - specification on the information to be recorded in farmed finfish distribution chains
ISO/WD TS 34700 (under development)	Animal welfare management – General requirements and guidance for organizations in the food supply chain
GS1 guideline for fish, seafood and aquaculture (2015)	GS1 Foundation for Fish, Seafood and Aquaculture Traceability Implementation Guideline
GS1 Global Meat and Poultry Traceability Guideline (2015)	Meat and poultry traceability
GS1 guideline for wine (2005)	Wine supply chain traceability
GS1 guideline for fruits and vegetables (2010)	Traceability for fresh fruits and vegetables - Implementation guide

Enhancement Act and other comprehensive laws and certain authorities, such as, the departments of Agriculture and Health, and the Environmental Protection Agency (EPA), share the responsibility of supervision over the livestock, food, water and pesticides (Tang et al., 2015).

At international level, World Health Organization (WHO) and Food and Agriculture Organization (FAO) of the United Nations have introduced Codex Alimentarius, otherwise "Food Code", which develops HACCP-based principles and guidelines contributing to safety, quality and fairness of food trade (Barling, 2008). Another non-governmental organization, GlobalGAP, former EurepGap, launches Good Agricultural Practice (G.A.P.) protocols and certification schemes for fruit and vegetables, crops, livestock, aquaculture aiming to introduce transparent, environment-friendly pesticide control requirements into standardized systems, such as traceability (Barling, 2008). Other stakeholders, the retailers, have imposed their own-developed food safety and quality specifications and certification requirements, such as the International Food Safety organization (IFS) and the British Retail Consortium (BRC).

GS1 are global IT standards, including GS1 barcodes, GS1 product numbers, electronic data interchange (EDI), extensible markup language (XML), radio-frequency identification (RFID), and data synchronization (GS1Net), that are administered by GS1 Global and aim at increasing supply chain efficiency (Power & Gruner, 2015). GS1 Global is a non-profit organization which provides identification keys for the items, services, locations, logistic units, returnable containers, and most of the numbering structures in terms of traceability including global trade item number, serial shipping container code, and global location number (Bevilacqua et al., 2009).

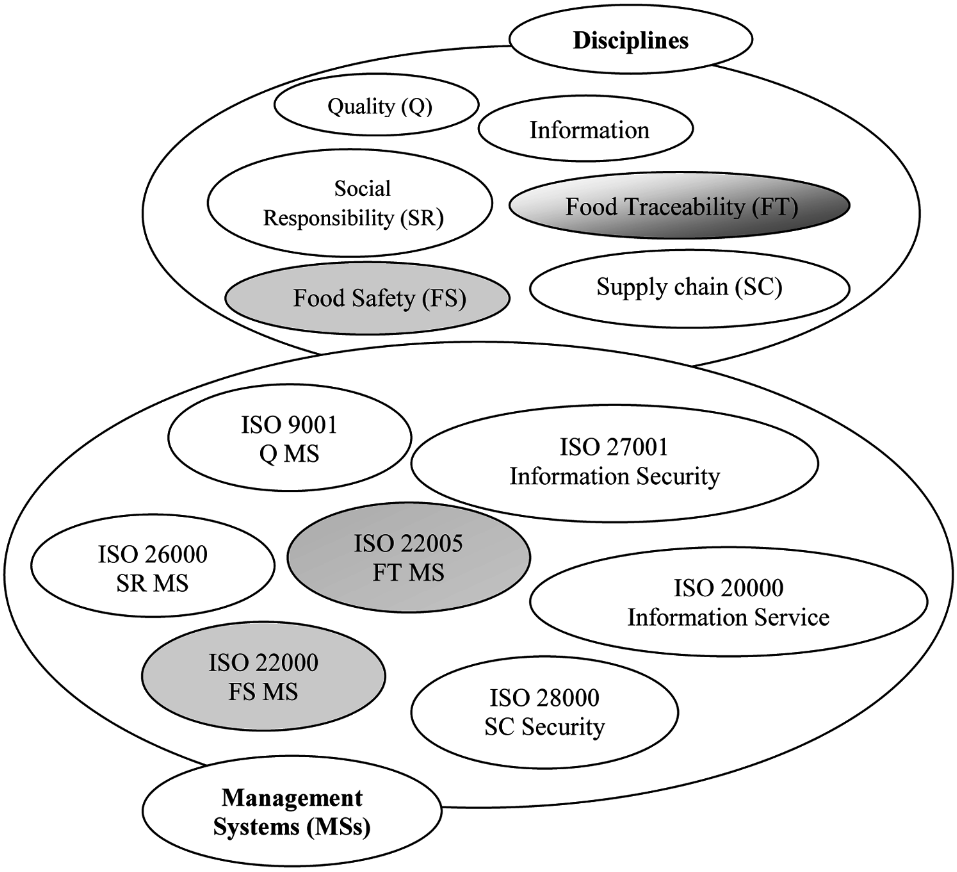
Integrated Management Systems and Traceability

It is evident that, traceability demands for a transdisciplinary approach covering a broad range of activities in various domains within an organization and beyond the borders of a single company. In other words, food traceability "penetrates" a variety of disciplines to be managed following respective standards (Figure 1). Wognum et al. (2011) stress the vertical along with the horizontal scope of traceability and discusses the "integrated or shared supply chain approach" where a common strategy is developed and integrated management and information systems are used. IMSs by definition may embed and bridge different management disciplines within a broad business scope both intra- and inter-organizationally. In a similar vein, scholars emphasize the quality and environmental management integration across supply chain actors (Wong et al., 2015; Zu & Kaynak, 2012). Particularly, with regard to "ethical traceability" IMSs embrace social responsibility principles both theoretically (Asif et al., 2013) and empirically (Botta et al., 2013; Weyandt et al., 2012). In this context, to adequately manage traceability the "conventional" IMS needs to adopt a stakeholder's approach driven by social responsibility principles towards a "responsible IMS".

BUSINESS INTELLIGENCE

BI platforms are specialized decision support systems. They provide business analysts access to information through rich applications and interfaces as interactive dashboards (Liu et al., 2010). Hiding them the multiplicity and diversity of data sources and information providers (human or IT), a BI platform offers an integrated and reconciled view on information spread all around an organisation. An overview of BI technologies can be found in prior research (see e.g. Chaudhuri et al., 2011). For this research purpose, it is underlined that, in standard BI systems the key element to achieve integration is the data warehouse, "a copy of transaction data specifically structured for query and analysis" (Kimball, 1996). It forms a "subject oriented, nonvolatile, integrated, time variant collection of data in support of management's decisions" (Inmon, 1992). Access to this information can be provided either by predefined reports, interactive views in dashboards or by querying tools as OLAP or Data Mining Systems.

Figure 1. Traceability-related disciplines, standards and management systems



Apart from the integrated view, BI architecture involves a set of characteristics that provides incomparable efficiency for analytical purposes which cannot be achieved by operational systems. In particular, its temporal and subject-oriented structure highly simplifies the formulation of analytical requests. Together with these business characteristics, specificities of analytic purpose slacken the constraints on the data base structures, in particular the non-redundancy constraint. Indeed, in BI systems, the datawarehouse structure can be de-normalized - without affecting the data integrity - which significantly improve the response time. Moreover, many optimizations are possible at a physical layer.

The conception of a BI system and its implementation face two main challenges: an analytical one and a technical one. At the analytical level, the difficulties rely in the identification of the specific requirements, the user needs elicitation. Several methodologies and formal models have been proposed to support this task (Britos et al., 2008; Burnay et al., 2014). From the technical perspective, data collection, and reconciliation and integration of sources have to be specified in an ETL process (Extract-Transform-Load). The definition and implementation of this kind of process is known to be highly demanding (Kimball, 1996). Moreover, it is emphasized that BI goes beyond a technical framework; it is also a management process with its integration in an organisation and adoption by users involving another set of factors to be taken into consideration (Howson, 2008).

Food Traceability Ontology

Food traceability management generates a set of requirements that need to be elicited and addressed. To date, scholars and practitioners have dealt with technical challenges. However, it is emphasized that the main obstacle for successful and efficient implementation of traceability in food product chains is organizational, not technical (Storøy et al., 2013). As such, the lack of a common and centralized data base to capture data in real-time at all stages of food and feed production, the lack of a uniquely identified and broadly employed ontology and the overlapping and non-harmonized regulations and standards are some of the barriers that are widely acknowledged. Ringsberg (2015) understands FT data within a shared information environment in the form of layers that need to be created based on standardized requirements.

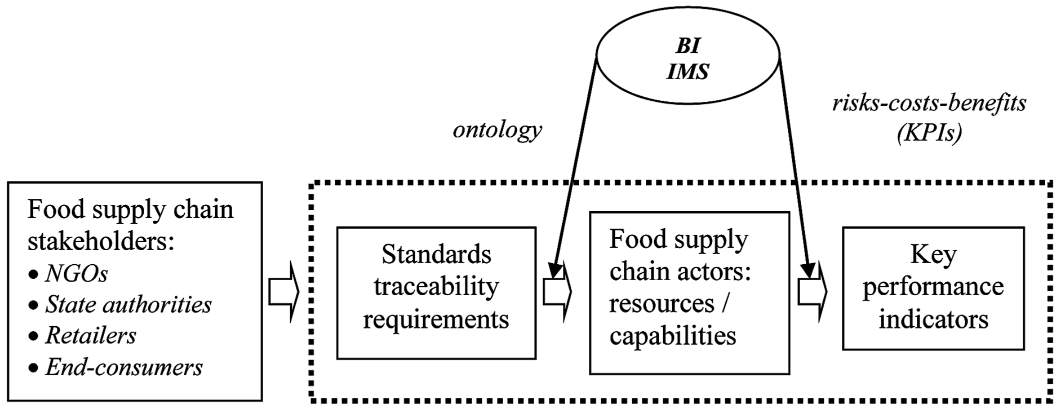
However, firms are not fully aware of their internal processes and, hence, are not internally motivated to perceive the value of standardized traceability systems. In this vein, a reduced use of IT-based GS1 standardized approaches over-time is stressed (Power and Gruner, 2015). Moreover, systems and stakeholders need to collaborate in terms of quality, safety, business and regulatory control within a cooperative decision support framework as the one proposed by Jankovic et al. (2009). To this end, an effective ontology-based information extraction is needed addressing questions as "what" (traceable unit), "where" (resource unit), "when" (trace event) and "who" (stakeholder) under a BI-IMS umbrella intertwining all related managerial and operational aspects, as identified and standardized by international institutions, such as the International Standardization Organization (ISO).

Traceability Key Performance Indicators

BI supports managers' decision-making via tools, like Key Performance Indicators (KPIs) and dashboards (Daly & Adam, 2011). According to Thakur and Hurburgh (2009) traceability is a risk-management tool that allows food business operators or authorities to withdraw or recall products which have been identified as unsafe. Traceability performance is currently assessed via indicators, such as the recall cost and the worst case recall cost. The overall cost of a traceability system is the sum of the recall cost, the cost of the system, and the costs induced by the possible reductions in efficiency and in quality caused by the adoption of the tracking and tracing system (Dabbene, Gay & Tortia, 2014). Further to the above, risk and cost indicators are required to evaluate quality, food safety, environmental and social performance in terms of traceability.

In general, food organizations are not motivated to adopt new standards for information exchange and traceability as they perceive this as an additional cost not being aware of the associated benefits. Ringsberg (2015) stresses the cost-related challenges in terms of semantic interoperability, unique product identification, and development and implementation of global traceability standards, that are affected by the volume of data registered and communicated in the food supply chain. Thus, in a limited resource framework, FT investments are kept to a minimum, and financial resources are allocated to profit-oriented choices (Storøy et al., 2013). A positive approach towards traceability management focuses on cost-benefit analysis, where decision making addresses improvement of processes and/or products based on resource hierarchy (Russell, Forgionne, & Yoon, 2009) and not mere hazard prevention. For example, traceability application can maintain an efficient seed segregation system for byers sensitive to biotechnology or determine the profitability associated with segregation of grain for different purity levels (Thakur et al., 2009). To this positive approach, IMS streamlined data warehouse structure using a standardized ontology may assure the exchange of valid, directly usable information and an effective decision-making. Furthermore, IMS approach focuses on standards and systems synergies and, thus, fosters the assimilation of performance standards, such as the ISO 9004, the ISO 14031 and the ISO 14044 (see Table 3). BI and IMS contribution in this context is depicted in Figure 2.

Figure 2. Food traceability interactive framework for decision making



CRITICAL SUCCESS FACTORS

Research on the critical success factors highlights the dynamic nature of BI solutions, meaning that some of the parameters need to be assessed before the actual implementation a BI system (Mungree et al., 2013). Furthermore, it is stressed that organizational and process-related factors are more influential and important than technological and data-related factors (Yeoh & Koronios, 2010). In the following table (Table 4.) a summary is given of the BI generic critical success factors (Yeoh & Koronios, 2010) and the corresponding traceability-specific contextual factors as elaborated by the authors based on reviewed literature.

In order for the traceability requirements to be addressed, technically advanced equipment and software need to be developed. In many cases, even if the required resources, such as funding and know-how are assured, there are specific factors that retain ambiguity. This is illustrated in dairy or cereal, where raw materials, like milk or grains, come in bulk form and from multiple sources. Human resources that are involved are often insufficiently trained and skilled (Daly & Adam, 2011) or even reluctant to comply with the recommended practices. Furthermore, certain stakeholders may withhold information that compromises the quality specifications of their products (Pizzuti & Mirabelli, 2015). Thus, the complexity of the problem rises and the traceability mission becomes really challenging. In a similar vein, when investigating BI from a rather general perspective, Yeoh and Popovič (2015) have acknowledged the potential impact of size and industry sector on the outcome of BI systems Correspondingly, traceability cost is found contingent on firm size, as well (Bourlakis et al., 2014; Karlsen et al., 2013).

CHALLENGES AND POTENTIAL BENEFITS

From the traceability perspective, two major entities must be identified: processes executed on products and actors who executed these processes (Pizzuti & Mirabelli, 2015). Moreover, institutions and regulations need to focus on the supply chain as a whole. In this context, IMSs may offer the adequate holistic approach leveraging the integration of processes and stakeholders both horizontally and vertically in the food commodities sector. However, particularly for the IMS in the food supply chain a tailored approach needs to be adopted focusing on the specific demands of the food processes and the food sector stakeholders. Among those specific demands, food traceability is a core sector-related parameter that raises additional requirements and brings about managerial improvements.

Table 4. Critical success factors related to a traceability-BI project

Critical Success Factors (Yeoh & Koronios, 2010)	*Specific contextual factors of traceability BI project (own elaboration)*
Committed management support and sponsorship	Top management commitment (Power and Gruner, 2015)
Clear vision and well-established business case	Requirements need to be clearly and fully elicited and articulated according to norms and specifications (Zhang, Lv, Xu & Mu, 2010)
Business-centric championship and balanced team composition	Stakeholders within and across supply chain need to collaborate in a balanced and efficient mode
Business-driven and iterative development approach	Cost-benefit analysis (Dabbene, Gay & Tortia, 2014) Risk analysis (Thakur, Martens & Hurburgh, 2011)
User-oriented change management	Stakeholder-oriented management (Pizzuti & Mirabelli, 2015)
Business-driven, scalable and flexible technical framework	Technical, semantic, organizational and legal interoperability (Ringsberg, 2015)
Sustainable data quality and integrity	Data uniformity and univocality impediments in various supply chain links
Overall business orientation approach	Supply chain and stakeholder-driven approach
Control factors	
Company size	Company size
Industry sector	Industry sector

Decision Making and Risk Analysis

Research on FT management is evidently ample. However, traceability requirements remain either ambiguous or narrow in scope. It is up to the organization to decide on the resources and capabilities of its traceability system depending on factors, such as the resources involved and the estimated level of the related risks. The information, when centrally gathered and coded in a single system connected to unique entities, can be extracted and used to meet both operational and analytical business requirements, supporting short- and long-term decision (Thakur, Martens & Hurburgh, 2011).

Furthermore, stochastic analysis is required in cases where a 100% traceability success rate is not technically feasible (Dabbene, Gay & Tortia, 2014), as when processing cattle to beef (Resende-Fihlo & Buhr, 2008; Wognum et al., 2011) or when aggregating grains. Under such conditions, a traceability system based on analytical considerations – within a BI framework, as this research claims – enables real time control on the data availability, provides fast access to information in the right time, allows interactive querying, facilitates the evaluation of risk probability and reduces information asymmetry, thus leading to improved allocation of economic value (Bevilacqua et al., 2009).

For instance, in the grain aggregation case, availability of historical data would allow managers to analyze the grain elevator handling practices and to define new procedures in order to optimize the logistics costs and to minimize the food safety risk by optimizing their blending practices (Thakur, Martens & Hurburgh, 2011). Furthermore, traceability data enable employees to make decisions by quantifying quality factors, and identifying needs for improved operating procedures and training for producers, processors, handlers, and other supply chain actors (Thakur et al., 2009) or to avoid food fraud, reduce off-season sales, and certify the total quality of the product (Pizzuti & Mirabelli, 2015). This way, traceability management may provide incentives for farmers, manufacturers and retailers to improve quality, safety and social responsibility.

CONCLUSION AND FUTURE RESEARCH DIRECTIONS

The work initiated in this paper opens a broad research line on the transdisciplinarity of food traceability and its associated perspectives. At this first exploratory stage the relative management disciplines and extant research in the field are discussed. From the managerial point of view, IMSs are highlighted as a possible route for improvement by offering efficient support to the decision makers dealing with various food traceability concerns. However, a highly complex IMS is needed to encompass the multiple management dimensions required. In addition, a huge amount of information from multiple sources and stakeholders has to be collected, stored, processed and disseminated in a wise and timely mode. In this context, BI solutions are emphasized as the most appropriate for the raised technical and managerial challenges to be addressed. Drawing on the latest food ontology unification efforts (Pizzuti et al., 2014) this research directs towards the holistic perspective of IMSs as a key interoperability factor for a BI platform that seems to emerge.

In this context, extant literature is reviewed to understand how regulatory authorities, NGOs, retailers and other stakeholder groups formalize their requirements and establish control mechanisms in terms of human health, animal welfare, environmental protection and consumers trust. It is shown that a variety of standards, guidelines, coding systems and certification schemes are available to cover different stakeholders' needs. Certain tailor-made solutions are devised, e.g. in the seed segregation case (Thakur & Hurburgh, 2009) where food safety, quality and food traceability standards requirements are adopted using integrated definition modeling (IDEF0). Furthermore, "intelligent traceability" is conceptualized to shift focus from the mere product origin to the chain design and the goods flow and turn the food chain into a dynamic and homogeneous system with centralized information that brings together technology and conceptual advancements (Badia-Melis, 2015). However, the lack of a unified decision support system with dedicated key performance indicators to capture, store and process data in a timely and universally recognized manner is highlighted as the main gap that needs to be filled. To address this gap, this research proposes the formation of a "responsible BI-wise IMS" to embrace all stakeholders requirements and streamline resources and capabilities for the management of food safety, quality, environment, corporate responsibility and sustainability across the food supply chain.

It is evidenced, that technical difficulties, such as the bulk commodities track and tracing, can be overcome. However, there are operational impediments that remain rigid. Managers, food industry practitioners, information and business analytics experts need to collaborate. To this end, common language, knowledge background and database structure are required along with a mutual understanding, sharing and agreeing upon certain social responsibility and sustainability concerns. Thus, a continuous, long-term exchange of valid, comprehensive information can be achieved across the entire food chain. This will provide support to effective and efficient corporate decision making in compliance with mandatory and voluntary specifications towards meeting the needs and expectations of multiple stakeholders.

Regrettably, it is found that, managers tend to reduce the use of standard-based information technologies for supply chain management mostly due to circumstantial, non-strategic selection criteria and therefore limited long-term benefits for the decision-makers (Power et al., 2015). To reverse this trend, this research illuminates a new perspective of information systems and management standards using a BI – IMS approach towards enabling their strategic and holistic joint adoption. However, there are certain limitations to be considered. First of all, case study analysis would deepen into the shortcomings of current traceability management approaches in real business settings. A within- and cross-case comparison would identify motives and reasons for improvement from a supply chain perspective. Another future research step would be the development of an IMS-based ontology and consolidated KPIs to be used and tested by food chain members.

REFERENCES

AccountAbility. (2015). AA1000 Stakeholder Engagement Standard - Revision for Public Comment.

Aggelogiannopoulos, D., Drossinos, H., & Athanasopoulos, P. (2007). Implementation of a quality management system according to the ISO 9000 family in a Greek small-sized winery: A case study. *Food Control*, *18*(9), 1077–1085. doi:10.1016/j.foodcont.2006.07.010

Aiello, G., Enea, M., & Muriana, C. (2015). The expected value of the traceability information. *European Journal of Operational Research*, *244*(1), 176–186. doi:10.1016/j.ejor.2015.01.028

Asif, M., Searchy, C., Zutshi, A., & Fisscher, O. A. M. (2013). An integrated management systems approach to corporate social responsibility. *Journal of Cleaner Production*, *56*, 7–17. doi:10.1016/j.jclepro.2011.10.034

Aung, M. M., & Chang, Y. S. (2014). Traceability in a food supply chain: Safety and quality perspectives. *Food Control*, *39*, 172–184. doi:10.1016/j.foodcont.2013.11.007

Badia-Melis, R., Mishra, P., & Ruiz-García, L. (2015). Food traceability: New trends and recent advances. *Food Control*, *57*, 393–401. doi:10.1016/j.foodcont.2015.05.005

Barata, J., & da Cunha, P. R. (2014). ISO2: A new breath for the joint development of IS and ISO 9001 management systems. In M. José Escalona et al. (Eds.), *Information System Development: Improving Enterprise Communication* (pp. 499–510). Switzerland: Springer International Publishing . doi:10.1007/978-3-319-07215-9_40

Barge, P., Gay, P., Merlino, V., & Tortia, C. (2014). Item-level Radio-Frequency IDentification for the traceability of food products: Application on a dairy product. *Journal of Food Engineering*, *125*, 119–130. doi:10.1016/j.jfoodeng.2013.10.019

Barling, D. (2008). Governing and governance in the agri-food sector and traceability. In C. Coff, D. Barling, M. Korthals, & T. Nielsen (Eds.), *Ethical traceability and communicating food* (pp. 167–191). Netherlands: Springer. doi:10.1007/978-1-4020-8524-6_3

Barnett, J., Begen, F., Howes, S., Regan, A., McConnon, A., Marcu, A., & Verbeke, W. et al. (2016). Consumers' confidence, reflections and response strategies following the horsemeat incident. *Food Control*, *59*, 721–730. doi:10.1016/j.foodcont.2015.06.021

Beekman, V. (2008). Consumer rights to food ethical traceability. In C. Coff, D. Barling, M. Korthals, & T. Nielsen (Eds.), *Ethical traceability and communicating food* (pp. 235–249). Netherlands: Springer. doi:10.1007/978-1-4020-8524-6_10

Bevilacqua, M., Ciarapica, F. E., & Giacchetta, G. (2009). Business process reengineering of a supply chain and a traceability system: Case study. *Journal of Food Engineering*, *93*(1), 13–22. doi:10.1016/j.jfoodeng.2008.12.020

Bosona, T., & Gebresenbet, G. (2013). Food traceability as an integral part of logistics management in food and agricultural supply chain. *Food Control*, *33*(1), 32–48. doi:10.1016/j.foodcont.2013.02.004

Botta, S., Comoglio, C., & Petrosillo, I. (2013). Implementing the environmental and social policies of a municipality through an integrated management system: Theoretical framework and case study. *Journal of Environmental Planning and Management*, *56*(7), 1073–1095. doi:10.1080/09640568.2012.743881

Bourlakis, M., & Bourlakis, C. (2006). Integrating logistics and information technology strategies for sustainable competitive advantage. *Journal of Enterprise Information Management*, *19*(4), 389–402. doi:10.1108/17410390610678313

Bourlakis, M., Maglaras, G., Gallear, D., & Fotopoulos, C. (2014). Examining sustainability performance in the supply chain: The case of the Greek dairy sector. *Industrial Marketing Management*, *43*(1), 56–66. doi:10.1016/j.indmarman.2013.08.002

Britos, P., Dieste, O., & Garcia-Martinez, R. (2008). Requirement elicitation in data mining for business intelligence projects. *Advances in Information Systems Research, Education and Practice*. IFIP – The International Federation for Information Processing 274, 139-150

Burnay C., Jureta, I., Linden, I., & Faulkner S. (2014). A framework for the operationalization of monitoring in business intelligence requirements engineering. *Software and System Modeling*, June.

Chaudhuri, S., Dayal, U., & Narasayya, V. (2011). An overview of business intelligence technology. *Communications of the ACM*, *54*(8), 88–98. doi:10.1145/1978542.1978562

Chen, C., Zhang, J., & Delaurentis, T. (2014). Quality control in food supply chain management: An analytical model and case study of the adulterated milk incident in China. *International Journal of Production Economics*, *152*, 188–199. doi:10.1016/j.ijpe.2013.12.016

Chrysochou, P., Chryssochoidis, G., & Kehagia, O. (2009). Traceability information carriers. The technology backgrounds and consumers' perceptions of the technological solutions. *Appetite*, *53*(3), 322–331. doi:10.1016/j.appet.2009.07.011 PMID:19631704

Crowder, M. (2013). Quality standards: Integration within a bereavement environment. *The TQM Journal*, *25*(1), 18–28. doi:10.1108/17542731311286405

Dabbene, F., & Gay, P. (2011). Food traceability systems: Performance evaluation and optimization. *Computers and Electronics in Agriculture*, *75*(1), 139–146. doi:10.1016/j.compag.2010.10.009

Daly, M., & Adam, F. (2011). Understanding organisational decision support maturity: Case studies of Irish organisations. *International Journal of Decision Support System Technology*, *3*(2), 57–77. doi:10.4018/jdsst.2011040105

Efstratiadis, M. M., & Arvanitoyannis, I. S. (2000). Implementation of HACCP to large scale production line of Greek ouzo and brandy: A case study. *Food Control*, *11*(1), 19–30. doi:10.1016/S0956-7135(99)00053-5

Fresner, J., & Engelhardt, G. (2004). Experiences with integrated management systems for two small companies in Austria. *Journal of Cleaner Production*, *12*(6), 623–631. doi:10.1016/j.jclepro.2003.09.013

Gianni, M., & Gotzamani, K. (2016). Integrated management systems and information management systems: Common threads. In P. Papajorgji, F. Pinet, A. M. Guimarães, & J. Papathanasiou (Eds.), Automated Enterprise Systems for maximizing Business Performance (pp. 195–214). Hershey, PA, USA: IGI Global. doi:10.4018/978-1-4666-8841-4.ch011

Gianni, M., Gotzamani, K., & Vouzas, F. (2014, September 14-16). Integrated management systems in the food sector: Insights from a dairy plant. *Proceedings of the1st International Conference on Quality Engineering and Management*, Guimarãez, Portugal (pp. 303-314).

Grimm, J. H., Hofstetter, J. S., & Sarkis, J. (2014). Critical factors for sub-supplier management: A sustainable food supply chains perspective. *International Journal of Production Economics*, *152*, 159–173. doi:10.1016/j.ijpe.2013.12.011

Halkier, B., & Holm, L. (2006). Shifting responsibilities for food safety in Europe: An introduction. *Appetite*, *47*(2), 127–133. doi:10.1016/j.appet.2006.05.004 PMID:16793171

Hoorfar, J., Wagner, M., Jordan, K., & Barker, G. C. (2011). 17 - Biotracing: a novel concept in food safety integrating microbiology knowledge, complex systems approaches and probabilistic modelling. In S. Brul, P. M. Fratamico, & T. A. McMeekin (Eds.), *Tracing Pathogens in the Food Chain* (pp. 377–390). Woodhead Publishing Series in Food Science, Technology and Nutrition. doi:10.1533/9780857090508.3.377

Howson, C. (2008). *Successful business intelligence: Secrets to making BI a killer app*. McGraw-Hill.

Hoy, Z., & Foley, A. (2015). A structured approach to integrating audits to create organisational efficiencies: ISO 9001 and ISO 27001 audits. *Total Quality Management & Business Excellence*, *26*(5-6), 690–702. doi:10.1080/14783363.2013.876181

Inmon, W. H. (1992). *Building the Data Warehouse* (1st ed.). Wiley.

ISO. (2010). *ISO 26000 – Guidance on social responsibility*. Geneva: International Organization for Standardization.

Ivanova, A., Gray, J., & Sinha, K. (2014). Towards a unifying theory of management standard implementation. *International Journal of Operations & Production Management*, *34*(10), 1269–1306. doi:10.1108/IJOPM-03-2013-0117

Jankovic, M., Zaraté, P., Bocquet, J.-C., & Le Cardinal, J. (2009). Collaborative decision making: Complementary developments of a model and an architecture as a tool support. *International Journal of Decision Support System Technology*, *1*(1), 35–45. doi:10.4018/jdsst.2009010103

Jin, S., & Zhou, L. (2014). Consumer interest in information provided by food traceability systems in Japan. *Food Quality and Preference*, *36*, 144–152. doi:10.1016/j.foodqual.2014.04.005

Karapetrovic, S., & Casadesús, M. (2009). Implementing environmental with other standardized management systems: Scope, sequence, time and integration. *Journal of Cleaner Production*, *17*(5), 533–540. doi:10.1016/j.jclepro.2008.09.006

Karlsen, K. M., Dreyer, B., Olsen, P., & Elvevoll, E. O. (2013). Literature review: Does a common theoretical framework to implement food traceability exist? *Food Control*, *32*(2), 409–417. doi:10.1016/j.foodcont.2012.12.011

Kimball, R. (1996). *The data warehouse toolkit* (1st ed.). Wiley.

Liu, S., Moizer, J., Subramaniam, P., Leat, M., & Linden, I. (2010). Decision support for ERP-based production management: a business intelligence perspective.*Proceedings of the 15th IFIP WG8.3 International Conference on Decision Support Systems.*

Manos, B., & Manikas, I. (2010). Traceability in the Greek fresh produce sector: Drivers and constraints. *British Food Journal*, *112*(6), 640–652. doi:10.1108/00070701011052727

Martins, C., Bulkan, A., & Klempt, P. (2011). Security excellence from a total quality management approach. *Total Quality Management & Business Excellence*, *22*(3), 345–371. doi:10.1080/14783363.2010.545556

Mesquida, A.-L., & Mas, A. (2015). Integrating IT service management requirements into the organizational management system. *Computer Standards & Interfaces*, *37*, 80–91. doi:10.1016/j.csi.2014.06.005

Mungree, D., Rudra, A., & Morien, D. (2013, August 15-17). A framework for understanding the critical success factors of enterprise business intelligence implementation.*Proceedings of the Nineteenth Americas Conference on Information Systems*, Chicago, Illinois.

Pizzuti, T., & Mirabelli, G. (2015). The global Track&Trace System for food: General framework and functioning principles. *Journal of Food Engineering*, *159*, 16–35. doi:10.1016/j.jfoodeng.2015.03.001

Pizzuti, T., Mirabelli, G., Sanz-Bobi, M. A., & Goméz-Gonzaléz, F. (2014). Food Track & Trace ontology for helping the food traceability control. *Journal of Food Engineering*, *120*, 17–30. doi:10.1016/j.jfoodeng.2013.07.017

Power, D., & Gruner, R. L. (2015). Exploring reduced global standards-based interorganizational information technology adoption. *International Journal of Operations & Production Management*, *35*(11), 1488–1511. doi:10.1108/IJOPM-01-2013-0016

Proto, M., Malandrino, O., & Supino, S. (2013). The implementation of integrated management system in Agri-Food SMEs. In Salomone, R. et al. (eds.), Product-Oriented Environmental Management Systems (POEMS) (pp. 89-101). Dordrecht: Springer Science+Business Media. doi:10.1007/978-94-007-6116-2_4

Renzi, M. F., & Cappelli, L. (2000). Integration between ISO 9000 and ISO 14000: Opportunities and limits. *Total Quality Management*, *11*(4-6), 849–856. doi:10.1080/09544120050008318

Resende-Filho, M. A., & Buhr, B. L. (2008). A principal-agent model for evaluating the economic value of traceability system: A case study with injection-site lesion control in fed cattle. *American Journal of Agricultural Economics*, *90*(4), 1091–1102. doi:10.1111/j.1467-8276.2008.01150.x

Resende-Filho, M. A., & Hurley, T. M. (2012). Information asymmetry and traceability incentives for food safety. *International Journal of Production Economics*, *139*(2), 596–603. doi:10.1016/j.ijpe.2012.05.034

Ringsberg, H. (2014). Perspectives on food traceability: A systematic literature review. *Supply Chain Management: An International Journal*, *19*(5/6), 558–576. doi:10.1108/SCM-01-2014-0026

Ringsberg, H. A. (2015). Implementation of global traceability standards: Incentives and opportunities. *British Food Journal*, *117*(7), 1826–1842. doi:10.1108/BFJ-10-2014-0353

Russell, S., Forgionne, G., & Yoon, V. (2009). Decision support-related resource presence and availability awareness for DSS in pervasive computing environments. *International Journal of Decision Support System Technology*, *1*(1), 15–34. doi:10.4018/jdsst.2009010102

Satolo, E. G., Calarge, F. A., & Cauchick Miguel, P. A. (2013). Experience with an integrated management system in a sugar and ethanol manufacturing unit: Possibilities and Limitations. *Management of Environmental Quality: An International Journal*, *24*(6), 710–725. doi:10.1108/MEQ-10-2012-0068

Savino, M. M., & Batbaatar, E. (2015). Investigating the resources for integrated management systems within resource-based and contingency perspective in manufacturing firms. *Journal of Cleaner Production*, *104*, 392–402. doi:10.1016/j.jclepro.2015.04.115

Storøy, J., Thakur, M., & Olsen, P. (2013). The TraceFood Framework – Principles and guidelines for implementing traceability in food value chains. *Journal of Food Engineering*, *115*(1), 41–48. doi:10.1016/j.jfoodeng.2012.09.018

Tang, Q., Li, J., Sun, M., Lv, J., Gai, R., Mei, L., & Xu, L. (2015). Food traceability systems in China: The current status of and future perspectives on food supply chain databases, legal support, and technological research and support for food safety regulation. *BioScience Trends*, *9*(1), 7–15. doi:10.5582/bst.2015.01004 PMID:25787905

Terlaak, A., & King, A. A. (2006). The effect of certification with the ISO 9000 quality management standard: A signaling approach. *Journal of Economic Behavior & Organization*, *60*(4), 579–602. doi:10.1016/j.jebo.2004.09.012

Thakur, M., & Hurburgh, C. R. (2009). Framework for implementing traceability system in the bulk grain supply chain. *Journal of Food Engineering*, *95*(4), 617–626. doi:10.1016/j.jfoodeng.2009.06.028

Thakur, M., Martens, B. J., & Hurburgh, C. R. (2011). Data modeling to facilitate internal traceability at a grain elevator. *Computers and Electronics in Agriculture*, *75*(2), 327–336. doi:10.1016/j.compag.2010.12.010

Thakur, M., Mosher, G.A., Brown, B.R., Bennet, G.S. Shepherd, H.E. & Hurburgh, C.R. (2009). Traceability in the bulk grain supply chain. Food safety series, *Resource, April/May*: 20-22.

Trienekens, J. H., Wognum, P. M., Beulens, A. J. M., & van der Vorst, J. G. A. J. (2012). Transparency in complex dynamic food supply chains. *Advanced Engineering Informatics*, *26*(1), 55–65. doi:10.1016/j.aei.2011.07.007

Vassiliou, A., Kabourakis, E., & Papadopoulos, D. (2008). Traceability and ethical traceability in the Greek olive oil chain. In C. Coff, D. Barling, M. Korthals, & T. Nielsen (Eds.), *Ethical traceability and communicating food* (pp. 167–191). Netherlands: Springer. doi:10.1007/978-1-4020-8524-6_7

Weyandt, A. J., da Costa, S. R. R., Nunes, M. L., & Gaspar, A. (2012). Social responsibility of fish processing companies located in Portugal and Spain. *Social Responsibility Journal*, *8*(1), 100–113. doi:10.1108/17471111211196601

Wognum, P. M., Bremmers, H., Trienekens, J. H., van der Vorst, J. G. A. J., & Bloemhof, J. M. (2011). Systems for sustainability and transparency of food supply chains – Current status and challenges. *Advanced Engineering Informatics*, *25*(1), 65–76. doi:10.1016/j.aei.2010.06.001

Wong, C. Y., Wong, C. W. Y., & Boon-itt, S. (2015). Integrating environmental management into supply chains. *International Journal of Physical Distribution & Logistics Management*, *45*(1/2), 43–68. doi:10.1108/IJPDLM-05-2013-0110

Xiao, X., Fu, Z., Qi, L., Mira, T., & Zhang, X. (2015). Development and evaluation of an intelligent traceability system for frozen tilapia fillet processing. *Journal of the Science of Food and Agriculture*, *95*(13), 2693–2703. doi:10.1002/jsfa.7005 PMID:25408190

Yeoh, W., & Koronios, A. (2010). Critical success factors for business intelligence Systems. *Journal of Computer Information Systems*, *50*(3), 23–32.

Yeoh, W., & Popovič, A. (2015). Extending the understanding of critical success factors for implementing business intelligence systems. *Journal of the Association for Information Science and Technology*. DOI: .10.1002/asi.23366

Zhang, X., Lv, S., Xu, M., & Mu, W. (2010). Applying evolutionary prototyping model for eliciting system requirement of meat traceability at agribusiness level. *Food Control*, *21*(1), 1556–1562. doi:10.1016/j.foodcont.2010.03.020

Zu, X., & Kaynak, H. (2012). An agency theory perspective on supply chain quality management. *International Journal of Operations & Production Management*, *32*(4), 423–446. doi:10.1108/01443571211223086