E-Grocery Supply Chain Management Enabled by Mobile Tools

(Article begins on next page)

16 August 2022

E-Grocery Supply Chain Management Enabled by Mobile Tools

Abstract

Purpose: This paper studies mobile services for supply chain management (SCM) in the e-grocery sector. The authors investigate their diffusion and formulate policies in order to stimulate the adoption.

Design/Methodology/Approach: A System Dynamics model is proposed for a short fresh food supply chain (SC). The model predicts how product traceability, mobile payment, and time-based delivery management functionalities contribute to the adoption of a SCM mobile application.

Findings: The three services drive the diffusion of the application. A high level of real time information brings decreased inventory levels and more frequent order placing, leading to an increased number of logistics transactions managed by the mobile application and growth in the associated revenue for the service provider company.

Research Implications: The proposed study fosters research on overcoming the barriers that prevent integration, collaboration, and better visibility in e-grocery SCs.

Practical Implications: This work constitutes a roadmap to identify the key enabling factors of e-grocery expansion.

Originality/Value: This is one of the few contributions focusing on increasing the efficiency of e-grocery SCs by applying management strategies supported by mobile devices.

Keywords: e-grocery, diffusion, product traceability, mobile payment, time-based deliveries, System Dynamics.

1. Introduction

Electronic grocery (e-grocery) is the process of ordering groceries from home in an electronic way and either having them delivered at one's house or collecting them at a store or at a pick-up point. It has a number of benefits over the traditional retail channels mainly related to shopping convenience and time savings, as well as 24-hour accessibility to a wide variety of products and virtual stores (De Kervenoael *et al.*, 2014; Durand and Gonzalez-Feliu, 2012). Such characteristics are currently making the popularity of e-grocery among consumers increase: it is estimated that it will account for 10% to 20% of the UK market by 2020 (Benn *et al.*, 2015). However, from the supply side several companies worldwide failed to enter the e-grocery industry because of the additional order preparation and delivery activities that such a business model requires compared to traditional grocers and the associated costs and investment efforts that have made e-grocery retailing scarcely financially viable (Goethals *et al.*, 2012). This is especially true for the agri-food sector that is often characterised by many small and medium-sized companies with very little integration (Zhang and Li, 2012).

Supply chain (SC) fragmentation is one of the root reasons for the scarce success of e-grocery among market players together with other supply chain management (SCM) deficiencies, namely a lack of operational efficiency and poor logistics consequent to an inappropriate control on the physical and information flows. Unwillingness to share information and unavailability of adequate means to do it lead to a significant information gap among SC partners (Prater *et al.*, 2005). Thus, a high level of integration among e-grocery SC echelons by means of timely and accurate information becomes vital in order to overcome these criticalities. The recent advances in wireless communication and mobile technologies help achieve such goals given the large diffusion of tools such as smartphones and tablets and of the related software applications. This is the field that has spawned mobile commerce as a branch of electronic commerce (e-commerce).

Despite the relevant number of literature contributions on motivations, benefits and drawbacks of e-grocery (Hand *et al.*, 2009; Lim *et al.*, 2009) and the design of the associated distribution systems

(Colla and Lapoule, 2012; Durand and Gonzalez-Feliu, 2012; Lee *et al.*, 2011), few works focus on the adoption of mobile instruments to enhance the e-grocery SC performance. In particular, a number of relatively new approaches to manage SC processes, such as product traceability, mobile payments, and time-based deliveries, are highly promising in order to add value to e-grocery and increase its efficiency level (Goebel *et al.*, 2012; Kumari *et al.*, 2015; Liébana-Cabanillas *et al.*, 2014). However there is a substantial lack of research about the interconnections between the implementation of these practices supported by mobile tools and the improvement of the e-grocery SC leading to its wider diffusion. Moreover, current studies in the field usually address Business to Consumer (B2C) transactions, while Business to Business (B2B) e-commerce may redefine inter-firm processes and strengthen business relationships in a SC through better visibility and increased collaboration (Cassivi *et al.*, 2005; Salo, 2007).

In order to contribute to bridging this research gap, the present paper builds on previous research analysing the diffusion of a mobile application to support SCM in the fresh food e-grocery sector (Cagliano *et al.*, 2015). The aim is to understand the benefits of the introduction of additional functionalities enabling the management of product traceability, mobile payment, and time-based deliveries and how these affect the dynamics of adopting the digital application among producers, retailers, and consumers. This, in turn, would help understand the extent to which the usage of a digital application drives the diffusion of e-grocery in short distance food SCs.

To this end a System Dynamics (SD) simulation model is developed to capture the cause and effect time-dependent relationships among the system variables and their feedback loops. The results show how the availability of new approaches to streamline SC processes can support e-grocery to overcome its current organisational limitations and can stimulate its diffusion. This is facilitated by the possibility of implementing such SCM strategies by means of widely used mobile devices, which is also an incentive to their more extensive application.

The outline of the paper is as follows. A review of the relevant literature is presented in Section 2 while Section 3 discusses the research context and the adopted methodology. Section 4 details the

SD model and Section 5 presents and elaborates on its results. Benefits, limitations, implications, and future research directions are addressed in Section 6.

2. Literature Review

The literature relevant to this study can be subsumed into four main streams of research, namely: factors and barriers to the adoption of mobile applications and associated technologies, product traceability, mobile payment, and customer deliveries, with particular focus on e-commerce and mobile applications in the grocery industry.

2.1 Factors and Barriers of Mobile Application and Technology Diffusion

The integration of advanced internet capabilities in mobile phones has paved the way to developing software applications for mobile devices assisting users in performing a number of tasks. There is a considerable body of literature that studies the diffusion of such applications and of the underlying mobile technologies mainly by focusing on the factors that either stimulate or hinder adoption. Different contexts have been addressed such as entertainment–oriented mobile services, mobile commerce, mobile banking, mobile health services, mobile insurance, and mobile couponing (Liu *et al.*, 2015).

Among the factors having a significant positive influence on mobile application adoption, the most recurrent ones are usefulness, ease of use, compatibility, convenience, social influence, and personal propensity towards the adoption of new information technology (IT) solutions (Alalwan *et al.*, 2016; Lee and Han, 2015; Lee *et al.*, 2015). Users are keener to adopt when they find a mobile application compliant with their lifestyle, values, and needs, or when such an application allows them to save time and effort while carrying out a given activity. Social influence refers to the perception about the use of an innovation that is formed through relationships between individuals (Yadav *et al.*, 2016). While in the past offline socialization was as an important driver for the diffusion of IT innovation, nowadays online socialization is becoming increasingly relevant, hence

social media and online word of mouth are emerging as communication channels supporting mobile application diffusion (Thi *et al.*, 2016). Some authors also focus on the technical aspects determining application adoption, for instance security, speed, accessibility, reliability, and real-timeliness (Shieh *et al.*, 2014), which have an undeniable influence on the above mentioned factors such as usefulness, ease of use, and convenience.

Additionally, a number of contributions deal with the adoption of mobile technologies. User expectations, social status gains, normative influence, cost and quality affect the use of such technologies (Song *et al.*, 2015).

Despite the many benefits supporting the use of mobile applications, some issues might represent barriers to their diffusion. On the one hand, both initial and operating costs, such as costs for establishing mobile services and fees for messaging and internet surfing as well as online transactions, play a significant role in diffusion (Lee and Han, 2015; Thi *et al.*, 2016). On the other hand, data security risk is a further factor that might hinder the adoption of mobile applications, especially when sensitive data are involved in financial transactions or healthcare services. Also, data privacy risk may result in information disclosure leading to abuse in tracking users' preferences and schedules (Alalwan *et al.*, 2016; Liu *et al.*, 2015).

Most of the studies about mobile application and technology diffusion are concerned with final private users and there are few works on the adoption by business organisations, with particular focus on applications for SCM. Among them, Pan et al. (2013) deal with mobile SCM systems in retail. Institutional pressures, top management commitment, and SC factors such as long term relationships with trading partners proved to influence the intention to adopt mobile SCM tools more than the perceived operational and strategic benefits. Cagliano et al. (2015) study the adoption dynamics of a mobile application supporting e-grocery SCM and formulate policies for encouraging its diffusion.

2.2 Product Traceability in the Grocery Industry

Barcodes, Radio Frequency Identification (RFID), and recently Near Field Communication (NFC) tags are used in the grocery sector to deal with the concerns about food safety (Bosona and Gebresenbet, 2013). Because of their nature RFID and NFC show the greatest potential for integration with mobile SCM tools.

Many authors develop and validate RFID-based traceability systems for perishable products and cold chain monitoring (Chen *et al.*, 2014; Sharma and Patil, 2011; Todorovic *et al.*, 2014). The use of the information collected by these systems to support decision-making and distribution strategies is also investigated (Shi *et al.*, 2010). Such information can be applied to predict the demand for time sensitive food products based on their residual shelf life and to change the price accordingly (Liu *et al.*, 2008). Other authors focus on the benefits of RFID application to the grocery sector, such as real-time tracking of product quality and shelf life prediction, with positive effects on spoilage reduction and identification and segregation of contaminated items (Kumari *et al.*, 2015), which add to the operational and economic advantages that this technology brings business processes in any sector (Barjis and Fosso Wamba, 2010).

A limited number of contributions are concerned with the use of RFID in the electronic management of the grocery SC. Some authors report on the role and the future trends of wireless product identification in the e-grocery business (Prater *et al.*, 2005). Folinas and Manikas (2010) and Martínez-Sala et al. (2009) develop traceability systems integrated in information management systems. Mainetti et al. (2013) and Chen et al. (2014) analyse the integration between RFID and NFC for food traceability enabled by mobile applications.

Despite the ability of RFID product traceability to gain inventory efficiency with high demand uncertainty and to overcome the traditional lack of information transparency, several limitations prevent its full diffusion. Significant investments are required that might not be affordable by grocery SC actors, given that profit margins are quite tight. Sometimes there is also inadequate knowledge about the potential benefits of traceability technologies and scarce management

experience to ensure successful implementations (Badia-Melis *et al.*, 2015). Finally, each player might use different track and trace systems hindering integration. As a matter of fact, until now few large scale traceability applications concern entire food SCs.

Thus, literature calls for more studies about traceability as an enabler of grocery SC collaboration, integration, and visibility by encompassing whole chains (Fosso Wamba, 2012; Narsimhalu *et al.*, 2015).

2.3 Mobile payment

Mobile payment is a crucial driver for the success of mobile commerce. A considerable number of works discuss the factors stimulating its adoption: the reliability, usefulness, ease of use, access speed, accuracy, timeliness, and relevancy of the provided information (Kim *et al.*, 2010; Teo *et al.*, 2015; Thakur and Srivastava, 2014; Upadhyay and Chattopadhyay, 2015; Zhou, 2014); the trust in the mobile payment service providers (Arvidsson, 2014; Zhou, 2014); external influences of social image and subjective norms; and the degree of personal innovativeness (Liébana-Cabanillas *et al.*, 2014). The service cost seems to be an important driver of first adoptions (Upadhyay and Chattopadhyay, 2015) but is no longer significant in determining adoption continuance (Yang *et al.*, 2012). Finally, a few recent works analyse the potential of NFC-based payments: fast transactions, secure exchange of information, and user-friendliness (Luo *et al.*, 2016; Pham and Ho, 2015).

Financial, privacy, and performance risks (Yang *et al.*, 2015), the intangible rather than tangible benefits, and the lack of cooperation between service providers and SC players make mobile payment adoption uncertain. In fact mobile payment is implemented at a slower pace than anticipated and few mass market solutions currently exist (Guo and Bouwman, 2016).

Literature pays scarce attention to B2B transactions, thus giving an incomplete understanding of the phenomenon (Dahlberg *et al.*, 2015). Nevertheless, mobile payment is one of the prominent technologies available in B2B electronic commerce, together with automatic product identification (Kurnia *et al.*, 2015), because it provides companies with a valuable complementary financial

channel, higher visibility, enhanced revenues, increased process efficiency, and flexibility (Ghezzi *et al.,* 2010).

Therefore, more research on mobile payments is advocated, especially on B2B e-commerce, by focusing not only on the situation after the adoption of a service, as most of the studies do (Yang *et al.*, 2012) but also on the processes prior to its implementation. Such research should also address the e-grocery SC, where studies on mobile payment are very rare.

2.4 E-grocery deliveries

Among the different types of e-grocery deliveries, home delivery is widely used (Goethals *et al.*, 2012; Morganti *et al.*, 2014). In fact, pick-up points are an appealing option but are scarcely adopted because they are costly and require long implementation times (Augereau and Dablanc, 2008). However, home delivery is quite expensive: it accounts for up to 15% of the order value. Moreover, it has been estimated that about 30% of the attended deliveries fail because nobody is at home (Colla and Lapoule, 2012). This situation adds further costs making e-retailers seek alternative solutions for releasing time and cost constraints.

Since failed deliveries ultimately compromise the customer service level and constitute a loss for companies, time-based home deliveries could be purposefully applied in the e-grocery sector. Under such a model the recipient of goods chooses a pre-defined time slot for the delivery (Goebel *et al.*, 2012). Time-based deliveries yield benefits to both customers and suppliers enabling the latter to capture a higher market share and raise revenues as a consequence of higher prices for the convenience (Geyskens *et al.*, 2002). Additionally, profit can be increased due to the lower costs associated with handling, storage, and transport activities. Although home delivery and e-grocery have been extensively discussed, little research has been carried out about the use of time-based deliveries as a tool to enhance distribution efficiency and make e-grocery more attractive to customers.

The performed literature review reveals that the topic related to the adoption of mobile application has received much attention in recent years. However, little work has been carried out with specific focus on the diffusion of digital applications and services in the SCM field and the e-grocery. Moreover, product traceability, mobile payments, and delivery models are already debated topics in either e-commerce or e-grocery. Nevertheless, there is a lack of works on how these management approaches can contribute to SC integration and collaboration, timely sharing of information and payments, and logistics efficiency in e-grocery, thus fostering the growth of the industry. Furthermore, their implications on B2B e-commerce have been little explored. Finally, studies about how e-grocery SC improvements can be achieved via mobile services have been scarcely addressed.

As a contribution to overcoming such research gap, the present paper analyses the advantages for a short food SC of the availability of product traceability, mobile payment, and time-based delivery functionalities in a mobile application for e-grocery SCM. The effects on the diffusion of the mobile application are discussed and policies for stimulating its adoption are formulated. Thus, the main novelty of this work is to explore the integration of management strategies in mobile applications in order to improve the e-grocery processes. This also contributes to understanding the mechanisms of diffusion of mobile applications and technologies within an e-grocery SC context.

3. Research Context and Methodology

The study presented in this paper is part of a feasibility analysis and preliminary design phase of a mobile application developed by a main telecommunication service provider company.

The focus application supports users in placing orders, monitoring inventory levels, dispatching and receiving goods, managing product lists and includes a functionality to plan optimized delivery ruotes. It can be adopted by producers, retailers, and final consumers. Being a database, the application has the same interface for everyone but different types of users access the application with different profiles that allow to accessing profiled information and performing different

activities according to the user's role. For instance, producers and retailers can manage deliveries and inventories, as well as modify product catalogues. On the contrary, final consumers are not given such functionalities but they can place orders and monitor the delivery status. The SC members are thus able to share product, order, inventory, and shipment information and are charged a fee for receiving orders and dispatching deliveries via the application. The base application can feature three additional services (Figure 1).

Take in Figure 1 about here

The first one concerns reading case-level RFID or NFC tags and getting information about products, their origin and cultivation methods, their current status as well as all the steps that they have undergone within the SC. This product traceability service assists in performing inventory and order fulfilling operations and informing both suppliers and customers about the actual product quality. It is available to producers and retailers, who can both read and add new data on tags, because they are the two SC echelons that most benefit from product traceability. Consumers are only informed about the purchased products; these pieces of information are either read by retailers from tags and then sent to consumers via the base mobile application, or directly read by consumers from NFC tags with smartphones. In both circumstances, consumers do not need the product traceability functionality. Smartphones can be used to read NFC tags only, while handheld readers interfaced with the mobile application via a wireless network are applied in case of RFID tags.

The second functionality relates to using the mobile application for supply payment transactions by relying on the contactless NFC technology embedded in many recent smartphones. Producers adopt this service to manage the payments from retailers. Retailers in turn may use it to both manage the payments by consumers and make payments to producers, and consumers adopt the service to pay the retailers.

The third service allows scheduling home deliveries according to predefined time windows chosen by customers that can be changed by the same customers even shortly before the planned execution time. Such a variant of time-based home deliveries is here named "time sensitive" deliveries. Producers may rely on the service to schedule deliveries to retailers, who in turn use it to both set the desired delivery times for their orders to producers and to schedule deliveries to consumers. The functionality at issue is not available to consumers since they do not perform deliveries. However, they can request specific delivery time windows to retailers through the order interface in the base mobile application.

The three services are chosen because they were ranked as the most preferred ones by panels of potential users during focus groups performed in collaboration with the provider company. Such an outcome was confirmed by the fact that, as outlined in Section 2, product traceability, mobile payment, and time-based deliveries are key levers able to increase the efficiency in all the e-grocery SC echelons.

The research unfolded through a number of steps. First of all, the considered system was defined: a three echelon short fresh food SC, composed of producers, retailers, and consumers of fruit and vegetables, was selected because of the particular relevance of timely and reliable material and information flows due to the product nature. The focus SC, which is the same already investigated in Cagliano et al. (2015), operates in an urban area of 1.5 million inhabitants in Northern Italy. Then, the authors performed semi-structured interviews with the targeted actors together with direct observation of operational activities. About sixty potential users, equally divided between producers, retailers, and consumers, were surveyed. Information about order handling, inventory management, and deliveries and data for subsequent quantitative analyses were collected. The outcomes of such an activity constituted the basis for developing the SD model as well as setting its assumptions. With this knowledge a first Causal Loop Diagram (Sterman, 2000) involving the most important system variables was created and shared with the representatives of the SC at issue. Their

comments helped refine the initial model that by means of successive checks with the mentioned stakeholders was finally transformed in the Stock and Flow Diagram and the associated equations used for running simulations. Model calibration and sensitivity analysis to random changes in input parameters were carried out. The observation of the trends of the main variables allowed understanding the dynamics of the diffusion of both the base mobile application and its three optional services. The interpretation of the results enabled proposing policies to stimulate the adoption of the application, and in particular of its additional functionalities, as a way of fostering e-grocery diffusion among the studied market players. All the phases of the study were conducted in close collaboration with the company providing the mobile services at issue.

4. Model Development

4.1 Model Structure

The developed SD model is an evolution of an existing model aimed at capturing the dynamics of the diffusion of the base mobile application without the possibility of integrating any of the optional functionalities (Cagliano *et al.*, 2015). It is structured in ten interconnected sub-models; producers are referred to as farms given the products at issue.

Six sub-models have been taken from the SD model presented in Cagliano et al. (2015). They are named according to their assessment purpose as "Consumer Diffusion and Orders", "Retailer Diffusion", "Farm Diffusion", "Retailer Inventory and Consumer Satisfaction", "Farm Inventory, Retailer Satisfaction and Farm Satisfaction", and "Revenue Growth". Four original sub-models, namely "Retailer Product Traceability Adoption", "Farm Product Traceability Adoption", "NFC Payment Adoption", and "Time Sensitive Delivery Adoption" are then introduced to describe the adoption process of the three optional functionalities and their impacts on the studied e-grocery SC. The first three new sub-models are described in the next sections; the structure of the one about "time sensitive" deliveries is very similar to that of the portion of the model on mobile payments.

The complete list of model equations as defined in the simulation software is available from the authors.

The model has been built via the Vensim DSS software package. The simulations have been performed with Euler integration, with one-day time intervals and a simulation horizon of 156 weeks, equalling approximately 3 years. According to the service provider company this is an appropriate time span to catch the complete diffusion process of the investigated services. The average behaviour of single farms and retailers in handling inventory and orders is represented as well as a standard order composition, not taking into account the variability of the kinds of products in the order. Since groups of products are usually moved in this SC within a variety of different unit loads, such as for instance pallets, boxes, and bags, the order is assumed as the unit of material in the model.

Users may adopt the mobile application either in its base version or integrated with at least one of the three optional services. Adopters of the base application might adopt the optional functionalities later on.

4.2 "Retailer Product Traceability Adoption" and "Farm Product Traceability Adoption" Sub-models

Retailers and producers are the SC echelons that benefit from the traceability functionality the most because they are able to use the associated information in their order fulfilment and inventory processes. Consumers can just read the information associated with tags to know the origin and the quality status of the products they receive. The structure is the same for both the "Retailer Product Traceability Adoption" and the "Farm Product Traceability Adoption" sub-model. Figure 2 presents the portion of the Stock and Flow Diagram associated with the "Retailer Product Traceability Adoption" sub-model: a plus sign indicates a positive relationship between two variables and a minus sign a negative one.

Take in Figure 2 about here

The variable "NFC RFID Retailer Adopters" calculates the cumulated number of adopters of the product traceability service in each time step T as the sum of the number of adopters up to the previous time step ("NFC RFID Retailer Adopters (T-1)") and the number of adopting retailers in the current time step. This is illustrated by Equation (1), where the variable "Retailers" shows the total number of retailers that adopted either just the base application or such application plus at least one additional service from the beginning of the simulation horizon up to the current time step:

$$NFC\ RFID\ Retailer\ Adopters\ =\ NFC\ RFID\ Retailer\ Adopters(T-1) + \{[Retailers(T-1) - NFC\ RFID\ Retailer\ Adopters(T-1)] + [Retailers - Retailers(T-1)]\} *$$
$$NFC\ RFID\ Retailer\ Adoption\ Fraction \tag{1}$$

"NFC RFID Retailer Adoption Fraction" is the fraction of retailers in the studied SC that adopt the product traceability service in each time step and is determined by the retailers' willingness to use such functionality ("Retailer Attitude to Adoption"), which depends on both the retailers' satisfaction with the mobile application and its traceability option and the investment costs. The higher the infrastructural costs to implement a product traceability system, the less money the retailers will spend on it ("Retailer Attitude to Investment"). "Weight of Investment Cost" represents the importance of the required investment cost in choosing whether to adopt the application option at issue (Equation (2)).

$$\begin{aligned} Retailer\ Attitude\ to\ Adoption \\ = Retailer\ Attitude\ to\ Investment\ *\ Weight\ of\ Investment\ Cost \\ + Retailer\ Satisfaction\ (T-1) * (1 - Weight\ of\ Investment\ Cost) \end{aligned}$$

$$\tag{2}$$

The more retailers adopting the product traceability mobile service the larger the quantity of real time information available and exchanged in the SC, improving the management of both stocks and

deliveries (Lee *et al.*, 2004). The increase in the information level ("Retailer Real Time Information Level") yields reduced order fulfilment times, inventory counting times (Sarac *et al.*, 2010) and good receiving times (Michael and McCathie, 2005). The time savings in the two last warehouse operations allow further acceleration of order processing. Moreover, real time monitoring of the inventory level reduces the probability of stock-outs, which brings as a consequence a lower safety stock (Sarac *et al.*, 2010). Thus, inventory management efficiency and shipment rate to customers increase. Finally, the availability of real time information positively affects the timeliness and accuracy of the information about orders received by consumers from retailers ("Data Timeliness and Accuracy (Shipping to Consumers)").

All these aspects impact the "Retailer Inventory and Consumer Satisfaction" sub-model, which is a modified version of the corresponding sub-model in Cagliano et al. (2015).

Figure 3 shows how the variables "Retailer Inventory Counting Time" and "Retailer Receiving Time", calculated in the "Retailer Product Traceability Adoption" sub-model, are positively connected to the minimum time to process an order ("Min Retailer Order Processing Time"). The variable "Retailer Real Time Information Level" is negatively linked to such time because the higher the availability of real time information the lower the minimum order processing time span. A reduced order fulfilment time makes the shipment rate grow.

An increased retailer shipment rate contributes to raise the consumer satisfaction of the use of the mobile services for e-grocery, which in turn stimulates the adoption of the application and its optional services by both consumers and retailers thanks to word of mouth. The positive adoption trend thus created is counterbalanced by the retailers' aptitude for technology investment that decreases as the associated cost increases.

The variable "Single Retailer Shipment Rate" also defines the average inventory level of each retailer in the SC. As a matter of fact, the value of the stock variable "Single Retailer Inventory" is calculated as the integral of the difference between the input flow variable ("Single Retailer Receiving Rate") and the output ones ("Single Retailer Shipment Rate" and "Single Retailer

Inventory Spoilage Rate"). Being a short food SC, the products quickly reach the final consumers and the time they remain in stock is very short. As a consequence, the average spoilage rate based on the interviews with producers and retailers is quite low. Hence, the variable "Single Retailer Inventory Spoilage Factor" is assumed to be approximate 1% of the daily incoming products. The same value is assumed for the spoilage rate affecting the producer inventory.

The variable "Data Timeliness and Accuracy (Shipping to Consumers)", again computed in the "Retailer Product Traceability Adoption" sub-model, is a further determinant of consumer satisfaction. As a matter of fact, a reliable flow of information about orders to consumers makes the receiving service level and the satisfaction increase.

Finally, Figure 3 depicts that a decreased probability of inventory stock-outs makes the order quantities to farms go down because of a reduced safety stock. Smaller orders can be fulfilled in a shorter time with obvious positive consequences on retailer satisfaction.

The sub-models discussed in this paragraph imply a willingness of the SC members to implement a product traceability system, which actually emerged from the performed interviews especially when incentives are provided by local authorities and trade associations.

Take in Figure 3 about here

4.3 "NFC Payment Adoption" Sub-model

The NFC-based functionality enabling payments can be adopted for all financial transactions. It is not a standalone system but it is offered as an additional integrated service to those that already use the base mobile application. This functionality provides all SC echelons with a reliable and quick payment approach without over increasing the number of different tools used on a daily basis. Additionally, it integrates all the SC partners through the financial flow, as already done by the other two additional functionalities and by the base mobile application for the material and information flows.

The pertinent part of the SD model is divided in three sections (Figure 4), one for each SC echelon. Since the adoption dynamics are similar, only the case of retailers is considered here.

The variable "Retailer NFC Payment Adopters" represents the total number of retailers that adopt the payment service in addition to the base mobile application: it is computed similar to the number of adopters of the product traceability functionality (Equation (3)).

$$Retailer\ NFC\ Payment\ Adopters = Retailer\ NFC\ Payment\ Adopters\ (T-1) +$$
$$\{[Retailers(T-1) - Retailer\ NFC\ Payment\ Adopters\ (T-1)] + [Retailers - Retailers(T-1)]\} * NFC\ Retailer\ Payment\ Fraction \tag{3}$$

The user fraction that adopts the payment functionality in each time step ("NFC Retailer Payment Fraction") is a function of the satisfaction of the retailers that already use such a service or the base mobile application. As far as the payment system is concerned, satisfaction mainly derives from operational convenience and security (Kim *et al.*, 2010; Thakur and Srivastava, 2014). Since all the transactions managed by the application are charged with a fee, users can enjoy the optional mobile services at no additional cost.

Given the current level of NFC technology maturity, it is assumed that the payments executed through the mobile application are completely reliable and all the transactions are successful (Luo *et al.*, 2016). Thus, the level of satisfaction generated by this payment system is proportional to the current ratio of its adopters to the mobile application users ("Fraction Retailer NFC Payment Adopters"). Such level of satisfaction is one component of the service level perceived by each of the three SC echelons when receiving or dispatching fresh food. For instance, the variable "Consumer Receiving Service Level", part of the "Retailer Inventory and Consumer Satisfaction" sub-model (Figure 3), is given by Equation (4):

$Consumer\ Receiving\ Service\ Level =$

$Consumer\ Order\ Fulfillment\ Ratio + Consumer\ Receiving\ Timeliness\ and\ Efficiency +$

$E\ Order\ Service\ Reliability + Fraction\ Consumer\ NFC\ Payment\ Adopters +$

$Fraction\ Retailer\ NFC\ Payment\ Adopters$

(4)where "Consumer Order Fulfillment Ratio" measures the portion of customer orders fulfilled by retailers in every time step, "Consumers Receiving Timeliness and Efficiency", assesses the efficiency of receiving goods with the support of the mobile application, and "E Order Service Reliability" evaluates the degree of reliability of the electronic system to place orders. The portion of the overall service level provided by the mobile payment system is a function of both the number of consumers adopting this functionality and how many retailers are able to accept mobile payments. It is worth mentioning that although some of the factors in Equation (4) have a multiplicative effect on the service level, this variable is modelled as the sum of the above mentioned factors in order not to underestimate the associated value. Such mathematical approach has been adopted to assure robustness of the simulations.

Increased service levels lead to augmented satisfaction levels by farms, retailers, and consumers, which are primary drivers for the diffusion of the mobile applications and its payment functionality through word of mouth, emulation, and persuasion actions (Cagliano *et al.*, 2015).

5. Model Simulation Results

5.1 Results

The SD model underwent calibration with the same numerical data and assumptions described in Cagliano et al. (2015). The consistency of the parameter values was checked by means of the interviews and the numerical data collected from the focus SC representatives, as well as the discussions with marketing and product development managers from the service provider company. All these pieces of information confirmed the validity of the data used in the previous study. The

lookup functions (Sterman, 2000) in the new sub-models developed were defined based on several sources. A lookup function describes the nonlinear empirical relationship between two variables, such as for example "Table for Retailer Receiving Time", which provides the good receiving time for each possible level of real time information available in the system, or "Table for NFC Retailer Payment Fraction", which gives the fraction of retailers adopting the payment service in each time step for each value of the retailer satisfaction. The setting of the lookup functions was based on the interviews with SC partners, knowledge of experts from the service provider company, and market studies about similar applications for mobile devices. When quantitative past data were available, the trend of these functions was also obtained through interpolation models. A first set of the numerical values characterizing each lookup function, meaning the possible values assumed by the independent variable and the related values of the dependent one, was defined and then refined by checking again with the SC and provider company representatives. According to the data made available by the service provider company, "RFID Unit Cost" was set equal to 0.4 €/order and "NFC Unit Cost" equal to 0.3 €/order. The total number of SC members was determined by cross-checking the previous study inspiring this work with recent reports of local trade associations. It is as follows: 75,000 consumers, 750 retailers, and 3,750 farms. The possibility of integrating the three optional services in the base mobile application shortens the saturation time of the investigated market. Without any additional functionality, all the farms, retailers, and consumers in the focus SC adopt the application in respectively 82.3 weeks, 10.2 weeks, and 12.6 weeks (Cagliano *et al.*, 2015). When the product traceability, mobile payment, and "time sensitive" delivery functionalities are offered, they adopt the base application in 79.6 weeks, 8.8 weeks, and 11.6 weeks respectively. The slight difference between the two saturation times for each echelon is due to the fact that the adoption period of the base mobile application is already quite reduced given its characteristics that are perceived as very innovative and convenient by the studied SC.

Simulations show that in each SC echelon the diffusion processes of the optional services are very similar to the diffusion process of the base mobile application. The adoption of the additional

services leads to greater satisfaction than when just benefitting from the base application, which implies a greater number of new users adopting both the application and at least one optional functionality in each time period, so that the diffusion processes go hand in hand. In fact, the functionalities supporting product traceability and "time sensitive" deliveries are adopted by farms and retailers in 79.6 weeks and 9 weeks respectively and the mobile payment service reaches all the farms, retailers, and consumers in 79.8 weeks, 8.8 weeks, and 11.8 weeks respectively.

The adoption of the optional services drives the adoption of the base application. Figure 5 contrasts its diffusion among consumers when no additional services are offered and when they are available and characterised by a normal adoption rate, a low adoption rate, and a very low adoption rate. Similar outcomes have been obtained for retailers and farms: the slower the adoption processes of the optional functionalities, the slower the diffusion of the base mobile application. These results suggest the great appeal the additional services have.

Take in Figure 5 about here

The diffusion of the additional functionality about product traceability improves inventory management and positively affects the revenue generated by the application services for their provider company. In particular, the increased availability of real time information allows lower inventory levels in the SC. The fresh food demand can be considered steady, so orders for smaller quantities will be issued more frequently. The increased order rate produces as a consequence a greater number of transactions via the mobile application. Since a fee is charged for every dispatching and receiving operation managed by the application, the service provider revenue will grow. The cumulated revenue at the end of the simulation period is equal to about 15 million Euros when no additional services are available. Three scenarios are considered, namely a 10%, 30%, and 50% increase in the order frequency due to the effects of the traceability system. As the order rate goes up, the total cumulated revenue significantly grows to about 17 million Euros, 20 million

Euros, and 22 million Euros respectively. In order not to overestimate the revenue, increases in the order frequency less than or equal to 50% are assumed.

Since the present analysis is part of a feasibility study about marketing new services, the SD model has been built not to reproduce an already existing phenomenon but to predict the behavior of a future one. Thus, being no past data to verify the model, testing its response to variations in input variables becomes a useful validation method (Sterman, 2000). To this end, a sensitivity analysis is carried out through the dedicated Vensim tool by making the values of the main input parameters vary as random distributions. The model proves its robustness to variations in all the key parameters such as the mobile application and additional functionalities adoption rates by the three SC echelons, SC lead times, the degree of advertising effectiveness, the reliability and the efficiency of the provided services, and the associated price. Such a model validation also allows us to perform scenario analysis in order to identify the levers available to the service provider company to launch and stimulate the diffusion of the services. The reminder of this section discusses the sensitivity analysis results relevant for such a purpose.

A way to make the mobile services appealing is ensuring their reliability and efficiency. Figure 6 depicts the diffusion of the mobile application when the model parameters "E Order Service Reliability", "Consumer Weight of Time Sensitive Delivery", and "Retailer Weight of Time Sensitive Delivery", simultaneously change out of a triangular distribution between 0 and 1 with peak value equal to 0.5. The last two quantities measure the relative importance of the time and efficiency benefits of "time sensitive" deliveries compared to those associated with real time information availability. These parameters are selected because they are the exogenous variables in the model that influence the assessment of the reliability, timeliness, and efficiency of the mobile services as perceived by users. The diagrams show the confidence bounds within which the values of the selected output variables can be found with a probability of 50%, 75%, 95%, and 100% as the three variables mentioned before randomly change. Such confidence bounds identify different market saturation curves and times caused by different levels of efficiency and reliability of the

services. These levels either increase or decrease the strength of the associated reinforcing loops supporting adoption compared to that of the balancing loops that hinder diffusion. As a consequence, either a quicker or a slower adoption process is originated. The width of the confidence bounds related to the variables "Farms" and "Consumers" is very limited but still proves a variation in the dynamics of adoption by these SC echelons. On the contrary, the diffusion curve of the retailers does not change with small variations in the input values under study. Thus, the adoption of the base mobile application and its optional services is moderately influenced by efficiency and reliability. In fact, this fresh food SC is characterised by so little coordination and information integration among partners that the advantages of using a single tool able to provide different pieces of real time information overcome small deficiencies in the service level. The insensitivity of retailers to efficiency and reliability is due to the fact that being the SC echelon that benefits from the services the most they still find it valuable to their business to adopt the application even with a slightly decreased service performance. The variability in user adoption is more limited than in Cagliano et al. (2015), especially for consumers and farms. The convenience of mobile payments and time-based deliveries as well as the role of product traceability in conveying real time information stress the usefulness of the services and make them be adopted regardless the performance in terms of efficiency and reliability.

Take in Figure 6 about here

Figure 7 presents the diffusion results when the three price parameters, "Receiving Unit Fee", "Dispatching Unit Fee", and "WebApp Unit Price", change according to random distributions. The confidence bounds all overlap. Thus, price variations do not affect the diffusion dynamics of the mobile application and the three optional services because benefitting from enhanced e-grocery SC efficiency and information integration is more important than price in adoption decisions. These results are in line with Cagliano et al. (2015): being free of charge, the three additional services do

not negatively impact the user attitude towards price compared to the situation when just the base mobile application is available but rather, with their highly desirable characteristics, they contribute to make the price even less significant when choosing whether to adopt.

Take in Figure 7 about here

Contrary to Cagliano at al. (2015)'s results, the adoption dynamics of all the three SC echelons are substantially insensitive to different levels of advertising campaigns sponsored by the provider company to promote the services. As an example, Figure 8 shows how the advertising targeted at farms affects the diffusion of the mobile application and its optional services. Even adoption by farms is influenced little by the advertising to this SC echelon. Similar results were found for retailers and consumers. Thus, advertising influences the adoption only when the mobile application is not associated with the three additional services. This outcome can be explained as follows. When just the mobile application is available, like in Cagliano et al. (2015), users might be willing to adopt it based on advertising without an extensive observation of the actual implications of the related services. As a matter of fact, the base application includes some functionalities that are similar to traditional tools such as spreadsheets for inventory management and order placement. So, users are already familiar with the nature of such services. In contrast, users are encouraged to adopt the three additional functionalities more by the benefits that can be observed from their use in practice than by the theoretical description of such advantages provided by advertising. This happens because short food SCs are usually composed by small and medium companies that are typically change resistant and have low propensity to investment: such business entities usually prefer to ex-post measure the benefits that can be obtained from product traceability, mobile payment, and "time sensitive" deliveries, rather than investing based on just advertised returns.

Take in Figure 8 about here

5.2 Implications and Policy Making

The additional services revealed to be important drivers of the diffusion of the mobile application and in particular the one supporting wireless product traceability affects the revenue of the service provider company. Therefore, as a first recommendation for the application service provider, the product traceability service deserves further analyses because its successful introduction promises to yield economic benefits.

Second, the simulation results show that a key element for adoption is the understanding of the advantages that the implementation of product traceability systems, mobile payment, and "time sensitive" deliveries managed through the mobile application is able to provide to the e-grocery SC. In particular, such knowledge leads to adoption when it is acquired by observation of the real benefits achieved by users. Thus, the provider company should support the marketing of these services with not only traditional advertising campaigns through the mass media but also events involving potential users and adopters.

Advertising actions such conceived enable users to directly learn about the actual positive features of the optional functionalities, which enhances their trust in the mobile application services (Arvidsson, 2014) and stimulates the adoption.

Third, the reliability of exchanging information through the mobile application as well as the efficiency of time-based deliveries proved to have a role in speeding up the adoption, especially by consumers and farms. On the one hand, the service provider should increase the reliability of data transmission through the 3G and 4G networks. On the other hand, retailers should ensure timely and customised home deliveries to increase consumers' satisfaction. Adopting farms will persuade new retailers to adopt and consumers will induce adoption from word of mouth by additional retailers. Retailers, in turn, will increase their community of adopters together with the farms' and consumers' thanks to the effects of emulation and persuasion.

Finally, as the adoption dynamics of the mobile application and its optional functionalities are not impacted by their prices, the service provider company has some room for manoeuvre in setting the

appropriate pricing policy, taking into account the revenue growth consequent to the predicted large number of orders in the SC.

In summary, the discussed positive effects on diffusion ensured by the three additional services suggest that the provider company should pursue the introduction of all of them. Given the less significant economic investment required to users, the company could first roll out the mobile payment and the "time sensitive" delivery services. Meanwhile, it could collaborate with the SC organizations and the local trade associations and authorities to facilitate the implementation of product traceability systems in order to pave the way for the launch towards product traceability management by means of the mobile application.

6. Discussion and Conclusion

Despite its tremendous potential for changing traditional buying habits, e-grocery still finds it hard to expand due to scarce coordination among SC players, leading to poor information sharing and control over logistics flows. Mobile communication devices as well as recent advances in SCM, such as product traceability and payment systems via wireless communication technologies and time-based deliveries, can help reshape business processes and make e-grocery SCs more efficient. Taking the opportunity offered by a lack of attention to this topic by recent literature, the present work puts forward a System Dynamics-based reference framework to study the impact of the above mentioned SC solutions on key stakeholders and to formulate business policies to foster the diffusion of e-grocery practices through the use of mobile communication tools. Studying the integration of a product traceability functionality in a mobile application for the e-commerce of fresh food contributes to develop knowledge about the benefits of traceability in the industry (Badia-Melis *et al.*, 2015). Analysing a payment functionality that also serves B2B transactions is an attempt to increase the understanding about the mobile payment applications (Dahlberg *et al.*, 2015). Finally, including a service supporting "time-sensitive" home deliveries helps leverage this

delivery model as a way of making e-grocery more attractive by overcoming the traditional limitations of shipping products to their customer's location (Colla and Lapoule, 2012).

The study here developed has both theoretical and practical implications. From an academic point of view, it contributes to stimulate the research stream about e-grocery and the approaches to address its current limitations, and thus promote diffusion, by taking into account the perspectives of all the main SC actors as well as their operational and economic interactions. By focusing on an entire SC, and not only on its downstream end, it fosters research on the role of B2B e-commerce to connect upstream partners and create improved visibility (Cassivi *et al.*, 2005) as well as on overcoming those barriers that prevent from creating product traceability and mobile payment systems involving all the SC partners (Ghezzi *et al.*, 2010; Hong *et al.*, 2011). Additionally, the proposed analysis could encourage specific research on the three addressed investigation areas and could be considered as a starting point to explore how managing innovative SC strategies by means of common mobile communication devices might contribute to the widespread diffusion of such approaches and to decrease the resistance to their implementation. Finally, this work might provide guidelines for interpreting innovation adoption not only from a commercial perspective but also from an operational one by capturing its effects on SCM processes. From a practitioner's point of view, the proposed work might constitute a roadmap to identify the key enabling factors of e-grocery expansion and to simulate their behaviour overtime. In particular, it might encourage the development of structured ex-ante evaluations of the potential advantages and disadvantages of new e-grocery systems that can assist in defining the correct characteristics they should have in order to then be successfully applied. It can also be a useful decision-making approach to work out and test business policies able to effectively stimulate the diffusion of e-grocery services. Furthermore, the proposed SD model can be modified to become part of feasibility studies in the design and development phases of new mobile applications. Besides being valuable to companies providing mobile services for e-grocery, the present work, and in particular the portion of the model representing the SC behaviour, may help producers, retailers, and consumers capture the impacts of

product traceability, mobile payment, and time-based deliveries on their businesses, in order to support strategic management choices.

The present study suffers from some limitations. First, since the authors have recently started exploring this research field, the effects of the deployment of innovative e-grocery management strategies by means of mobile tools have been analysed in only one SC, thus the results cannot be generalised. Second, the present research has focused on the economic impact of the diffusion of the mobile application on the service provider company, without assessing the effects on the profit margins of retailers and farms.

Future research will validate the proposed approach by applying and adapting the SD model to other SCs in the e-grocery industry. Also, the profit margins of retailers and farms will be investigated together with the introduction of new services and how they might change the results achieved in this work.

Acknowledgements

References

Alalwan, A.A., Dwivedi, Y.K., Rana, N.P. and Williams, M.D. (2016), "Consumer adoption of mobile banking in Jordan. Examining the role of usefulness, ease of use, perceived risk and self-efficacy", *Journal of Enterprise Information Management*, Vol. 29 No.1, pp. 118-139.

Arvidsson, N. (2014), "Consumer attitudes on mobile payment services – results from a proof of concept test", *International Journal of Bank Marketing*, Vol. 32 No.2, pp. 150-170.

Augereau, V. and Dablanc, L. (2008), "An evaluation of recent pick-up point experiments in European cities: The Rise of two competing models?", in: Taniguchi, E. and Thompson, R.G. (Ed.), *Innovations in city logistics*, Nova Science, Washington, D.C., pp. 301-320.

Badia-Melis, R., Mishra, P. and Ruiz-García, L. (2015), "Food traceability: New trends and recent advances. A review", *Food Control*, Vol. 57, pp. 393-401.

Barjis, J. and Fosso Wamba, S. (2010), "Organizational and business impacts of RFID technology", *Business Process Management Journal*, Vol. 16 No. 6, pp. 897-903.

Benn, Y., Webb, T.L., Chang, B.P.I. and Reidy, J. (2015), "What information do consumers consider, and how do they look for it, when shopping for groceries online?", *Appetite*, Vol. 89, pp.265-273.

Bosona, T. and Gebresenbet, G. (2013), "Food traceability as an integral part of logistics management in food and agricultural supply chain", *Food Control*, Vol.33 No.1, pp.32-48.

Cagliano, A.C., De Marco, A., Rafele, C., Bragagnini, A., Gobbato L. (2015), "Analysing the diffusion of a mobile service supporting the e-grocery supply chain", *Business Process Management Journal*, Vol. 21 No. 4, pp. 928-963.

Cassivi, L., Léger, P-M., Hadaya, P. (2005), "Electronic commerce and supply chain integration: the case of the telecommunication equipment industry", *Business Process Management Journal*, Vol. 11 No. 5, pp. 559-572.

Chen, Y.-Y., Wang, Y.-J. and Jan, J.-K. (2014), "A novel deployment of smart cold chain system using 2G-RFID-Sys", *Journal of Food Engineering*, Vol.141, pp.113-121.

Colla, E. and Lapoule, P. (2012), "E-commerce: exploring the critical success factors", *International Journal of Retail & Distribution Management*, Vol. 40 No. 11, pp.842-864.

Dahlberg, T., Guo, J. and Ondrus, J. (2015), "A critical review of mobile payment research", *Electronic Commerce Research and Applications*, Vol. 14 No.5, pp. 265-284.

De Kervenoael, R., Elms, J., Hallsworth, A. (2014), "Influencing online grocery innovation: Anti-choice as a trigger for activity fragmentation and multi-tasking", *Futures*, Vol.62, pp. 155-163.

Durand, B. and Gonzalez-Feliu, J. (2012), "Urban logistics and e-grocery: Have proximity delivery services a positive impact on shopping trips?", *Procedia - Social and Behavioral Sciences*, Vol.39, pp.510-520.

Folinas, D. and Manikas, I. (2010), "Design and Development of an e-Platform for Supporting Liquid Food Supply Chain Monitoring and Traceability", *International Journal of Information Systems and Supply Chain Management*, Vol.3 No.3, pp. 29-49.

Fosso Wamba, S. (2012), "Achieving supply chain integration using RFID technology. The case of emerging intelligent B-to-B e-commerce processes in a living laboratory", *Business Process Management Journal*, Vol. 18 No. 1, pp. 58-81.

Geyskens, I., Gielens, K. and Dekimpe, M.G. (2002), "The market valuation of internet channel additions", *Journal of Marketing*, Vol. 66 No. 2, pp. 102-119.

Ghezzi, A., Renga, F., Balocco, R. and Pescetto, P. (2010), "Mobile payment applications: offer state of the art in the Italian market", *Info*, Vol.12 No.5, pp. 3-22.

Goebel, P., Moeller, S. and Pibernik, R. (2012), "Paying for convenience. Attractiveness and revenue potential of time-based delivery services", *International Journal of Physical Distribution & Logistics Management*, Vol. 42 No. 6, pp. 584-606.

Goethals, F., Leclercq-Vandelannoitte, A. and Tütüncü, Y. (2012), "French consumers' perceptions of the unattended delivery model for e-grocery retailing", *Journal of Retailing and Consumer Services*, Vol.19 No.1, pp.133-139.

Guo, J. and Bouwman, H. (2016), "An analytical framework for an m-payment ecosystem: A merchants' perspective", *Telecommunications Policy*, Vol.40 No.2-3, pp.147-167.

Hand, C., Dall'Olmo Riley, F., Harris, P., Singh, J. and Rettie, R. (2009), "Online grocery shopping: the influence of situational factors", *European Journal of Marketing*, Vol. 43 No. 9/10, pp. 1205-1219.

Hong, I-H., Dang, J-F., Tsai, Y-H., Liu, C-S., Lee, W-T., Wang, M-L. and Chen, P-C. (2011), "An RFID application in the food supply chain: A case study of convenience stores in Taiwan", *Journal of Food Engineering*, Vol.106 No.2, pp.119-126.

Kim, C., Mirusmonov, M. and Lee, I. (2010), "An empirical examination of factors influencing the intention to use mobile payment", *Computers in Human Behavior*, Vol.26 No.3, pp. 310-322.

Kumari, L., Narsaiah, K., Grewal, M.K. and Anurag, R.K. (2015), "Application of RFID in agri-food sector", *Trends in Food Science & Technology*, Vol.43 No.2, pp. 144-161.

Kurnia, S., Karnali, R.J. and Rahim, M.M. (2015), "A qualitative study of business-to-business electronic commerce adoption within the Indonesian grocery industry: A multi-theory perspective", *Information & Management*, Vol.52 No.4, pp. 518-536.

Lee, C-Y., Tsao, C-H. and Chang, W-C. (2015), "The relationship between attitude toward using and customer satisfaction with mobile application services. An empirical study from the life insurance industry", *Journal of Enterprise Information Management*, Vol. 28 No. 5, pp. 680-697.

Lee, E. and Han, S. (2015), "Determinants of adoption of mobile health services", *Online Information Review*, Vol. 39 No.4, pp. 556-573.

Lee, L.H., Lee, C. and Bao, J. (2011), "The Impacts of an Electronic Marketplace with Multiple Independent Retailers for Smart Grocery Ordering Systems", *Wireless Personal Communications*, Vol. 60 No.3, pp. 475-487.

Lee, Y.M., Cheng, F. and Leung, Y.T. (2004), "Exploring the impact of RFID on supply chain dynamics", in Ingalls, R.G., Rossetti, M.D., Smith, J.S. and Peters, B.A. (Ed.), *Proceedings of the 2004 Winter Simulation Conference in Washington*, *D.C.*, *2004*.

Liébana-Cabanillas, F.J., Sánchez-Fernández, J. and Munõz-Leiva, F. (2014), "Role of gender on acceptance of mobile payment", *Industrial Management & Data Systems*, Vol. 114 No. 2, pp. 220-240.

Lim, H., Widdows, R. and Hooker, N.H. (2009), "Web content analysis of e-grocery retailers: a longitudinal study", *International Journal of Retail & Distribution Management*, Vol. 37 No. 10, pp. 839-851.

Liu, F., Zhao, X., Chau, P.Y.K. and Tang, Q. (2015), "Roles of perceived value and individual differences in the acceptance of mobile coupon applications", *Internet Research*, Vol. 25 No. 3, pp. 471-495.

Liu, X., Tang, O. and Huang, P. (2008), "Dynamic pricing and ordering decision for the perishable food of the supermarket using RFID technology", *Asia Pacific Journal of Marketing and Logistics*, Vol. 20 No. 1, pp. 7-22.

Luo, J.N., Yang, M.H. and Huang, S-Y. (2016), "An Unlinkable Anonymous Payment Scheme based on near field communication", *Computers and Electrical Engineering*, Vol.49, pp. 198-206.

Mainetti, L., Mele, F., Patrono, L., Simone, F., Stefanizzi, M.L. and Vergallo, R. (2013), "An RFID-based tracing and tracking system for the fresh vegetables supply chain", *International Journal of Antennas and Propagation*, Volume 2013.

Martínez-Sala, A.S., Egea-López, E., García-Sánchez, F. and García-Haro, J. (2009), "Tracking of Returnable Packaging and Transport Units with active RFID in the grocery supply chain", *Computers in Industry*, Vol.60 No.3, pp. 161-171.

Michael, K. and McCathie, L. (2005), "The Pros and Cons of RFID in Supply Chain Management", paper presented at the International Conference on Mobile Business (ICMB'05), 11-13 July, Sydney, Australia.

Morganti, E., Dablanc, L. and Fortin, F. (2014), "Final deliveries for online shopping: The deployment of pickup point networks in urban and suburban areas", *Research in Transportation Business & Management*, Vol.11, pp. 23-31.

Narsimhalu, U., Potdar, V. and Kaur, A. (2015), "A Case Study to Explore Influence of Traceability Factors on Australian Food Supply Chain Performance", *Procedia-Social and Behavioral Sciences*, Vol.189, pp. 17-32.

Pan, Y., Nam, T., Ogara, S. and Lee, SS. (2013), "Adoption model of mobile-enabled systems in supply chain", *Industrial Management & Data Systems*, Vol. 113 No. 2, pp. 171-189.

Pham, T-T. T. and Ho, J.C. (2015), "The effects of product-related, personal-related factors and attractiveness of alternatives on consumer adoption of NFC-based mobile payments", *Technology in Society*, Vol. 43, pp. 159-172.

Prater, E., Frazier, G.V. and Reyes, P.M. (2005), "Future impacts of RFID on e-supply chains in grocery retailing", *Supply Chain Management: An International Journal*, Vol.10 No.2, pp.134-142.

Salo, J. (2007), "Business relationships redesign with electronic commerce tools. An empirical investigation", *Business Process Management Journal*, Vol. 13 No.4, pp. 488-502.

Sarac, A., Absi, N. and Dauzère-Pérèz, S. (2010), "A literature review on the impact of RFID technologies on supply chain management," *International Journal of Production Economics*, Vol. 128 No.1, pp. 77-95.

Sharma, S. and Patil, S.V. (2011), "Development of Holistic Framework Incorporating Collaboration, Supply-Demand Synchronization, Traceability and Vertical Integration in Agri-Food

Supply Chain", *International Journal of Information Systems and Supply Chain Management*, Vol. 4 No.4, pp.18-45.

Shi, J., Zhang, J. and Qu, X. (2010), "Optimizing distribution strategy for perishable foods using RFiD and sensor technologies", *Journal of Business & Industrial Marketing*, Vol.25 No.8, pp.596-606.

Shieh, L-F., Chang, T-H., Fu, H-P., Lin, S-W. and Chen, Y-Y. (2014), "Analyzing the factors that affect the adoption of mobile services in Taiwan", *Technological Forecasting & Social Change*, Vol. 87, pp. 80-88.

Song, J., Sawang, S., Drennan, J. and Andrews, L. (2015), "Same but different? Mobile technology adoption in China", *Information Technology & People*, Vol. 28 No. 1, pp. 107-132.

Sterman, J.D. (2000), *Business Dynamics: systems thinking and modeling for a complex world*, McGraw – Hill, Boston, MA.

Teo, A-C., Tan, G. W-H., Ooi, K-B., Hew, T-S. and Yew, K-T. (2015), "The effects of convenience and speed in m-payment", *Industrial Management & Data Systems*, Vol. 115 No.2, pp. 311-331.

Thakur, R. and Srivastava, M. (2014), "Adoption readiness, personal innovativeness, perceived risk and usage intention across customer groups for mobile payment services in India", *Internet Research*, Vol.24 No.3, pp. 369 -392.

Thi, H., Tran, T. and Corner, J. (2016), "The impact of communication channels on mobile banking adoption", *International Journal of Bank Marketing*, Vol. 34 No.1, pp. 78-109.

Todorovic, V., Neag, M. and Lazarevic, M. (2014), "On the Usage of RFID Tags for Tracking and Monitoring of Shipped Perishable Goods", *Procedia Engineering*, Vol.69, pp.1345-1349.

Upadhyay, P. and Chattopadhyay, M. (2015), "Examining mobile based payment services adoption issues", *Journal of Enterprise Information Management*, Vol. 28 No.4, pp. 490-507.

Yadav, R., Sharma, S. K. and Tarhini, A. (2016), "A multi-analytical approach to understand and predict the mobile commerce adoption", *Journal of Enterprise Information Management*, Vol. 29 No. 2, pp. 222-237.

Yang, S., Lu, Y., Gupta, S., Cao, Y. and Zhang, R. (2012), "Mobile payment services adoption across time: An empirical study of the effects of behavioral beliefs, social influences, and personal traits", *Computers in Human Behavior*, Vol. 28 No.1, pp. 129-142.

Yang, Y., Liu, Y., Li, H. and Yu, B. (2015), "Understanding perceived risks in mobile payment acceptance", *Industrial Management & Data Systems*, Vol. 115 No.2, pp. 253-269.

Zhang, M. and Li, P. (2012), "RFID Application Strategy in Agri-Food Supply Chain Based on Safety and Benefit Analysis", *Physics Procedia*, Vol. 25, pp.636-642.

Zhou, T. (2014), "Understanding the determinants of mobile payment continuance usage", *Industrial Management & Data Systems*, Vol. 114 No.6, pp. 936-948.
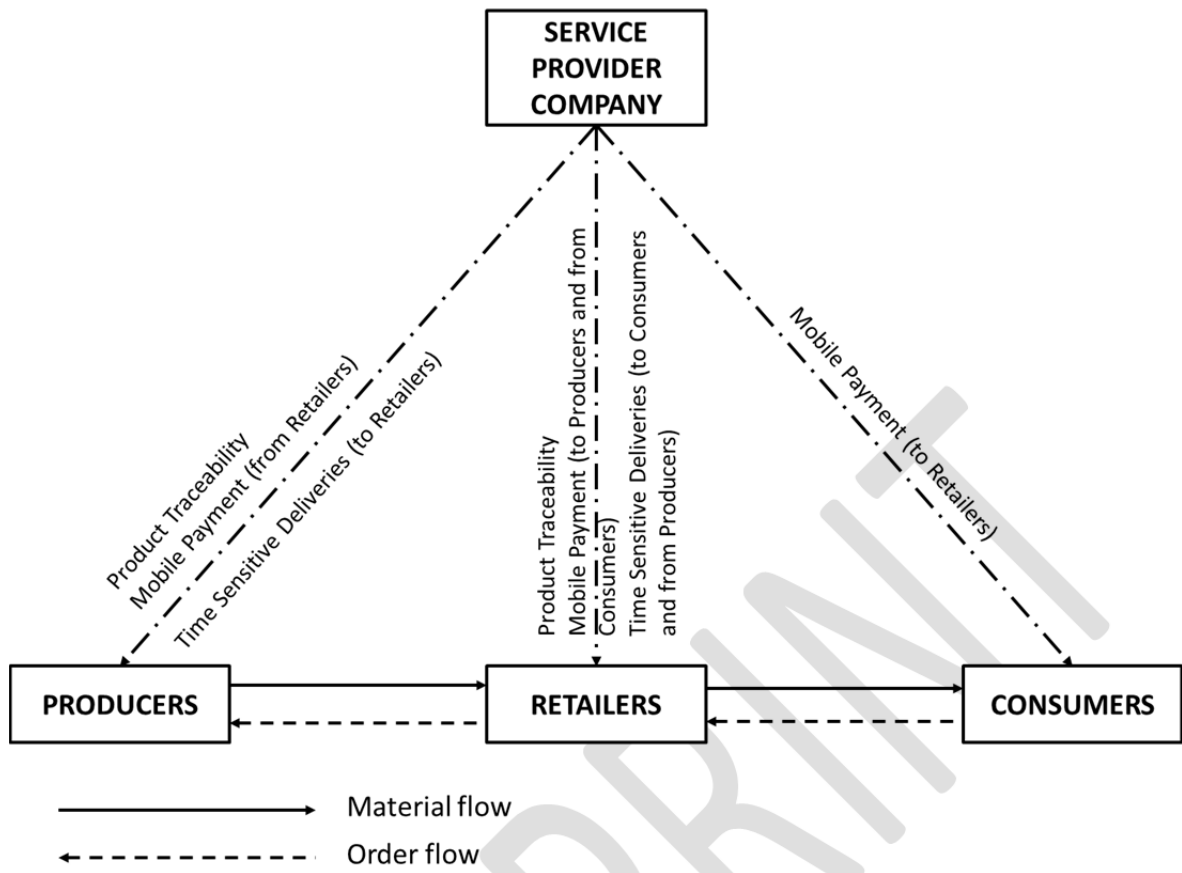
Figure 1. Supply chain overview of the additional services
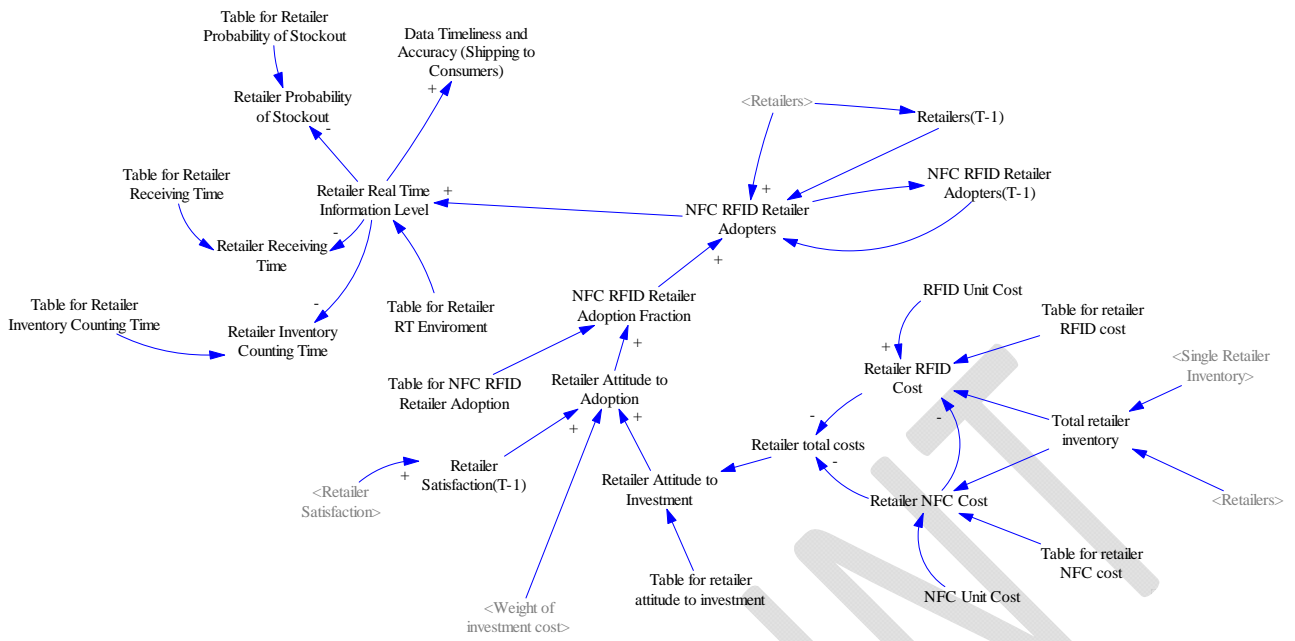
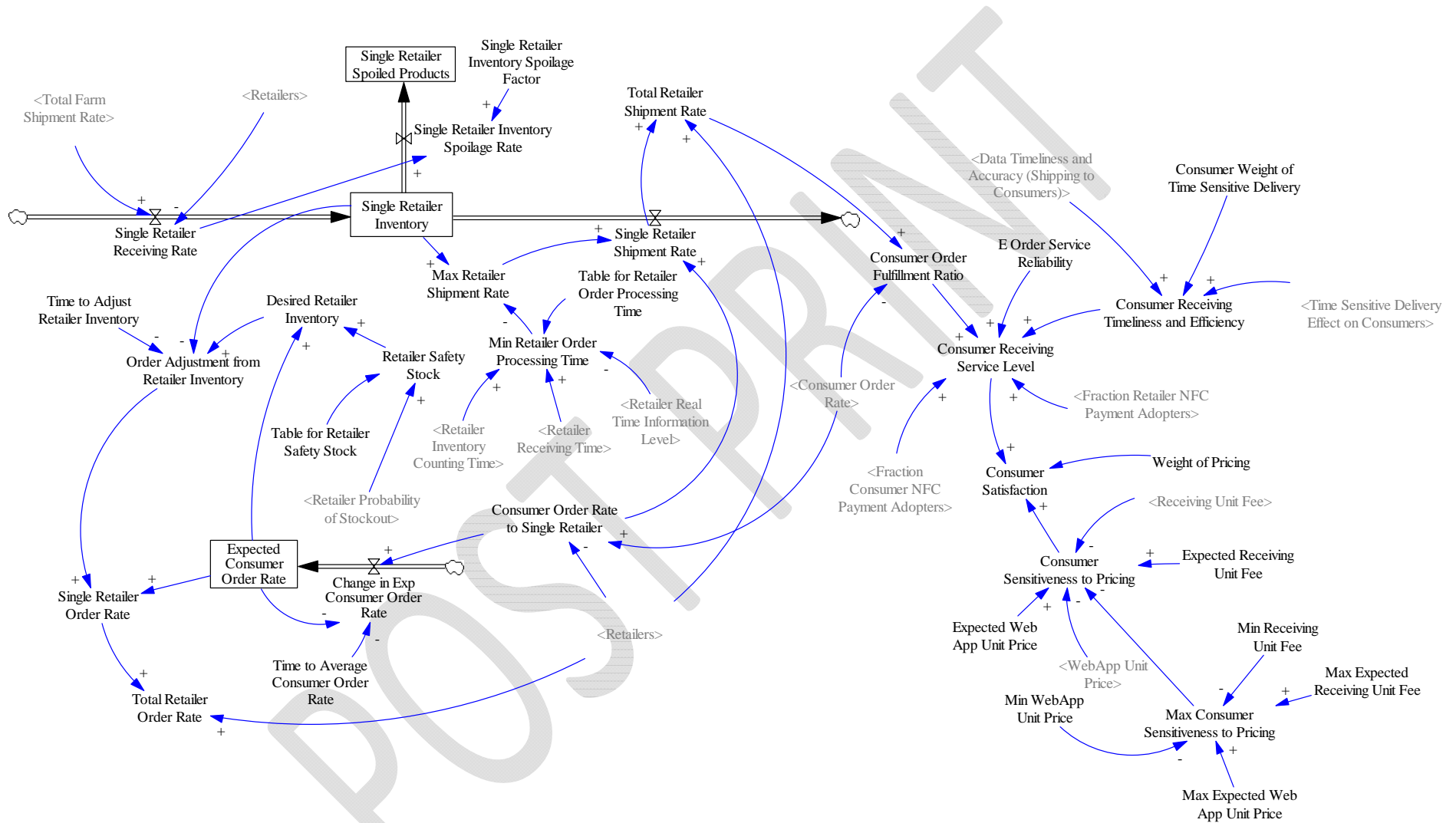**Figure 2. "Retailer Product Traceability Adoption" sub-model**

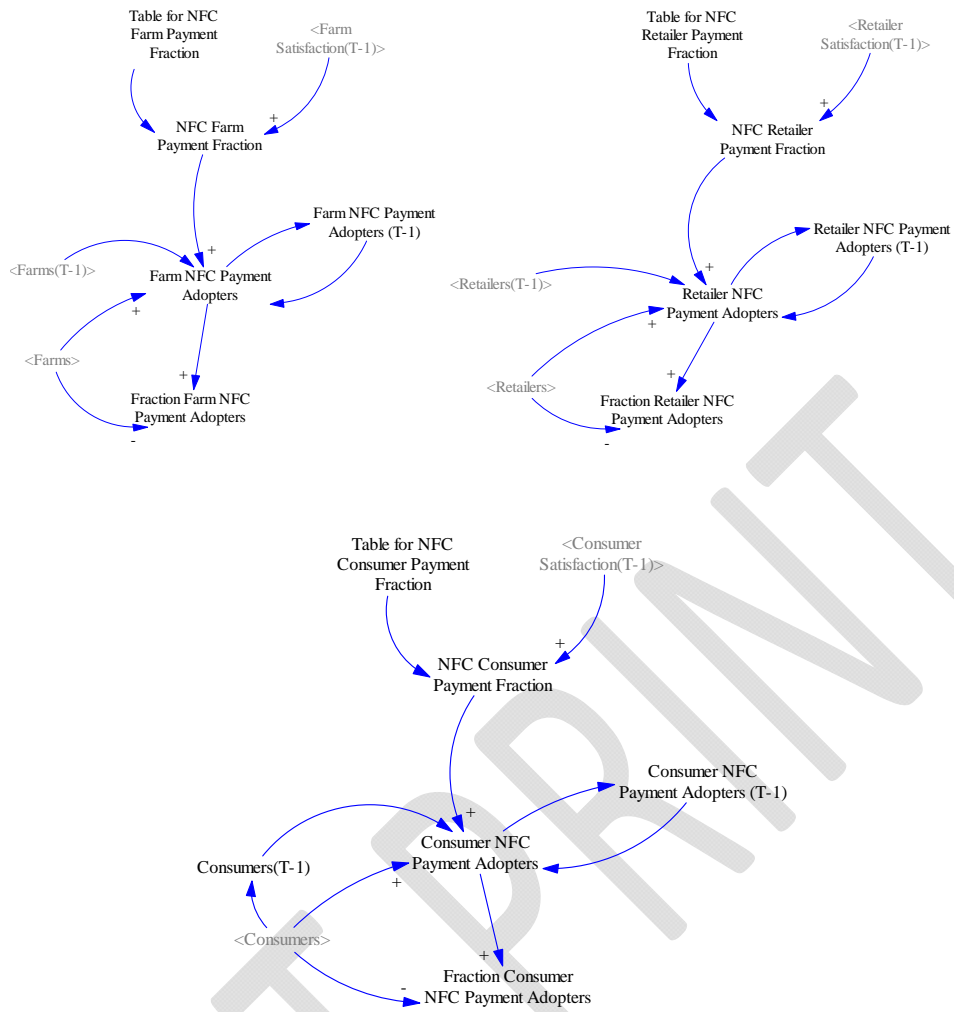**Figure 3. "Retailer Inventory and Consumer Satisfaction" sub-model**

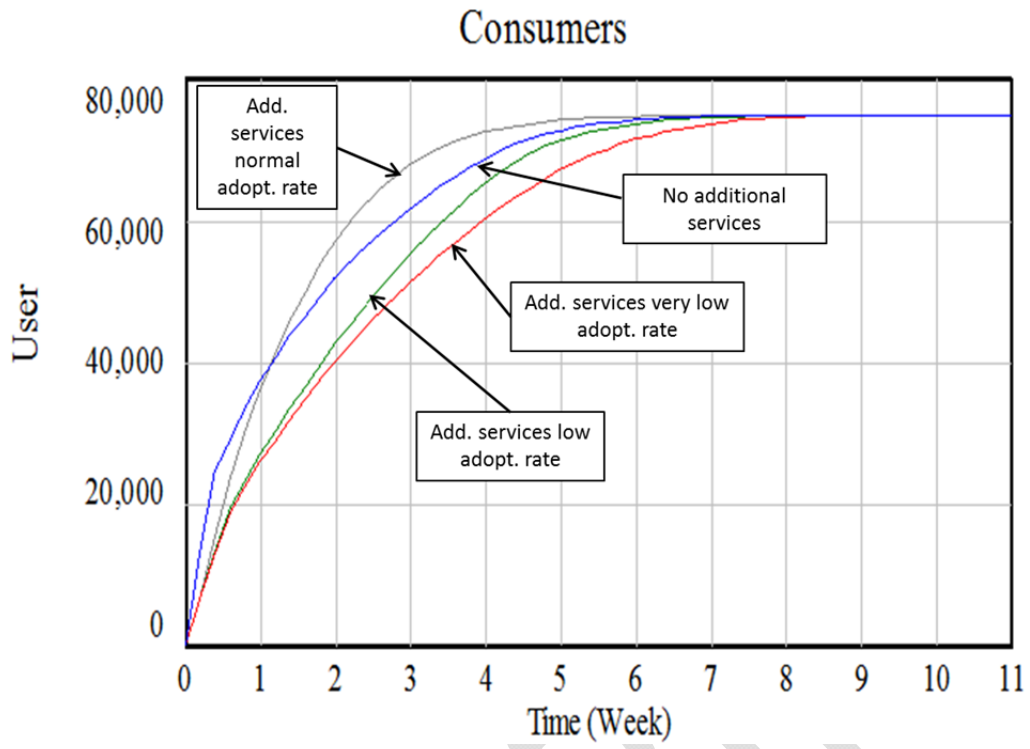**Figure 4. "NFC Payment Adoption" sub-model**

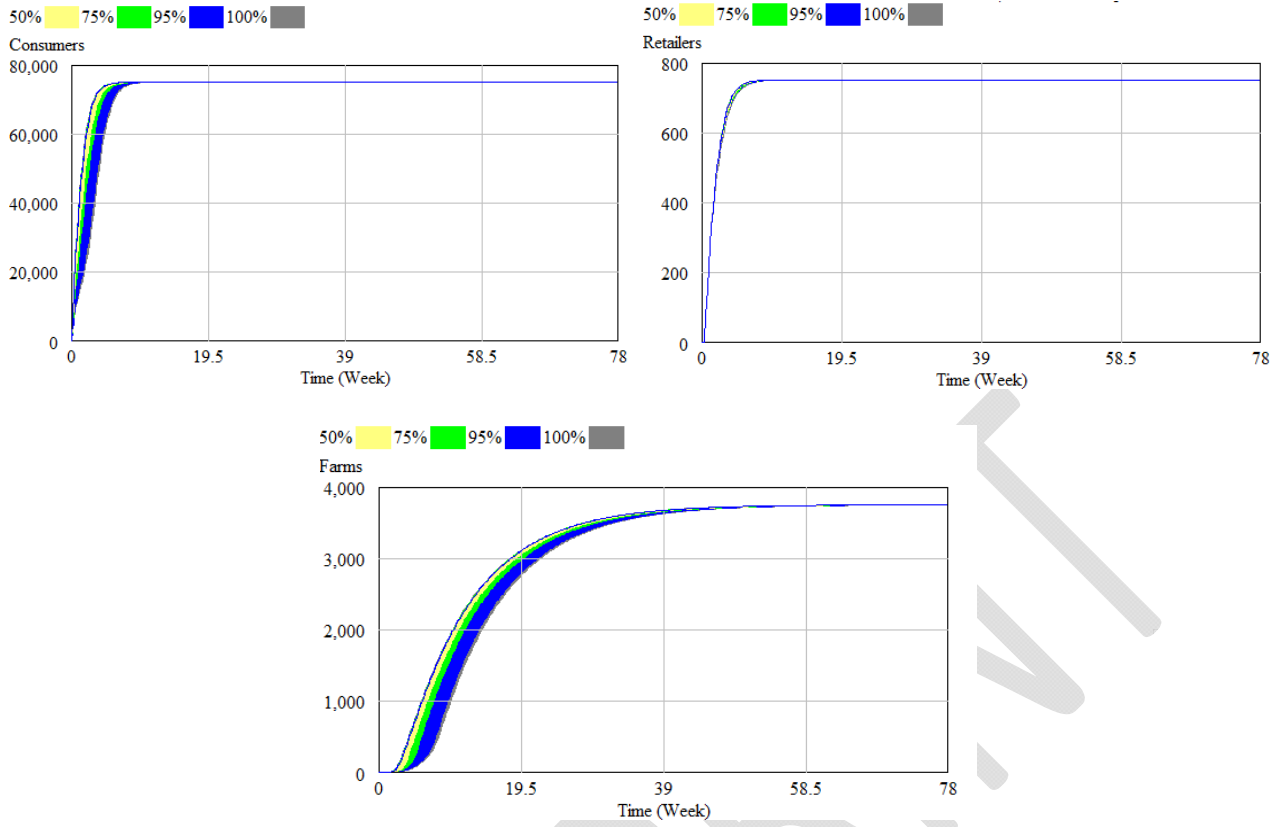**Figure 5. Comparing the base application diffusion among consumers**

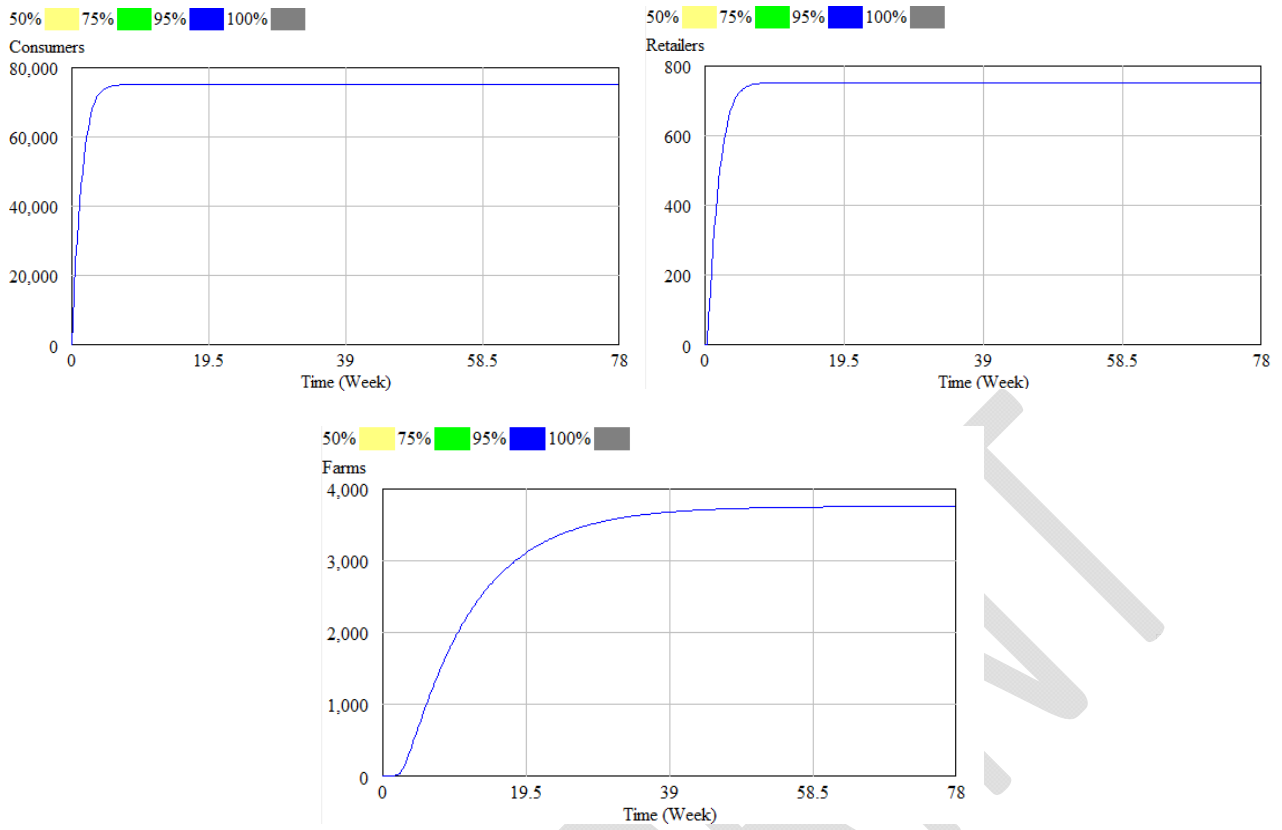**Figure 6. Sensitivity analysis on efficiency and reliability parameters**

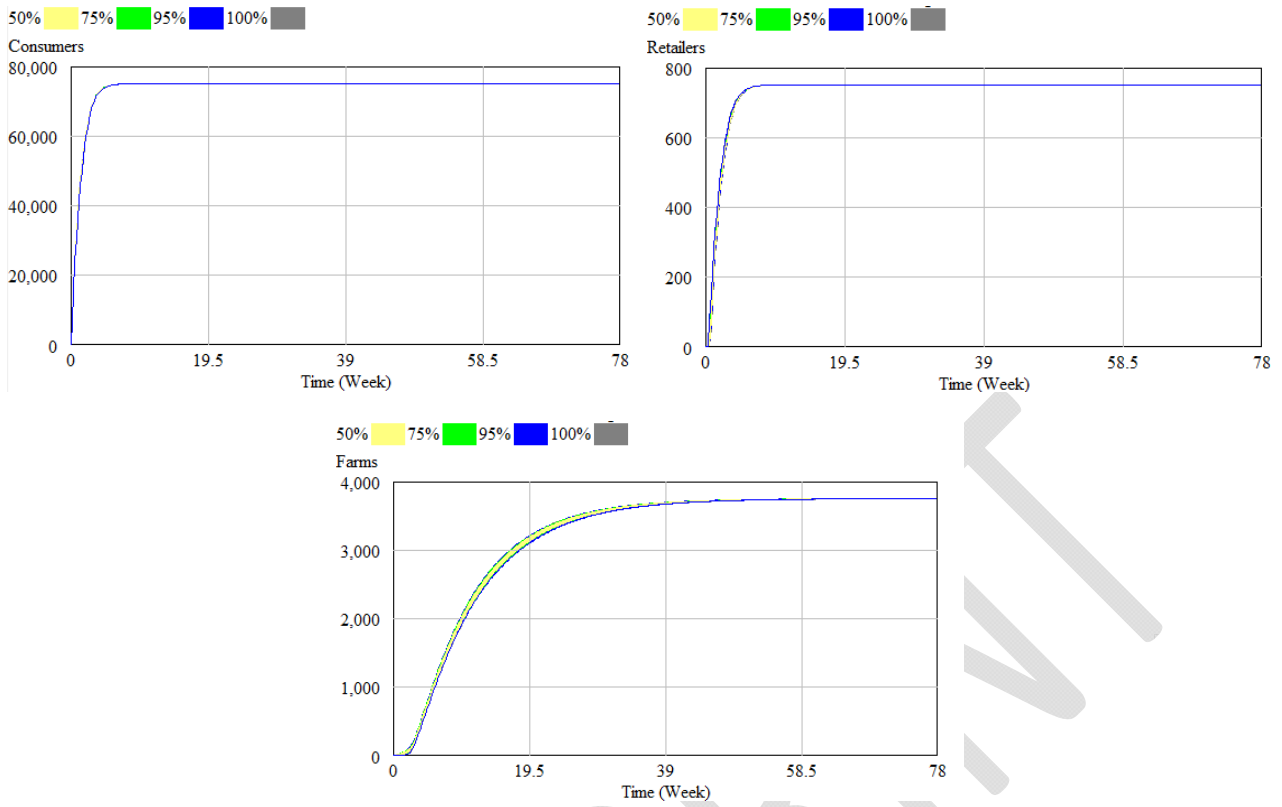**Figure 7. Sensitivity analysis on pricing parameters**

Figure 8. Sensitivity analysis on "Provider-Farm Advertising Effectiveness" parameter