The Impact of Information Technology on the Six "Ts" of Supply Chain Management

Completed Research Paper

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ABSTRACT
Product recalls can highlight strengths and weaknesses in an organization's supply chain. To date, few studies have explored the role of information systems in the recall process. This study presents Roth et al. (2008)'s 6Ts of global recall effectiveness as a useful framework for assessing the role of information technology (IT) in the recall process. In this study, we use a qualitative methodology to capture the richness of this phenomenon. The results offer new insights into the value of IT in the recall process. We highlight diverse management strategies utilized by supply chain stakeholders during the recall process. In particular, we discuss important themes that emerged from the data analysis. We conclude with a discussion of the research and practical implications.

Keywords
Supply Chain Management, Information Technology, Six Ts, Product Recalls, Recall Effectiveness

INTRODUCTION
The manufacturing sector is a volatile environment; hence, it is important for supply chain managers to develop tools that enable stakeholders to adapt to emerging challenges and opportunities. One of the biggest challenges in this sector is managing product recalls. Product recalls can have an impact on a firm's reputation, sales and financial value. Areas such as the food industry continue to be under pressure of improving food safety, implementing efficient risk management and managing quality from farm to fork (Wang et al., 2009). Factors that affect recall announcements are the recall strategy (either proactive or reactive), the type of defect and the proximity of the recalling company to consumers (Marucheck et al., 2011; Hora et al., 2011).

Regarding the recall strategy, firms that develop a proactive strategy for managing recalls (i.e., voluntarily initiating a recall to prevent a public disaster) have a negative impact on the firm's perception than firms using a passive recall strategy (Yubo, Shankar, and Yong 2009). The proactive strategy is identified as a "last resort" strategy to protect the firm from potential financial losses. The proactive recall of one firm also causes financial losses for the entire industry of the recalled product, which can have a greater impact on the competitors than the manufacturer of the recalled product (Jarrell and Peltzman 1985). Frequently, it also causes consumers to lose confidence in the company.

Product recalls are an important element of supply chain management, especially in a global economy. However, few studies have looked at this specific process. According to (Roth et al. 2008) recalls are difficult because of issues related to the six "Ts" of supply chain management: traceability, transparency, time, trust, training and testability. This study explores the recall effectiveness of information technology by utilizing Roth et al. (2008)'s 6Ts of global recall effectiveness. To date, few studies have explored the role of information systems in the recall process. This study offers new insights into the value of information technology (IT) in the recall process.

BACKGROUND LITERATURE
Recall Process

As volatility continues to impact the strategies of organizations, product recalls have become a function for firms to address within the marketplace (Marucheck et al., 2011; Hora et al., 2011). The impact of recalls can reduce shareholder value and increase costs related to the recall process (Jarrell and Peltzman 1985, Lyles, Flynn, and Frohlich 2008). Recalls have

occurred within food, automotive, pharmaceutical, toys and medical devices. Issues that impact recalls are the expansion of globalization of sources, consolidation of firms and commoditization of products (Roth et al., 2008).

Researchers have explored diverse elements of recall strategies such as proactive and reactive strategies, the type of defect, the proximity of recalling company is to consumers and product-harm crises (Haunschild and Rhee 2004, Yubo, Shankar, and Yong 2009). The literature identified the importance of developing proactive strategies to reduce costs and identify issues within the product development process. Product security within areas such as the food industry has not been a high priority due to the concern of reducing costs to address price demands from customers (Voss et al. 2009). The food industry continues to be under pressure to improve food safety, implement efficient risk management and manage quality from farm to fork (Wang et al., 2009).

Roth et al. (2008) identified traceability, transparency, time, trust and training as traits needed to improve recall processes. When recalls are conducted, the *traceability* and *transparency* of products is important to consumers in terms of determining product contents and their origin (Roth et al., 2008). Gaining visibility within production facilities and supply chains provides governing agencies the ability to determine the source of recalls. This is difficult to trace because products are processed or assembled through a multi-tiered and multichannel supply chain with multiple subcontract partners. One of the issues in this process is the lack of information technology and captured knowledge (Roth et al., 2008). This decreases government agencies ability to determine issues through the supply chain. All partners throughout the supply chain may not be required to have information technology capability needed to process documents and information needed to identify components responsible for the recall.

Another component that complicates a product recall is *testing* products and managing time constraints within the supply chain. Components such as electronics and other durables are easier to test, but ingredients and contaminations within food are not due to testing procedures that can be destructive to the product (Roth et al., 2008). Enterprise information systems tools such as Enterprise Resource Planning (ERP), Transportation Management Systems (TMS) and Warehouse Management Systems (WMS) can assist in determining the need for testing products that are in need of testing. Although this doesn't complete testing needs of perishable products, it can assist with identifying products in need of testing. It also identifies areas where testing is needed. Roth et al. (2008) identified additional chances of contamination after inspections of food products are completed.

Another component that complicates recalls is the *time* components involved assessing of product quality in the supply chain management process. There are several time metrics that are relevant to the supply chain, including time in transit, time between discovering and reporting issues and the time allowed for recovery of damaged or contaminated goods within the supply chain (Roth et al., 2008). Identifying potential areas that could extend lag periods can allow the supply chain to develop strategies. These strategies would divert products in optimized routes to final destinations while reducing opportunities of contamination due to extended lag periods due to constraints. A potential solution would be implementing IT solutions previously mentioned (ERP, TMS and WMS) to identify potential contamination periods when perishable items are in transit. These issues can be submitted to regulation agencies to prevent perishable and non-perishable items from matriculating through the supply chain.

Enablers are enhanced with the implementation of IT applications. Information technology applications can enhance traceability and transparency. Supply chain partners can enhance *trust* through the use of IT applications. One of the major issues in building a proactive supply chain is the lack of shared values between supply chain partners (Roth et al., 2008). As these applications are used to trace products and develop visibility, relationships can be strengthened between the supply chain and through regulation agencies. *Training* personnel to utilize IT applications within organizations can enhance the supply chain. As supply chains struggle with the wide range of education levels and culturally based behaviors (Roth et al, 2008), IT can be used to standardize procedures and reduce time needed for training.

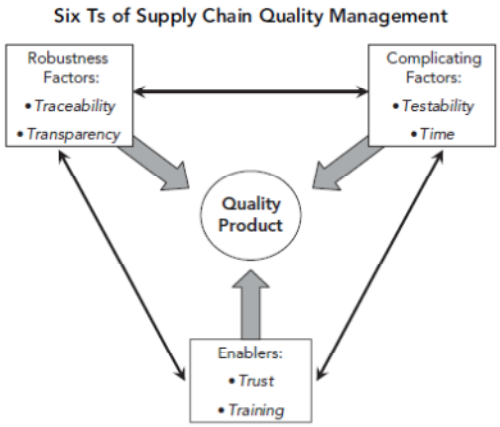

Figure 1. The Six "Ts" of Supply Chain Quality Management (Roth et al., 2008)

Information Systems & Product Recalls

Organizations have looked to information technology (IT) to assist in improving productivity (Cooper, Lambert, and Pagh 1997, Evans and Wurster 1997, Derocher and Kilpatrick 2000, Sabherwal and Chan, 2001) and a competitive advantage (Byrd and Turner 2001). In addition to this research, researchers have called upon additional research in supply chain management and information technology to gain an understanding of the relationship between the two entities (van Donk, 2008). Additional literature has identified sharing information in the supply chain can improve supply chain performance (Myers and Cheung 2008, Griffith and Myers 2005, Forslund 2007, Bartlett, Julien, and Baines 2007, Thatte 2007, Zhang and Wang, 2011).

Wittenberger and Dohlman (2010) reviewed the salmonella outbreak within peanut butter manufacturers in 2009. The research identified the process related to the challenges of regulatory agencies identifying products that were related to the contaminated peanut butter. Although the contaminated peanut butter from the Peanut Corporation of America was two percent of the market, the contaminated peanut butter contaminated more than 3,000 products. Despite the announcements made through the media, there was a challenge in the identification of products with peanut butter tainted with salmonella within an effective manner. One of the issues identified in the literature was the communication between regulatory agencies and firms identified with tainted products. Despite the communication between the entities, there seem to be a lack of communication between the all supply chain participants (Akkermans et al. 2003). Insufficient communication can lead to poor performance within the supply chain. In this case, the poor communication within a recall process can create issues with food security and corporate stability (Akkermans et al. 2003). Fawcett et al. (2007) identified found dimensions (connectivity and willingness) of information sharing have an impact supply chain management performance. Fawcett et al (2011) and Vanpouke et al. (2009) found that substantial IT investments do not provide the desire of improved supply chain management performance. Information systems can be used to help improve communication among supply chain stakeholders.

METHODOLOGY

We utilized a qualitative methodology to assess the impact of information systems on the Six Ts of supply chain management. Qualitative research facilitates in-depth analysis of complex, contemporary and under researched activities (Yin, 2009). In light of the sparse research on the role of information technology on product recalls, this methodology was ideal. Hence, we conducted case studies of five companies to explore the role of information technology on the 6Ts of supply chain management. The interview questions were adapted from Fryling (2010). We identified various open ended questions that enabled the interviewee to present his perception of the recall process. The interview questions and company information are provided in the Appendix. The ability of the firm to trace recall products was assessed through recall effectiveness questions. Transparency was assessed using IT, recall effectiveness and knowledge of supply chain effectiveness questions. Testability, Time, Trust and Training were explored using all questions within the interview.

The sample consisted of a convenient sample of professionals in diverse industries. Interviews were scheduled and respondents were contacted via telephone (Kumar, 2005; Salant and Dillman, 1994). A total of five interviews were conducted with seven managers (two companies allowed us to interview two managers). During the semi-structured interviews, we interviewed mid-level managers from firms that had history with managing recalls with regulatory agencies.

Two respondents were logistics service providers; one participant was in the medical devices industry; one participant was from the telecommunications industry; and the remaining participants were in the consumer goods industry).

Two members of the research team participated in each interview. The interviews were between twenty to thirty minutes in length. The researchers asked the respondents questions and transcribed their responses. After interviews were completed, the researchers reviewed the transcribed responses through post interview conversations and editing of transcribed comments to ensure reliability.

The unit of analysis is the company. Company size ranged from 10, 000 to 170,000 employees and total assets from $4- $37 billion. Depending on industry, the total time to complete a recall ranged from under 24 hours (in the consumer goods industry) to 30 days (in the telecommunications industry).

FINDINGS

Traceability

Traceability at the firm level has a major impact on recall effectiveness. The recall process is conducted differently in different organizations. For instance, one respondent in the telecommunications industry stated:

> *A problem of the recall system at organization is the absence of a closed loop system. Only 40% of recall products were collected from customers. It is important for assets to be collected. However, there aren't many recalls in the organization (telecommunications industry). Since there are no urgent issues involving telecommunications products, there is no sense of urgency to collect product.*

The respondent also mentioned the importance of recall assurance as a tool to ensure the firm receives credit from suppliers. Another respondent in the snack food industry stated his firm has an internal and external process for recalls. He said:

> *If there is contamination of units and it is identified in the facility, products that contain the identification of the contaminated product are identified and removed. An enterprise resource planning (ERP) system is also used to identify the source of the contaminated item and the supplier of those items. If the contaminated product(s) are being delivered to a supply partner, the carrier of the products are identified and rerouted for return. If the products are being used in additional products, the supply partner is informed to recall the product within their facility or from the retail partner.*

Surprisingly, one respondent in the consumer goods industry stated:

> *An ERP system in a recall environment is not of value. We just push information out to our suppliers. Lots of suppliers use EDI, some e-mail, but there is still some faxing in the process.*

Transparency

One respondent mentioned recalls are communicated using email and spreadsheets. The respondent mentioned that they have an ERP, but the application is used primarily for finance and accounting functions. The respondent also mentioned the need for an electronic footprint to improve visibility of products delivered to customers and retail partners. A participant in the snack food industry stated that an ERP is used to complete internal recalls within the manufacturing facility and the distribution center/warehouse. Managing recalls that are external to the facility and delivered to supply chain partners such as retailers or individual customers are difficult to manage because there is limited visibility of the products outside the facilities. Products delivered from suppliers are difficult to manage due to bulk sizes suppliers use to deliver products to the firm.

With regards to communication among supply chain members, the chosen media varies across industries. For instance, in food services respondents rely heavily on technology.

> *Communication is primarily done through e-mail. Once an email is sent out, it gets expedited. People recognize the importance of a recall and jump on the e-mails quickly.*

However, in the medical services industry recall announcements are handled very differently. The interviewee stated that the process is:

> *All paper based. The relationship with the physician is so critical. To e-mail [the announcement] would have been too cold. You have to deliver it personally.*

This respondent went on to say:

> *The only thing we get via email would be copies of letters that we have given to physicians and patients.*

Testability

Respondents with poor visibility with supply chain partners had difficulty testing components for contamination. One respondent mentioned the limitations of testing products after products have been shipped to consignees. He stated:

> *We can track products to consignees. However, there's a limitation in testing product beyond the consignee due to the lack of ability to trace products to small independent retailers. We do well with large retailers, but struggle to have small retailers comply with requirements.*

Another respondent also discussed issues with testing ingredients from suppliers due to bulk sizes. He posited:

> *It is difficult to test because we receive ingredients from the supplier hundreds of pounds at a time.*

Additional responses from snack food manufacturers included using third party groups to sample products to ensure successful recalls with retailers and implementing a dedicated recall team to identify contaminated ingredients from suppliers.

Time

Respondents with an ERP system integrated with their recall process decreased the time needed to recall products within the manufacturing facility and the warehouse. One group respondents mentioned the ability to interact with suppliers when the supplier of contaminated ingredients is identified. Firms with poor IT systems or poor integration of the recall process within the IT system experienced an extended time identifying and retrieving recalled product from supply chain partners. One respondent stated that the time to complete a recall:

> *…depends on the nature of the recall and [the] complexity.*

Trust

All respondents discussed the limited capability of interacting with supply chain partners. All communication is not automated. Their interaction with suppliers and customers is conducted using email and spreadsheets. Trust increases within the facility utilizing IT applications that are integrated within the organization. However, the respondents did not extend integration of their IT application to supply chain partners. Respondents have the desire to extend their IT applications through the supply chain to increase transparency and traceability, but the firm has not selected partners to develop this process. One respondent has a team to interact with suppliers, but did not integrate their IT application with the supplier nor the supply chain partners downstream. One respondent stated:

> *There is a non-IT linked process that establishes the risk profile of a product and we only buy from approved suppliers.*

Training

There were only a few comments on training. One respondent mentioned conducting mock recalls in regards to risk mitigation. Two respondents mentioned mock recalls are conducted if an actual recall has not occurred over a period of time as a method of preparedness for recalls. One respondent in the food services industry stated:

> *We have mock recalls on a regular basis. Every quarter we have a certain number of mock recalls. We do it throughout the supply chain and even on the manufacturer level.*

DISCUSSION

The findings from this study indicate the importance of IT applications such as ERPs to mitigate risk within the manufacturing and warehouse facilities. However, there are limited solutions to resolve issues of transparency, traceability, testability, time, trust and training. In addition, firms that manufacture, manage or deliver foods through the supply chain have more visibility within the supply chain compared to industry such as telecommunications. This is due to the proactive strategy to prevent announcements from regulatory agencies such as the US Food and Drug Administration. Firms that aren't affected by recall announcements of regulatory organizations have not invested in their IT applications enhancing recall procedures. Firm preparedness for recalls is dependent upon the recall and the repercussions of the experience. We posit that supply chain managers can take advantage of information technology tools to improve recall management. Considering

the wide array of products that are available to consumers, there isn't a one-size-fits-all approach to initiating and managing a recall. Depending on the type of product (car vs. medical equipment), there may be a different recall timeline and communication strategy. Respondents in different industries highlighted the benefits and limitations of the technology (email notification vs. a hand delivered letter). Based on participant feedback, the utilization of IT for recall management should not follow a one-size-fits-all approach. Hence, we posit that the task-technology fit model would be a useful tool for future exploration of this phenomenon. Based on the interview responses that we received, future research should integrate utilize theories that focus on the unique technology needs of diverse jobs and processes. For instance, the task-technology fit (TTF) model (Goodhue 1988) may be a valuable tool for exploring this phenomenon. Future studies should integrate TTF and Roth et al. (2008)'s six T's to evaluate the role of technology in the recall process. As indicated by the manager's interviewed in this study, the IT infrastructure and strategy that works for a retail company may not be appropriate for a company that sells medical devices. Future research is needed to explore this phenomenon.

The concept of fit was introduced by Lengel (1984), (Daft and Lengel 1986) and later extended by Goodhue and Thompson (1995) and Dishaw and Strong (1999). At the core of the task-technology fit model is the assumption that information systems provide value by aiding in the completion of some tasks and that this value will be reflected in user evaluations of the system. Hence, "the strongest link between information systems and performance impacts will be due to a correspondence between task needs and system functionality (task-technology fit) (Goodhue and Thompson 1995)." According to Goodhue and Thompson (1995) this link leads to positive user evaluations and positive performance impacts. Several studies have explored the role of task-technology fit in diverse contexts. Bouwman and Wijngaert (2009) explore the impact of both task-technology fit and technology acceptance factors on intention to use mobile applications. The results indicate that task-technology fit factors were more salient than technology acceptance factors. The authors posit that "future research should aim at developing models that take contextual and task-related factors into account."

Though initially introduced to measure the impact of fit between task and technology on performance at the individual level (Goodhue and Thompson 1995), Zigurs and Buckland (1998) extend the model to assess its impact on performance at the group level. In both cases, the fit between technology and task affects performance. Goodhue and Thompson (1995) found that technology deemed useful relative to the characteristics of the task can lead to improved performance. Past studies (Ting-Peng et al. 2007, Turban, Liang, and Wu 2011) have considered the match between the characteristics of technology and task in commerce-related implementations. They have found that the fit between task and technology can increase the utilization of electronic tools and services, while increasing task performance (Turban, Liang, and Wu 2011).

Limitations & Suggestions for Future Research

As with any research study there were limitations. There were a limited number of respondents that participated in the study. Conducting research regarding recalls of food or any other product can be difficult due to the negative image recalls have on firms. Findings from the study may be biased by researchers conducting and analyzing the case study interviews and are drawn from perceptions of a limited number of participants (Esper et al., 2007). More companies, particularly in the food and beverage industry should be examined through quantitative surveys or additional case studies.

The research focused on the role of IT applications in the recall process. The recalls were compared to research conducted by Roth et al. (2008) and found that IT applications can influence recall procedures within a specific organization. However, the effectiveness of IT applications tend to be reduces due to lack of implementation of the same six factors of supply chain management. Future research is needed to develop a framework regarding IT applications on recall effectiveness and the impact on supply chains within food, electronic, telecommunication and additional industries.

CONCLUSION

This study utilizes case analysis to explore the role of IT in Roth (2008)'s six "Ts" of the recall process. It makes initial observation on the impact of IT applications on recall effectiveness. It contributes to the existing literature by 1) discussing the role of IT on the 6Ts, 2) highlighting an interesting theme that emerged from interviewing middle-level supply chain managers: the importance of task-technology fit and 3) calling for future research that integrates these two research streams. Based on participant feedback, the utilization of IT for recall management should not follow a one-size-fits-all approach. Instead, firms in diverse industries have varied technological needs. Future research should employ the task-technology fit model to explore which IT applications would be most beneficial to diverse supply chain stakeholders.

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Appendix - Interview Questions

Category	Question
General	How many product recalls has your firm been involved in during the past year, 2 years, 3 years?
General	Describe the general product recall procedure your firm follows including who you contact, presence of a formal recall center, etc….
Recall Effectiveness	How quickly is your firm able to initiate and complete a recall after a reason is discovered?
Recall Effectiveness	How do you define a "complete" recall? When all product has been collected from supply chain partners or the remaining product that has not been purchased/consumed? Is there a goal to collect a certain percentage?
Recall Effectiveness	How do you verify with supply chain partners that recalled product has truly been removed from the shelf of retailers?
Recall Effectiveness	Have your partners adapted standards (i.e. GS1) to improve the recall process? If not, do you have plans to implement industry standards?
Information Technology	Describe the management information systems your firm uses to communicate recall information to suppliers, to customers, to service providers, and to consumers. Are EDI or ERP applications used to communicate with supply chain partners during recalls?
Information Technology	Is your firm capable of tracking recalled product through the complete supply chain cycle? How do you track product (i.e., by brand, SKU number, RFID, etc…)If not, which tiers within the supply chain have been challenging in accessing information to track your product? Can the challenges be contributed to ineffective IT applications?
Information Technology	What type of technology do you use to determine that a recall may be necessary? If technology isn't used, does your supply chain rely upon government agencies to detect recalls?
Information Technology	Do you employ an IT application (i.e. ERP) that allows your firm to determine the relative risk of a supplier with regard to the probability that any given supplier's product may be at higher risk to cause a recall of your product? If so, describe. If not, do you classify suppliers by risk in some other manner to create a risk matrix?
Knowledge of Supply Chain Structure/Characteristics	How would you describe your upstream and downstream supply chain?
Knowledge of Supply Chain Structure/Characteristics	Do you feel you have enough knowledge of your downstream supply chain to recall 100% of your product if needed?
Knowledge of Supply Chain Structure/Characteristics	Do you feel you have enough knowledge of your upstream supply chain to accurately determine any suppliers that may have potentially caused the recall?
Knowledge of Supply Chain Structure/Characteristics	Does your firm keep an updated database of all carriers used to move product to and from your facility? Is this knowledge integrated/shared through the organization?

Risk Mitigation Strategy	Does your firm employ a formal recall plan based on commodity, distribution channel, etc…? If so, is this plan tested though simulations and table top exercises?
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Risk Mitigation Strategy	Has your firm made contact with all applicable internal and external parties (e.g., government agencies, supply chain partners, etc.) prior to an actual recall?