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Mobile Technology for Supply Chain Management: The Case of a Brazilian Beef Chain

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MOBILE TECHNOLOGY FOR SUPPLY CHAIN MANAGEMENT: THE CASE OF A BRAZILIAN BEEF CHAIN

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Abstract

The use of mobile technologies is important for Supply Chain Management (SCM) because these technologies allow for the ubiquitous flow of information, higher agility and risk reduction in supply chains. These issues are particularly relevant to avoid food safety risks in global food chains. The main goal of this paper is to analyse the diffusion of mobile technology for management and risk control in the Brazilian beef supply chain, since Brazil is one of the main producers and beef exporters in the world. The research method was a single case study in the beef chain of the state of Goias (one of Brazil's main beef producers). Results show the actual level of mobile technology use and the main elements that affect the diffusion of mobile technology in the supply chain studied.

Key Words: Mobile Technology Diffusion, Mobile Supply Chain Management, Risk, Beef Chain

1 Introduction

Mobile technology is everywhere and its extensive use, together with wireless networks and other technologies, such as Radio Frequency Identification (RFID) and Global Positioning System (GPS), has spawned new concepts such as mobile business and enterprise mobility (Basole, 2008; Sorensen, 2011). Mobile Supply Chain Management (m-SCM), for instance, is gaining recognition for cost reduction and performance improvement (Eng, 2006). Through m-SCM firms can promptly identify and meet customers' needs, obtain processes and product traceability, operational efficiency and agility along the chain (Tseng et al., 2011; Ngai et al., 2011, p. 233; Chan & Chong, 2013).

Despite the interest of managers about this subject, there is still little research on m-SCM from a management perspective, rather than only a technology one (Salo, 2012). Studies about the use of mobile technologies for SCM in developing countries are even scarcer, despite the growing importance of these countries for global economy. In food markets, this issue is particularly relevant because operations of several firms have increased food safety risks to global food chains (Manning & Baines, 2004) and developing countries are important as global food suppliers (Roth et al., 2011).

Services provision via mobile technology can have a greater importance for developing countries, especially for poor communities and people in rural areas, than for developed countries. This happens as developed countries tend to have other options of services provision (e.g. via fixed phones/computers). Therefore, unique, creative, innovative and effective solutions can be locally created using mobile technology to improve people´s life conditions and to strengthen local economies (Ngugi et al., 2010). On the other hand, it is necessary to consider the challenges of ICT and mobile technology adoption in developing countries, such as unreliable and inadequate technology infrastructure, highly volatile political environments and lack of public regulation and funding for ICT investments (Yayla & Hu, 2012; Billon et al., 2009). Demographic factors such as population size and/or density, can also affect the diffusion of ICT/mobile technology. Other barriers are the lack of management culture of IT use and IT education, training and literacy.

The main goal of this article is to analyse the use of mobile technology for management and risk control in a Brazilian beef supply chain, since Brazil is one of the world's largest beef producers and exporters (USDA, 2012). We address the following research questions: (1) What is the level of mobile technology use in this chain? (2) How mobile technology has been applied to beef traceability and risk reduction throughout the chain? (3) What are the elements that affect mobile technology diffusion in this chain?

This article is structured as follows: section 2 presents the research literature review; section 3 presents the method; section 4 shows the research results and section 5 presents discussions and final remarks.

2 Theoretical Background and Literature review

Supply Chain Management (SCM), can be defined as an effective coordination on material, product, delivery, payment, and information flows between enterprises and trading partners (Wu et al., 2010). Mobile SCM (mSCM), is the use of mobile applications and devices to support supply chain activities, and ultimately to help firms to achieve cost reductions, supply chain responsiveness and competitive advantage (Eng, 2006; Chan & Chong, 2013).

Within the supply chain, mobile technologies can be used to enhance information quality and speed between buyers and suppliers, sharing accurate information in real time, in order to reduce information delays and distortions about demand (Lee et al., 2004; Fawcett et al, 2011). These technologies support decision makers in promptly respond to market needs (Siau & Shen, 2002, Wang et al., 2011) as well as reduce thefts, pilferage, transportation damage and other losses in the chain (Salmela et al. 2010).

More specifically, RFID can be used to integrate software applications with mobile devices, reducing information gaps, delivering more information to the end customer, reducing inventory losses, increasing efficiency and agility in SCM processes (Angeles, 2005; Chen & Pai, 2008; Sarac & Absi,

2010; Zhu et al., 2012; Tzeng et al., 2008). For example, RFID becomes an important technology for agriculture, cattle, and food production because it allows for animal traceability (Attaran, 2007).

Mobile technology can be applied to reduce supply chain risks, which can be defined as the probability that an event occurs along the supply chain either because of failures by individual suppliers, or because of hazards, such as an outbreak of disease, natural catastrophes or terrorism. These risks create problems for companies to produce and meet their demands (Hendricks & Singhal, 2005; Kleindorfer & Saad, 2005). Many factors are related to supply chain risk, such as natural and unplanned catastrophes (Knemeyer et al., 2009), preventive maintenance (Johnson, 2000), firm's operational characteristics (e.g. supply delays and machine breakdowns) (Tomlin, 2006), and supply chain characteristics (Choi & Krause, 2006; Zsidisin & Ellram, 2003; Zsidisin & Smith, 2005). In the food supply chain, Roth et al. (2008) call attention to the risk of contamination spread throughout the chain.

However, mobile technology by itself does not improve SCM. Many organisations have failed to obtain a better supply chain performance despite their ICT investments (Fawcett et al., 2011). ICT applications in SCM depend on set of infrastructural, social, and economical elements. Investments in long-term infrastructures for supply chain integration can be costly and involve different members of the chain. In many industries, though, there is lack of trust between business partners and resistance to share information (Archer et al., 2008; Power et al., 2010; Fawcett et al., 2011). For example, Balloco et al. (2011) assert that despite the numerous studies illustrating the RFID benefits in the in the fast moving consumer goods supply chain, the technology is not yet adopted by most of the companies.

Therefore, it is important to understand the elements that influence the diffusion of mobile technologies in a supply chain. These technologies have the potential to improve and help to create new forms of Inter Organizational Systems (IOS), which can be defined as information and communication technology-based systems that transcend legal enterprise boundaries (Kumar & Van Dissel, 1996).

Traditionally, the literature on IOS focused on rational and economic reasons that motivate its adoption, (e.g.: economies of scale, specialization). However, several studies show that other aspects, such as technological adequacy, political and socio cultural elements also influence IOS diffusion (Kumar & Van Dissel, 1996; Kumar & Crook, 1999, Damsgaard & Lyytinen, 1998; Chwelos et al., 2001; Teo et al., 2003; Chang & Chen, 2008; Chan & Chong, 2013). Damsgaard & Lyytinen (1998) emphasize that IOS adoption involves two or more independent adopters and the involvement of several other actors, like standard setters, service providers, software houses etc. Therefore, the whole network of adopting actors and their dynamic behaviour over time should be the unit of analysis, not individual adopters. Following this rationale, three levels of analysis of IOS adoption must be considered simultaneously: a micro level (individual firms), a meso level (industry) and a macro level (national or intergovernmental regulatory regimes). This study follows this perspective.

Chang & Chen (2008) identified a set of variables in the literature that help to understand the process of RFID adoption. These variables are related to (1) industry environment, (2) organization and (3) innovation of technology. Chan & Chong (2013) studied mobile SCM diffusion considering four types of factors: technological, organizational, environmental and interorganizational. These factors influence different stages of m-SCM diffusion (evaluation, adoption and routinisation). All these references are considered to analyse the elements that can affect the diffusion of mobile technologies for SCM and they are summarized in Table 1.

Focus	**Elements**	**References**
Micro level of analysis		
Organization	Organizational scale (number of employees)	Chang & Chen (2008), Chan & Chong (2013)
	Product complexity and product volume and frequency	Bensaou & Venkatraman (1995), Chong et al. (2009)
	Organizational IT infrastructure and maturity, IT competence	Chwelos et al., (2001), Bensaou & Venkatraman (1995), Chang & Chen (2008), Chan & Chong (2013)

	Burden of cost to the firm to implement the new technology, financial resources available to invest in technology	Chwelos et al., (2001), Chang & Chen (2008), Chan & Chong (2013)
	SCM strategy definition and integration with organizational strategy	Chang & Chen (2008)
	Support and participation of top executives in the adoption process	Chwelos et al., (2001), Chang & Chen (2008), Chan & Chong (2013)
Meso level of analysis		
Industry environment	Level of uncertainty/change of environment	Bensaou & Venkatraman (1995), Kumar & Van Dissel (1996), Chang & Chen (2008)
	Degree of competition in the marketplace and market requirements	Chang & Chen (2008), Chan & Chong (2013)
	Expectation of market trends	Chwelos et al., (2001), Chan & Chong (2013)
	Pressure of transaction partners to adopt the technology	Chwelos et al., (2001), Teo et al., (2003), Chang & Chen (2008), Chan & Chong (2013)
	Suppliers´ of technology characteristics (experience in the industry, knowledge, training capacity, reputation).	Chang & Chen (2008)
Inter Organizational relations	Trust between business transaction partners	Bensaou & Venkatraman (1995), Chong et al. (2009), Balloco et al. (2011), Chan & Chong (2013)
	Collaboration among business transaction partners	Bensaou & Venkatraman (1995), Damsgaard & Lyytinen, (1998), Chan & Chong (2013)
	Information sharing among business transaction partners	Chan & Chong (2013)
	Transaction partner´s power, dependency on the transaction partner	Damsgaard & Lyytinen, (1998), Chwelos et al., (2001), Teo et al., (2003), Chan & Chong (2013)
Technology features	Technology's degree of maturity	Chang & Chen (2008)
	Complexity of technology	Chang & Chen (2008), Chan & Chong (2013)
	Compatibility/integration with other technologies used in the industry	Chang & Chen (2008), Chan & Chong (2013)
	Perceived costs of technology	Kumar & Van Dissel (1996), Chan & Chong (2013), Balloco et al. (2011)
	Perceived benefits of technology (e.g.: cost reduction, SCM improvements, efficacy, efficiency gains)	Kumar & Van Dissel (1996), Chwelos et al., (2001), Chang & Chen (2008), Balloco et al. (2011), Chan & Chong (2013)
	Perceived problems for technology use (reliability, privacy issues, etc.)	Chang & Chen (2008), Chan & Chong (2013)
Macro level of analysis		
Technology infrastructure	Dependence of advanced/public infrastructure for technology use	Damsgaard & Lyytinen, (1998)
Standards	Clear and mutual standards for technology use	Damsgaard & Lyytinen, (1998), Chang & Chen (2008)
Governmental regulations	Regulatory regimes, norms and laws related to technology use	Damsgaard & Lyytinen, (1998), Teo et al., (2003)

Table 1. Elements that can affect the diffusion of mobile technologies for SCM

3 Method

The research adopted a qualitative approach (Silverman, 2001), with a single case study with embedded units of analysis. The case uses the criterion of typicality (Yin, 2009) to study the use of mobile technology for SCM, since the beef chain is heterogeneous, geographically dispersed and has a high level of risk related to food safety. The main unit of analysis was the beef chain in the state of Goias

(Brazil), which is the one of the largest beef producer in the country. The embedded units of analysis are the supply chain members: producers (breeders, raisers and fatteners), slaughterhouses and traders.

The research method was divided into two phases: (1) exploratory and (2) descriptive. The exploratory stage (Creswell, 2003) was conducted in two main steps. The first step included an extensive review of the literature and analysis of secondary data about the supply chain studied. The second step involved interviews with three companies that provide ICT and mobile solutions to the beef chain analysed, as well as interviews with three managers from beef industry associations and two traceability certifiers. Eight (8) people were interviewed in total.

After the exploratory phase of research, a case study protocol (Yin, 2009) was created for the next step (descriptive). The case protocol was created based on the literature review and on the data collected in the exploratory phase, taking into account the unique aspects of the context studied. This protocol was validated by two academic experts and a practitioner who works in the beef chain analysed.

The descriptive phase was conducted based on semi-structured interviews and field observation. Firms representing each tier of the beef supply chain were analysed. They were selected based on the following criteria: (1) producers had to be registered in the Brazilian information system for beef traceability (SISBOV); (2) the slaughterhouse had to be a beef exporter (in which case beef traceability is mandatory). Nine producers were interviewed; the JBS Company was interviewed as the slaughterhouse chain agent, and a manager from JBS Global (United Kingdom) was interviewed as the trader chain agent. This is because JBS is the largest company in processed animal protein in the world.

The data analysis followed Creswell´s (2003) and Miles & Humberman´s (1994) qualitative data analysis steps. Data were organized by type of supply chain agent (embedded units of analysis). The content of interviews was analysed by open codification (Strauss & Corbin, 1998). A synthesis of results was done for each one of the supply chain agents and, finally, general results were generated considering all the agents in the supply chain and the similarities and differences between their points of view.

4 Research findings

4.1 Supply chain features and the traceability system used

First, the research results point out that the relations among beef supply chain members are characterized by a lack of integration, trust and collaboration. Slaughterhouses are the strongest member in this chain as they control the market and set the prices. However, the coordination is not clear and opportunistic behaviour prevails among its members.

Food safety control is one of the main issues concerning risk in the beef supply chain. Cattle must be tracked in order to guarantee good quality beef and to monitor diseases outbreaks. In Brazil, the SISBOV (Brazilian Information System for Beef Traceability) was created by the government in 2002, and improved in 2006 (MAPA, 2012). Compliance with SISBOV is not mandatory for all producers, only for those that export beef, because their clients require such compliance. In that case, all members need to adopt the system during all production phases. In order to join the system, companies accredited by MAPA (the Brazilian Ministry of Agriculture, Livestock and Supply) must certify the producers.

Historically in Brazil, cattle have been tracked by fire branding a number on the animal's hide, but traceability tools have evolved to the use of ear tags (with numbers and barcodes), rumen bolus microchips monitored by wireless readers, and buttons and ear tags with RFID tags. However, MAPA does not consider rumen bolus microchips or RFID tags as reliable devices for cattle traceability. Therefore, even if using these devices, the use of bar code ear tags is mandatory. According to SISBOV, all cattle and buffalo must be individually registered in a national database, along with all the inputs used in the production processes. Each animal is identified with a unique 15-digit number, and the producer can choose the method of double identification to be fixed on each animal: a standard ear tag and button; an ear tag or a badge and an electronic device; a standard ear tag in one ear and a tattoo on the other; an ear tag and fire branding; a single device with visual and

electronic identification. The producer can choose to adopt only a standard ear tag, but if the animal loses such tag, the traceability is lost.

Souza-Monteiro & Caswell (2004) analysed the main countries involved in beef trade. Developed countries, such as the EU countries and Japan, have mandatory traceability that links information on the origin of the animal to the retail store inserting bar codes in the label. In developing countries (including Argentina and Brazil), traceability is mandatory only for beef export. However, large retailers have been requiring that their food suppliers use a traceability system. Countries such as the US, Canada, Australia, Japan and EU countries use RFID to assure beef quality and risk control (Ribeiro et al., 2010). In the EU system, Automatic Identification and Data Capture (AIDC) is the way to provide accurate information from "farm-to-fork" (Schwagele, 2005; Schroeder & Tonsor, 2012).

Therefore, when compared with other countries, Brazil presents some unique features. It is the world´s leading beef producer and exporter but has a voluntary traceability system. Producers and slaughterhouses have an alternative domestic market for beef commercialization, because the income of Brazilians have been growing. For the domestic market, the costs of using technology to trace back are unnecessary. Compliance with traceability is only an international market requirement.

All the data collected in the case study, and the analysis of secondary data, led to the identification of the following problems in the Brazilian beef traceability system, centred on SISBOV:

- High costs and excess bureaucracy to join the system (certifications, cattle control, etc.). There is a set of documents that must be filled out and checked during animal handling and transportation. Most of these documents are filled manually (increasing the risk of errors) or are not properly checked during the transporting of animals from one agent to another.
- There is a lack of basic infrastructure (computers, information systems and vehicles) at the government checkpoints, responsible for auditing the application of SISBOV and all the traceability processes and requirements.
- There is no culture or awareness about the importance of traceability by the ranchers.

The lack of trust makes some producers that export their production ignore the traceability processes done by the previous agents in the supply chain, and makes them put animals in quarantine in their own property/facility to guarantee food safety. In this case, such producers have the traceability costs and additional costs to safeguard animals in quarantine. In addition, every time a producer buys animals from another producer, the animals need to receive new ear tags.

4.2 Mobile Technology use in the supply chain

First, it is important to highlight that all interviewees (from the different chain activities/tiers) associated technology in their industry with management and cattle handling techniques, nutrition techniques, knowledge of pasture irrigation, feedlots and breeding technologies. They did not associate technology with any type of Information Technology (IT). IT and mobile technologies are not considered as a priority in this supply chain. Despite this view, mobile technologies are used, including laptops, cell phones, radios, barcode readers and GPS (Table 2).

Technology	Users	Supply chain agent	Technology applied to...
Electronic buttons (with RFID)	3	Producer	Traceability international regulation
Testing RFID ear tags	2	Producer	Traceability international regulation
Application of RFID tags	2	Producer	Record food supplies
Ear tags with barcodes	7	Producer	Traceability international regulation
GPS	4 1	Producers Certifiers	Harvesting and land control Referencing ranches to SISBOV
Pocket PC with mobile web IS	1	Slaughterhouse	Production control

Table 2. Technologies used in the beef supply chain

Mobile phones and laptops are the mobile devices most often used. Four ranches use GPS in their production processes, for tractor route control, seeding, and fertilizing to indicate the mowed area. Certifications companies use GPS for georeferencing properties. The collected data are forwarded to MAPA, checked and updated during auditing. The slaughterhouse (JBS) applies pocket PCs with web information systems access to production control inside its facilities and uses a mobile ERP. At the end of the supply chain, which is the beef trader, there are no specific mobile solutions for business operations or transactions.

In some agents in the chain, mobile technology is applied more intensively than in others. For instance, in the case of fatteners, all producers interviewed were well versed in terms of ICT/mobile applications use. This can be explained by the fact that this agent is the closest to the slaughterhouses.

Among the key drivers for mobile technology adoption in the supply chain are the premium prices paid for tracked animals, the traceability required for beef exportation and SISBOV monitoring. Only one producer cited the need for control and individual interest as main drivers for mobile technology adoption. However, companies that deployed mobile technology in order to get premium prices and meet export requirements recognize the benefits of using it for management control and processes improvements. The benefits cited were: better financial/cost control, better inventory control, higher professionalism in rancher's management, better purchase forecast, better production control (e.g.: animal's weight, life cycle, cost, etc.), faster information for decision making, better information quality, productivity gains in animal handling, increased management control, animal traceability and productivity gains in storage and loading. It is important to note that none of the interviewees mentioned the supply chain integration as a benefit of mobile technology adoption, since it is not used for this purpose. Only one rancher said he exchanges information with a slaughterhouse, via e-mail.

There are several barriers and limitations in mobile technology adoption, especially when considering the reality of producers (ranchers). First, the Brazilian telecommunications network and the electric energy supply infrastructure are precarious in rural areas, especially in the state of Goias, which is far from the main industrial region of the country. Internet connection and cell phone networks are unavailable or unstable in some spots, with narrow bandwidth. The Internet connection speed and quality are not adequate for online operations. The electric energy supply infrastructure is fragile. For instance, lightning bolts occur frequently in the countryside, causing power outages and damage to electronic devices.

There are also insufficient enterprise information systems for management to enable it to integrate management processes with cattle traceability control. There are few information systems and mobile technology suppliers familiar with the unique aspects of beef production. The few specialized suppliers have difficulty in providing support, since most ranches are located far from the main cities of Goias, where IT/mobile technology suppliers are located. The physical conditions on ranches are also inadequate for mobile technology use. Devices such as RFID tags and buttons, RFID readers and laptops can be damaged when they are exposed to rain, dirt, animal manure, etc. during fieldwork.

In addition to these technological and physical barriers, there are important social factors affecting technology use. The labour force on ranches is unskilled. According to the last agricultural census in Brazil, only 19% of people working in agriculture have completed elementary school (IBGE, 2006). This low educational level influences the level of technical knowledge applied in rural properties. According to the interviewees, there is also a lack of management culture for IT use and awareness about the value of accurate information systems for ranch management. Conservatism and traditionalism are also cited as major impediments in spreading IT/mobile technology use. However, new generations are taking control of the properties and bringing these technologies to management processes.

The slaughterhouse link in the chain also poses some barriers to mobile technology adoption. It is important to take into account usability issues faced by slaughterhouse workers with regard to mobile information systems. Usually they work on a moving production line inside cold rooms with poor lighting and excessive noise, and there is also humidity and high temperatures in the slaughter room.

5 Discussion and conclusions

After describing the case, we discuss our research results, considering different levels of analysis and the elements that can affect the diffusion of mobile technology for SCM indicated in the literature review (see Table 1).

At the micro level of analysis (organizational), the firms in the supply chain (in general) have a lack of organizational maturity in IT and mobile technology use. IT is not considered as a priority. There is no clear SCM strategy in the firms and there is a lack of management culture for IT use, as well as conservatism and traditionalism, especially by ranch managers. The costs of technology use for traceability are considered high and have to be paid only by the producers. Despite that, the individual firms in the supply chain use mobile technologies such as mobile phones, laptops, and some of them use GPS applications and RFID. Firms that deploy mobile technology recognize the benefits of using it for management control and processes improvements, but they do not recognize its benefits for SCM.

At the meso level of analysis (industry), we can see that only buyers in some foreign markets (developed countries) demand traceability. The domestic market in Brazil is rising and do not requires traceability, therefore the pressure for technology adoption for this purpose is low. The opportunistic behaviour of supply chain members and the lack of trust, collaboration and information sharing among them reduce the beef supply chain's competitiveness. Power is concentrated in the slaughterhouses but they do not develop their suppliers or share the costs of technology use for traceability. There is also a lack of technical support and specialized knowledge from the mobile/IT technology suppliers.

Finally, at a macro level of analysis, the lack of reliable, basic technological infrastructure (e.g. telecommunications and electrical energy supply) strongly affects the diffusion of mobile technology in the beef supply chain. There are huge disparities in investments in technology infrastructure between the urban and rural areas in Brazil, which may prevent the sustainability of beef (and food) production and export in the long term. Brazil is one of the largest countries in the world; therefore the coverage provided by telecommunication carriers is limited. The labour force in the rural areas of the country is unskilled, which also generates difficulties for technology diffusion. In addition, the national traceability system is not mandatory for all and does not apply mobile technology.

Our finding are summarized at Table 3. In this table, we highlight in gray the most important elements identified according to the evidences from the case studied.

Focus	**Elements**	**Evidences in the case studied**
Micro level of analysis		
Organization	Organizational IT infrastructure and maturity, IT competence	• IT is not intensively spread or valued by the firms
	Burden of cost to the firm to implement the new technology	• Cost of technology for traceability is high compared to the premium price for using it and has to be assumed only by the producers
	SCM strategy definition and integration with organizational strategy	• There is no clear SCM strategy
	Support of top executives	• Lack of management culture of IT use • Conservatism and traditionalism
Meso level of analysis		
Industry environment	Degree of competition in the marketplace and market requirements	• The domestic market in Brazil is increasing and do not requires traceability; only buyers from developed countries demand traceability, there is no pressure to adopt mobile technology for SCM
	Suppliers´ of technology characteristics	• Lack of IT technical support due to large distances • IT/mobile technology suppliers are not familiar with the need of ranchers/producers

Inter Organizational relations	Trust between business transaction partners	• Low level of trust between the supply chain members
	Collaboration among business transaction partners	• Low level of collaboration in the supply chain
	Information sharing among business transaction partners	• Lack of information sharing and systems integration among the supply chain firms
	Transaction partner´s power, dependency on the transaction partner	• Power is concentrated in the slaughterhouses but they do not develop their suppliers or share the costs of technology use for traceability
Technology features	Perceived costs of technology	• Costs of mobile technology are considered high
	Perceived benefits of technology	• There are perceived benefits of mobile technology use only by individual firms • Benefits not perceived for SCM
	Perceived problems for technology use	• The physical conditions on ranches are not adequate for mobile technology use.
Macro level of analysis		
Technology infrastructure (national)	Dependence of advanced/broad/public technological infrastructure for the new technology use	• Lack of adequate telecommunications infrastructure • Lack of adequate supply of electricity infrastructure • Unskilled labour force in rural areas in Brazil
Governmental regulations	Regulatory regimes for technology use	• Traceability is not mandatory • The traceability system does not apply mobile technology

Table 3. Elements that affect the diffusion of mobile technologies for SCM in the supply chain studied

Some of the elements that influence the diffusion of mobile technologies in the case were also found in similar studies. Chang & Chen (2008) pointed that, in the context they studied (logistic companies in Taiwan) the degree of competition in the marketplace and market requirements, cost and integration of supply chain strategy (among others) are critical factors for RFID diffusion. Balloco et al. (2011) assert that the non-homogeneous distribution of costs and benefits among the supply chain actors is one of the barriers for the use of RFID for SCM. Chan & Chong (2013) showed that environmental factors such as competitive pressures have a significant relationship with mobile SCM adoption.

However, our study highlight the importance of considering a macro level of analysis in mobile technology adoption for SCM, related to basic but essential technological infrastructure such as telecommunications, electricity and a skilled labor force, in the context of a developing country such as Brazil. These results partially support previous research on ICT in developing countries which indicate barriers for technology diffusion, such as inadequate or unreliable country level ICT infrastructure, low consumer level of ICT adoption, lack of human capital and resources/funding for investments in infrastructure (Yayla & Hu, 2012; Billon et al., 2009).

Considering the main elements identified in the case studied, we can argue that a market that demands detailed information about the beef exported by Brazil, as well as the availability of a technology infrastructure and governmental regulation to assure traceability in the beef chain in the future are likely to influence the investments made in mobile technology for these purposes. The main advantage of such investment is precise and accurate information about the animal health along the chain. In the same sense, a scarce flow of information may have an impact on the flow of animals and beef along the supply chain because a contaminated animal or batch of beef may continue to flow from one agent to another instead of being removed. This flow of contaminated food may increase the risk of contamination of healthy animals and/or beef in the supply chain.

Many of these problems can be reduced with mobile technology applications for cattle traceability and the proper use of inter-organizational information systems along the chain. These systems could be connected to the national traceability system and accessed via mobile devices anytime, anywhere, such

as during fieldwork, animal handling, shipping and receiving, taking advantage of location based services and context aware information. With precise information, supply chain agents can manage problems more easily and mitigate risks in the chain.

Therefore, the results of this case study generate insights into the process of mobile technology diffusion for SCM in complex environments such as the Brazilian beef chain and how mobile technology can be used to reduce food safety risks - see Figure 1.

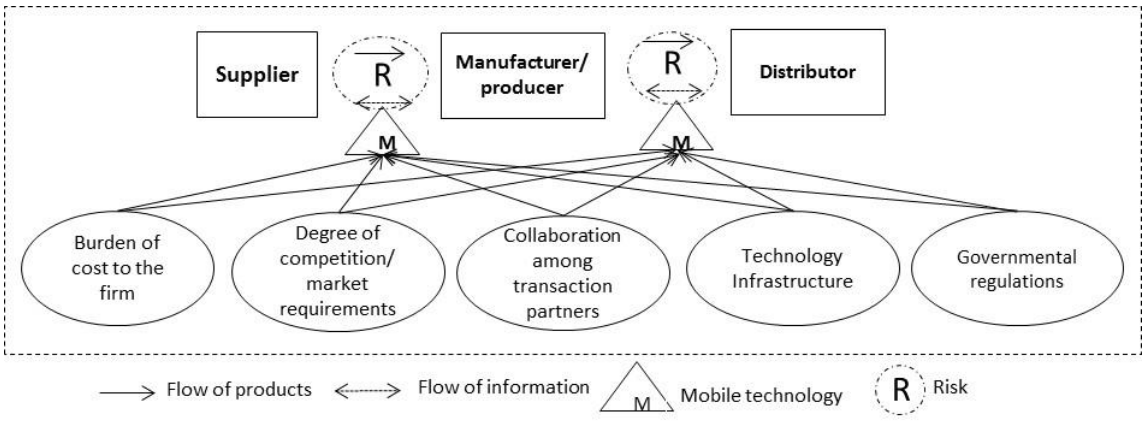

Figure 1: Elements that affect the diffusion of mobile technology for SCM and risk control in the supply chain

These insights can be useful for managers, especially of food supply chains, since there are still few studies that discuss mobile technology diffusion for SCM in this type of chain and in the context of a developing country. The study points out a set of problems for integration in the supply chain studied, analysing the fragility and risks of a traceability system such as SISBOV, and the potential use of mobile technology to improve it.

The results of this study can also be considered for the definition of governmental actions and policies, in order to improve the beef chain and strengthen the local economy. As other implication for practice, the two largest beef slaughterhouses in the world, both located in Brazil, do not help to upgrade or develop their beef suppliers. The slaughterhouses are missing an opportunity to manage their suppliers to have cattle delivered on time with the required quality for export markets, avoiding supply chain risks.

The main limitations of this study are the small number of interviewees for some tiers of the chain, such as breeders, raisers and slaughterhouses. Also, no interviews were conducted with representatives from MAPA and logistics operators. Further studies could replicate the research in other chains and country contexts and also investigate in depth how the institutionalization of management and government practices affect the entire food supply chain.

References

Angeles, R.(2005). RFID Technologies: supply-chain applications and implementations issues. Information Systems Management, 22 (1), 51-65.

Archer, N., Wang, S., & Kang, C. (2008) Barriers to the adoption of online supply chain solutions in small and medium enterprises. Supply Chain Management, 13(1), 73 – 82.

Attaran, M. (2007), RFID: an enabler of supply chain operations. Supply Chain Management, 12(4), 249 – 257.

Balocco, R., Miragliotta, G., Perego, A., & Tumino, A. (2011). RFId adoption in the FMCG supply chain: an interpretative framework. Supply Chain Management, 16(5), 299 – 315.

Basole, R. C. (2008). Enterprise mobility: Researching a new paradigm. Information, Knowledge, Systems Management 7(1-2), 1-7.

Bensaou, M., & Venkatraman, N. (1995). Configurations of Inter-Organizational Relationships : A Comparison Between US and Japanese Automakers. Management Science, 41(9), 1471–1492.
Billon, M.; Marco, R., & Lera-Lopez, F. (2009). Disparities in ICT adoption: A multidimensional approach to study the cross-country digital divide. Telecommunications Policy, 33(10–11), 596-610.
Chan, F. T. S., & Chong, A. Y. (2013). Determinants of mobile supply chain management system diffusion: a structural equation analysis of manufacturing firms. International Journal of Production Research, 51(4), 1196–1213.
Chang, S., & Chen, Y. (2008). The Determinants of RFID Adoption in the Logistics Industry - A Supply Chain Management Perspective. Communications of the Association for Information Systems: 23, Article 12.
Choi, T. Y. & Krause, D. R. (2006). The supply base and its complexity: implications for transaction costs, risks, responsiveness, and innovation. Journal of Operations Management, 24(5), 637-652.
Chong, A. Y.-L., Ooi, K.-B., & Sohal, A. (2009). The relationship between supply chain factors and adoption of e-Collaboration tools. International journal of production economics, 122(1), 150–160.
Chwelos, P., Benbasat, I., & Dexter, A. S. (2001). Research Report: Empirical Test of an EDI Adoption Model. Information Systems Research, 12(3), 304–321.
Craighead, C. W., Blackhurst, J., Rungtusanatham, M. J., & Handfeld, R. B. (2007). The severity of supply chain disruptions: design characteristics and mitigation capabilities. Decision Sciences, 38(1), 131-156.
Creswell, J. W. (2003). Research Design. Thousand Oaks: Sage.
Damsgaard, J., & Lyytinen, K. (1998). Contours of diffusion of electronic data interchange in Finland Overcoming technological barriers and collaborating to make it happen. Journal of Strategic Information Systems, 7, 275–297.
Eng, T. Y. (2006). Mobile supply chain management: Challenges for implementation. Technovation, 26(5-6), 682-686.
Fawcett, S. E., Wallin, C., Allred, C., Fawcett, A. M., & Magnan, G.M. (2011). Information Technology as an enabler of supply chain collaboration: a dynamic-capabilities perspective. Journal of Supply Chain Management, 47(1), 38-59.
Ghadge A., Dani, S., & Kalawsky, R. (2012), Supply chain risk management: present and future scope. The International Journal of Logistics Management, 23(3), 313 – 339.
Hendricks, K. B., & Singhal, V. R. (2005). Association between supply chain glitches and operating performance. Management Science, 51(5), 695-711.
IBGE (2006) Censo Agropecuário 2006. Retrieved April 24, 2012 from http://www.ibge.gov.br
Johnson, P. (2000). Towards a holistic understanding of disruptions in Operations Management. Journal of Operations Management, 18(6), 701-718.
Kleindorfer, P. R., & Saad, G. H. (2005). Managing disruptions risks in supply chains. Production and Operations Management, 14(1), 53-68.
Knemeyer, A. M., Zinn, W., & Eroglu, C. (2009). Proactive planning for catastrophic events in supply chains. Journal of Operations Management, 27(2), 141–153.
Kumar, K., & Van Dissel, H. G. (1996). Sustainable Collaboration : Managing Conflict and Cooperation in Interorganizational Systems. MIS Quartely, (September), 279–298.
Kumar, R. L., & Crook, C. W. (1999). A multi-disciplinary framework for the management of interorganizational systems. ACM SIGMIS Database, 30(1), 22–37.
Lee, H. L., Padmanabhan, V., & Whang, S. (2004). Comments on "Information distortion in a supply chain: the bullwhip effect". Management Science, 50(12), 1887-1893.
Manning L., & Baines R.N. (2004), Effective management of food safety and quality. British Food Journal, 106(8), 598-606.
MAPA. SISBOV. Retrieved April 20, 2012 from http://extranet.agricultura.gov.br/primeira_pagina/extranet/SISBOV.html
Miles, M., & Humberman, A. (1994). Qualitative Data Analysis: an expanded sourcebook. Sage.

Ngai, E. W. T., Chau, D. C. K., & Chan, T. L. A. (2011). Information technology, operational, and management competencies for supply chain agility: Findings from case studies. Journal of Strategic Information Systems, 20(3), 232-249.
Ngugi, B., Pelowski, M., & Gordon, J. (2010). M-Pesa: A Case Study of the Critical Early Adopters' Role in the Rapid Adoption of Mobile Money Banking in Kenya. The Electronic Journal on Information Systems in Developing Countries, 43 (3), 1-16.
Power D., Hanna, V., Singh, P. & Samson, D. (2010). Electronic markets, data access and collaboration: relative value to performance in firm operations. Supply Chain Management, 13(1), 73-82.
Ribeiro, P., Scavarda, A., & Batalha, M. (2010). RFID in the international cattle chain: traceability, context and legislation. International Journal of Service and Operation Management, 6(2), 149-164.
Roth, A. V., Tsay, A. A., Pullman, M. E., & Gray, J. V. (2008). Unraveling the food supply chain: strategic insights from China and the 2007 recalls. Journal of Supply Chain Management, 44(1), 22–39.
Salmela, H., Toivonen, S., Scholliers, J. (2010). Enhancing supply chain security with vulnerability management and new technology. IET Intelligent Transport Systems, 4(4), 307-317.
Salo, J. (2012). The role of mobile technology in a buyer-supplier relationship: a case study from the steel industry. Journal of Business & Industrial Marketing, 27(7), 554 – 563.
Sarac, A., & Absi, N. (2010). A literature review on the impact of RFID technologies on supply chain management. International Journal of Production Economics, 128(1), 77-95.
Schroeder, T.C., & Tonsor, G.T. (2012). International cattle ID and traceability: Competitive implications for the US, Food Policy, 37(1), 31-40.
Schwägele,F. (2005) Traceability from a European perspective, Meat Science, 71(1), 164-173.
Siau, K., & Shen, Z. (2002). Mobile Commerce Applications in Supply Chain Management. Journal of Internet Commerce, 1(3), 3-14.
Silverman, D. (2001) Interpreting qualitative data: methods for analyzing talk, text and interaction. London: Sage.
Sorensen, C. (2011). Enterprise Mobility: tiny technology with global impact on work. London: Palgrave MacMillan.
Speier, C., Whipple, J.M., Closs, D.J., & Voss M.D. (2011). Global supply chain design considerations: Mitigating product safety and security risks. Journal of Operation Management, 29(7–8), 721–736.
Strauss, A., Corbin, J. (1998). Basics of Qualitative Research. London: Sage.
Teo, B. H. H., Wei, K. K., & Benbasat, I. (2003). Predicting intention to a dopt interorganizational linkages : MIS Quartely, 27(1), 19–49.
Tomlin, B. (2006). On the value of mitigation and contingency strategies for managing supply chain disruption risks. Management Science, 52(5), 639-657.
Tseng, M.-lang, Wu, K.J., & Thoa, T. (2011). Information technology in supply chain management: a case study. Procedia, 25, 257-272.
Tzeng, S.F., Chen, W. H, & Pai, F, Y. (2008). Evaluating the business value of RFID: Evidence from five case studies. International Journal of Production Economics, 112(2), 601-613.
USDA (2012). Livestock and Poultry: world markets and trade. Retrieved January 20, 2012 from http://www.fas.usda.gov/psdonline/circulars/livestock_poultry.pdf
Wang, W., Dai, W., Zhao, W., & Li, T. (2011). Research on mobile agent system for agile supply chain management. Journal of Software, 6(8): 1498-1505.
Wu, I, & Chuang, C. (2010) Examining the diffusion of electronic supply chain management with external antecedents and firm performance: A multi-stage analysis. Decision Support Systems, 50(1),103–115.
Yin, R. K. (2009). Case Study Research. Thousand Oaks: Sage.
Zsidisin, G. A., & Ellram, L. M. (2003). An agency theory investigation of supply risk management. Journal of Supply Chain Management, 39(3), 15-27.
Zsidisin, G. A., & Smith, M. (2005). Managing supply risk with early supplier involvement: a case study and research propositions. Journal of Supply Chain Management, 41(4), 44-57.