Testing the Potential of RFID to Increase Supply-Chain Agility and to Mitigate the Bullwhip Effect

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ABSTRACT
This study examines the potential of RFID technology to increase the agility of supply-chain e-commerce systems by mitigating the bullwhip effect. The bullwhip effect is a supply-chain phenomenon that reveals a lack of business agility characterized by the amplification of inventory variance. This study employs an experiment involving a modified Beer Distribution Game to simulate an RFID-enabled supply chain. The results provide empirical evidence that RFID technology can increase a supply chain’s agility and reduce the bullwhip effect by reducing inventory holding costs, stockout costs, and inventory-level variances. The results are all the more important when applied to interorganizational e-commerce systems.

Keywords: Beer Distribution Game, Bullwhip Effect, E-Commerce, Information Systems, Interorganizational Systems, RFID, Supply-Chain Agility

INTRODUCTION
Given the volatile nature of markets and increasingly dynamic performance requirements of business, agility is one of the challenges to international business (Van Hoek, Harrison, & Christopher, 2001). Agility is a vital characteristic that companies need in order to sustain their competitive advantage in the new order of world business (Sharifi & Zhang, 2001). This is especially true with the more complex, rapid, and integrated nature of e-commerce, where solving supply-chain issues is paramount, such as with interorganizational systems where companies share information about their supply chains and other data (Chi, Holsapple, & Srinivasan, 2007; Hsu, Kraemer, & Dunkle, 2006). Finding ways to proactively manage the supply-chain electronically and to reduce uncertainty has long been a key goal of e-commerce (Bodendorf & Zimmermann, 2005; Ho, Chi, & Tai, 2005). We

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posit that RFID is a key technology that will help with this proactive management.

RFID technology has received much attention in recent years as major manufacturers such as Wal-Mart, Gillette, Target, the U.S. Department of Defense, Albertsons, Best Buy, and hundreds of others have committed themselves to incorporating this technology into their supply-chain information systems in an effort to increase the agility of these systems and gain a competitive advantage (Kinsella, 2003, 2005). Agility leading to competitive advantage is particularly critical with e-commerce, where pressure on trading partners can be enormous with interorganizational systems (Hsu, et al., 2006). For example, as of January 2005, Wal-Mart has required its top 100 suppliers to utilize RFID technology at the pallet level for products entering its distribution system. Experts have estimated that Wal-Mart could save $8.4 billion a year when its RFID system is fully implemented (Roberti, 2003). These savings include $6.7 billion in reduced labor costs, $600 million in out-of-stock supply-chain cost reduction, $575 million in theft reduction, $300 million in improved tracking through warehousing and distribution centers, and $180 million in reduced inventory holding and carrying costs (Asif & Mandviwalla, 2005). Leading UK retailer Marks & Spencer field-tested RFID by tagging 3.5 million storage bins. Formerly it took approximately 17.4 minutes to scan 25 trays with barcodes. With RFID tags, 36 pallets were read in 3 minutes (Wilding & Delgado, 2004).

Because Radio Frequency Identification (RFID) is a technology with the potential to increase the agility of traditional supply chains and interorganizational supply chains, RFID has strategic and global implications for e-commerce. Because of its range of applications and its increasing adoption, RFID technology is a potentially strategically disruptive technology that can change many information management and supply-chain practices. Proponents claim that RFID technology can potentially enable supply-chain managers to overcome problems caused by imperfect or insufficient information inherent in current inventory management systems (e.g., Asif & Mandviwalla, 2005). One way strategic advantage can occur with RFID is that RFID “increases the feasibility of implementing alliances of firms that exchange information to coordinate production and distribution, outsource functions and services, and partner with suppliers and intermediaries” (Straub, Rai, & Klein, 2004).

Of particular interest to this study is the concept that RFID technology can potentially increase the business agility of inventory supply chains by mitigating what is known in supply-chain management circles as the bullwhip effect (Asif & Mandviwalla, 2005; Lee, Padmanabhan, & Whang, 1997b). The bullwhip effect is a supply-chain phenomenon in which suboptimal inventory order levels occur due to the amplification of imperfect information as it is transmitted through the supply chain (Lee, et al., 1997b). Amplified order variance caused by distorted information, in turn, results in alternating inventory stockouts and surpluses that cause large cost inefficiencies (Steckel, Gupta, & Banerji, 2004). This phenomenon directly relates to business agility in using information systems to increase supply-chain coordination (Bowersox, Closs, & Stank, 2000).

RFID tags provide each tier of a supply chain with accurate, real-time information about inventory levels along the supply chain. This information can increase supply chain agility and decrease the bullwhip effect by helping prevent information distortion. Although the technical merits of RFID tags are well documented, because RFID technology is still emerging, there is little available information that examines the extent of RFID technology’s capability to mitigate the bullwhip effect.

The wireless technology involved with RFID is proven and can be mass produced. However, what is not fully known or proven are the effects that RFID can have on information in a supply chain. The object of this study is to examine the effect that can result from the bi-directional flow of supply-chain information using RFID. Accordingly, this study presents hypotheses and an experiment in an effort to

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