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LOGISTICS INFORMATION TECHNNOLOGY ADOPTION: THE EFFECT OF A POSITIVE BUYER-SUPPLIER RELATIONSHIP ON PERFORMANCE OUTCOMES

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Abstract

Extant literature is inconclusive regarding how adoption of logistics information technology affects various measures of performance. We propose that an organization's adoption of logistics information technology is positively related to increased levels of efficiency, effectiveness, and flexibility and contrary findings may be partially attributed to the moderating role of a positive buyer-supplier relationship. A meta-analysis approach is used to investigate popular logistics information technologies, specifically EDI and RFID, and evidence in support of these relationships is uncovered. The results suggest the inclusion of additional constructs to an existing logistics innovation model. The implications of these findings are discussed and further research is recommended.

Keywords: logistics, innovation, radio frequency identification, electronic data interchange, meta-analysis, buyer-supplier relationship

1 INTRODUCTION

Information technology (IT) has emerged as one of the most popular categories of technological innovation being implemented in the supply chain (Russell & Hoag 2004). Although some firms have reported positive results from adoption of IT, implementation can be risky and expensive, especially if the ramifications and outcomes of such innovations are not fully understood by the adopting firm (Heinrich & Simchi-levi 2005). Considering the Council of Supply Chain Management's definition of logistics and Rogers' (2003) definition of innovation, we define a logistics information technology (LIT) innovation as an IT application that is perceived as new to the organization of adoption that is used for planning, implementing, and/or controlling procedures for the transportation and storage of goods and services from the point of origin to the point of consumption. Organizations looking to adopt LIT are often interested in understanding how adopting such technologies will aid in achieving positive operational and strategic benefits. However, inconsistent findings in the literature suggest that additional phenomena may moderate the relationship between LIT adoption and performance outcomes (Narayanan et al. 2009).

Like any innovation, firms generally adopt LIT for the purpose of realizing improvements in various measures of performance. However, the logistics arena may present a unique set of challenges because of the inherent inter- and intra-organizational interdependencies required for the effective transportation and storage of goods and services. Thus, adoption of LIT may not automatically translate into realized improvements in performance for the adopting firm. For example, a study of electronic data interchange (EDI) use in large German and US firms revealed a variety of conflicting findings regarding the benefits of adoption (Reekers 1994). Although EDI was demonstrated to improve trading partner communication, data accuracy, and customer service, other anticipated benefits such as reductions in inventory and reductions in paperwork were not demonstrated. One explanation for these inconsistencies may be found in lack of inter-organizational integration and/or forced adoption by firms with more powerful market position (Reekers 1994). This assertion is supported by the work of Riggins and Mukhopadhyay (1994) who also addressed coerced adoption and found that EDI benefits may be interdependent upon both trading partners. The importance of positive trading relationships alluded to above may be explained by social exchange theory, which views the exchange relationship between specific actors as being contingent upon rewarding reactions from others (Blau 1964). When one firm is coerced into adopting a collaborative technology that it believes will only benefit the other organization, then it may not be motivated toward successful implementation and usage. Conversely, firms who have cultivated a positive buyer-supplier relationship may view the adoption of a given LIT as mutually beneficial and thus put forth the effort and resources that are necessary for both firms to reap positive rewards. Unfortunately, empirical research to date has not addressed how positive buyer-supplier relationships may affect the performance outcomes realized via LIT adoption. Our research effort investigates the importance of these relationships for firms seeking to increase performance via adoption of LIT.

The resource-based view (RBV) of the firm suggests that capital resources may be utilized to create competitive advantage (Barney 1991). Although off-the-shelf information technologies usually do not directly induce competitive advantage, these technologies have been shown to provide capabilities that may lead to enhanced operational performance (Wade & Hulland 2004). This operational perspective is based on the argument that the first-order effects of IT innovation adoption occur at the functional/operational level via enhancing various aspects of efficiency, effectiveness, and flexibility (Barua et al. 1995; Grant 1991). However, when combined with additional organizational resources, adoption of off-the-shelf information technologies may provide a preliminary foundation for a firm to realize sustained competitive advantage (Mata et al. 1995; Nevo & Wade 2010; Ray et al. 2005). Thus, the RBV perspective provides an adequate context in which to examine the complimentarity of LIT adoption and positive buyer-supplier relationships.

The purpose of this study is two-fold. First, this study investigates the relationship between LIT adoption and performance outcomes via consolidating existing research. Accordingly, this study asks:

RQ 1: Does LIT induce positive performance outcomes for the adopting firm?

Second, this study investigates whether the presence of a complimentary firm resource, specifically a positive trading relationship, may enhance the performance outcomes realized by LIT adoption. As such, our second research question is:

RQ 2: How does a positive buyer-supplier relationship affect the relationship between LIT adoption and performance outcomes?

To further develop these questions and describe the outcome of our investigation, the remainder of this manuscript is organized as follows. First, we review relevant background literature and develop hypotheses. The review begins with a discussion of diffusion of innovation theory with an emphasis on logistics innovation. The artifacts used to characterize LIT, namely EDI and radio frequency identification (RFID) are then introduced. Next, the expected performance outcomes of LIT adoption as cited in the literature are briefly discussed, which leads to development of our first set of hypotheses. Our conversation then turns to the proposed moderating role of positive buyer-supplier relationships, which leads to our second set of hypotheses. We then discuss the meta-analytic methods employed in this study to illustrate how extant empirical literature is utilized for analysis. The results of the research are then presented. Finally, we discuss the findings, to include practical and theoretical implications, and end with a discussion of limitations and recommendations for future research.

2 BACKGROUND LITERATURE AND HYPOTHESES

2.1 Logistics innovation

Everett Rogers (2003) offers a generalized model of the innovation diffusion process, which has been used extensively as the basis of innovation research in the supply chain management (SCM) field. For example, Skipper et al. (2009) examine the relationship between Rogers' antecedents of innovation adoption (relative advantage, compatibility, ease of use, trialability, and observability) and a firm's adoption of supply chain contingency planning processes, extending Rogers' work by proposing two additional antecedents (top management support and centralization) from extant management information systems (MIS) literature (Moore & Benbasat 1991; Tornatzky & Klein 1982). In addition, the IT implementation model (Kwon & Zmud 1987; Zmud & Apple 1992) has been used by a variety of authors to investigate IT diffusion within supply chain settings (Cooper & Zmud 1990; Premkumar et al. 1994). As demonstrated above, many innovation diffusion studies in the SCM context have focused on IT artifacts (e.g. Chen et al. 2009; Germain et al. 1994; Patterson et al. 2003, 2004; Williams 1994).

Although research in the MIS and SCM fields has expanded upon diffusion of innovation theory to develop more discipline-specific conceptualizations of innovation diffusion, the literature is scarce in offering a unified model of logistics innovation. Grawe's (2009) recent review of logistics innovation research suggests such a model of logistics innovation and provides a basis for further research. Grawe (2009) proposes that logistics innovation is positively related to competitive advantage. This proposition is rooted in resource-advantage (R-A) theory and based on a critical survey of logistics innovation literature. As described by Hunt and Morgan (1996), the R-A theory of competition posits that organizations seek competitive advantage in the marketplace via obtaining a comparative advantage in resources, which then leads to superior financial performance. However, this proposition and accompanying model do not clearly address how a firm may create competitive advantage from the adoption of logistics innovation. As suggested by Barney (1991) and the RBV, a firm may only realize competitive advantage when it implements a value creating strategy that is not being implemented by current or potential competitors. Although adoption of a homogeneous and perfectly mobile resource (e.g. off-the-shelf logistics innovations such as EDI, RFID, containerization, etc.) may induce a short-term competitive advantage, such adoption likely will not foster sustained competitive advantage unless

paired with heterogeneous firm resources. Thus, our research initiates an investigation into this apparent gap in the current model between logistics innovation adoption and competitive advantage.

This current research seeks to extend current SCM innovation diffusion literature, and specifically the model presented by Grawe (2009), by investigating a moderating construct that may aid in fostering increased performance for a firm via the adoption of logistics innovation. This construct, complementary firm resources, is operationalized in our study via positive buyer-supplier relationships. We posit that these positive relationships complement LIT adoption. This complementarity then intensifies the relationship between LIT adoption and performance outcomes. Evidence confirming this assertion may suggest modification to Grawe's (2009) model to account for the moderating effect of complimentary firm resources.

2.2 LIT Artifacts

Ideally, our study would investigate the entire population of ITs that meet our definition of LIT. However, as with any research endeavor, we were required to adopt a valid sampling technique in order to study a representative sample of the target population. Purposive sampling is a nonrandom sampling technique in which the researcher uses judgment in selecting cases for a specific purpose (Neuman 2006). This sampling technique is appropriate to select unique cases that may be especially informative (Neuman 2006). To this end, we choose two popular LIT artifacts as the basis of our investigation: RFID and EDI. RFID is a type of automated data collection system that uses radio waves to identify objects (Angeles 2005). Interest in RFID applications in the supply chain has generated a rapidly growing body of knowledge in recent years. Some posit that use mandates from industry leaders such as Wal-Mart has quickly brought RFID to the attention of academicians and practitioners alike (Visich et al. 2007). This has motivated many authors to discuss cases of RFID implementation success and suggest anecdotal or perceived outcomes of RFID adoption. Academicians are currently working to develop the body of empirical literature investigating actual benefits derived from RFID use (Visich et al. 2009).

EDI is a technology used to exchange information and data across organizations (Germain & Droge 1995) and may be defined as, "business to business transfer of repetitive business processes involving direct routing of information from one computer to another without human interference, according to predefined information formats and rules" (Holland et al. 1992, p. 539). Unlike RFID, EDI research has spanned the last two decades and is widely viewed as a relatively mature technology (Narayanan, et al. 2009). However, although the literature is insightful in examining many phenomena surrounding EDI (e.g. antecedents to adoption, implementation techniques, etc.), the quantitative academic literature investigating actual operational benefits is not well assimilated and sometimes inconclusive (Ahmad & Schroeder 2001; Narayanan, et al. 2009).

In this study, we combine EDI and RFID into a single unit of analysis that we label LIT. No one sample is ever perfectly reflective of the population. However, because these technologies are widely used in logistics and meet our definition of LIT, we posit that EDI and RFID should be representative of most LIT artifacts. We chose to study two LITs in lieu of just one for two specific reasons. First, research into the performance outcomes of just one LIT may limit the generalizability of conclusions drawn from this study. Although we are still careful to generalize our results to all LIT, the study of just one technology would limit our ability to generalize even further. Second, the study of more than one LIT will provide more data for analysis. An LIT may be thought of as simply a means for acquiring, processing, storing, or disseminating information that is used for logistics purposes. Thus, we propose that use of any LIT should produce similar increases in levels of efficiency, effectiveness, and flexibility for the adopting firm. As such, we believe that combining RFID and EDI in to a single unit of analysis is appropriate. Evidence to support this theoretical justification may be garnered via testing for statistical homogeneity, which will be demonstrated in the Results section of this manuscript. The expected benefits of these LITs are discussed in the following section.

2.3 Expected Performance Outcomes of LIT Adoption

A variety of expected performance outcomes of LIT adoption are touted in the literature. As such, EDI and RFID diffusion studies often suggest that anticipation of benefits derived from the implementation of LIT is a key antecedent to adoption (e.g. Crum et al. 1996; Premkumar 2003). Benefits investigated in the literature range from reduced order cycle times and inventory levels (Leonard & Davis 2006) to reduced labor costs and increased profits (Samad et al. 2010). Some suggest that this wide range of benefits related to LIT adoption seems to have perpetuated many inconsistencies in construct development and measurement in the literature (Narayanan, et al. 2009). This problem is exacerbated by the fact that LIT research is published in academic journals representing nearly 100 different subject categories (Irani et al. 2010). Therefore, in order to adequately investigate this study's research questions, these numerous performance outcomes must be categorized in such a way as to allow for proper analysis. To this end, we adapt a typology of outcomes proposed in recent literature (Karimi et al. 2007).

Although each individual technology boasts a unique set of anticipated benefits, we suggest that the vast majority of the performance outcomes (both anticipated and actual) resulting from the adoption of any LIT may be categorized into one of three higher-order outcomes. We define a performance outcome as any result that affects a business function of the organization, whether in a positive or negative manner. In this study, performance outcomes are classified within one of the following three categories (adapted from Karimi, et al. 2007):

- Efficiency: Encompasses outcomes that reduce cost, reduce cycle time, or increase productivity.
- Effectiveness: Encompasses outcomes that improve decision making, improve planning, improve resource management, or improve delivery.
- Flexibility: Encompasses outcomes that build flexibility into IT infrastructure, encourage differentiation of products and services, or establish, enhance, or maintain external linkages to customers and suppliers.

Measures of efficiency and effectiveness capture the extent to which an organization not only does the right things, but does them right. However, these two categories do not capture a multitude of performance outcomes that are relevant to the context of LIT. For instance, logistics firms often adopt practices that serve to mitigate potential risk, thus of averting future disruptions to the supply chain (Zsidisin & Wagner 2010). Thus, we include flexibility as a category in our typology to capture these additional performance outcomes. Of note, the MIS literature and SCM literature seemingly employ differing operationalizations of the term "flexibility." Although these operationalizations differ, they are not contradictory. For example, MIS literature often describes flexibility in terms of modularity of system components or integration with infrastructure (Byrd & Turner 2000) whereas the SCOR model describes flexibility as the ability to respond quickly to an unplanned increase in demand without service or cost penalty. Because of this disparity in the two literature areas that we draw on in this study, we adopt Golden and Powell's (2000) characterization of flexibility, which they describe simply as the capacity to adapt. This combines both MIS and SCM operationalizations into one concept and is used as the basis for classifying related performance outcomes. Any performance outcome that facilitates a firm's ability to adapt is categorized as a flexibility outcome. Table 1 provides an example of the categorization of performance outcomes used in this study. The method for categorizing these outcomes is described in the Methods section.

	Performance Category		
Performance Outcome	Efficiency	Effectiveness	Flexibility
Reduce processing costs	X		
Improve equipment utilization		X	
Improve planning process		X	
Improve responsiveness			X
Facilitate decision making		X	
Improve relationship with trading partner			X

Decrease number of administrative employees	X		
Reduce cycle times	X		
Increase productivity	X		
Enhance channel cooperation			X
Reduced delivery of incorrect product		X	

Table 1. Example of Performance Outcome Categorization.

Our first hypothesis is concerned with the relationship between LIT adoption and business process efficiencies. Efficiency is a measure of productivity in which what has been accomplished is measured against what is possible to accomplish. A technology may be defined as "a means of uncertainty reduction" (E. M. Rogers 2003, p. 13). Thus, by definition, any technology should enhance the efficiency of the process in which it is applied. However, this has not always been demonstrated in the literature. For example, Iskandar et al. (2001) found that employees in firms utilizing EDI perceived no reduction in the number of employees required to support operations. These findings are congruent with that of Sriram and Banerjee (1994), who found that EDI did not necessarily reduce employee workload. For example, Sriram and Banerjee (1994) found that employees were often still required to approve routine orders, monitor suppliers, and provide a signature for EDI orders. This lack of reduction in labor may be due to the fact that EDI does not always completely automate the processes in which it is applied, which results in the continuance of processing work for staff to complete. In addition, EDI may sometimes merely convert the type of work that employees are required to carry out. For example, although EDI may reduce paperwork processing for some organizations, it may also increase the amount of work required at computer terminals.

Although instances are cited above which support the idea that LIT does not improve levels of efficiency for an organization, additional research suggests that LIT does improve efficiencies. For instance, contrary to the findings noted above, Wang (2010) demonstrated via simulation how LIT may significantly reduce manpower requirements. Other simulation studies offer similar findings regarding efficiencies derived from IT implementation (e.g. Hou & Huang 2006; Veronneau & Roy 2009). In addition, Hou and Huang (2006) demonstrated a variety of operational efficiencies (e.g. reduced time for product identification) derived from use of LIT. Similarly, Bendavid et al.'s (2009) case study of B-to-B e-commerce applications in the supply chain suggests that these technologies may yield significant reductions in transaction time while also reducing costs. Because of these findings, we posit that:

H1: Organizational adoption of LIT increases business process efficiencies.

Our next hypothesis is concerned with the relationship between LIT adoption and business process effectiveness. We define effectiveness as the degree to which business objectives are achieved. Thus, measures of effectiveness are usually concerned with higher-order organizational outcomes. For instance, efficiency may be concerned with reducing order processing costs, whereas effectiveness is concerned with whether or not process initiatives affect the bottom line.

The literature offers many examples where LIT is shown to increase effectiveness. Srinivasan et al. (1994) demonstrated the complimentary of LIT and just-in-time (JIT) practices on manufacturing supply chains. Their study demonstrated a large reduction in shipments with discrepancies when EDI was employed along with JIT. Chow et al. (2006) found similar benefits in shipping accuracy via use of RFID. Furthermore, Clark and Hammond's (1997) examination of LIT in the grocery industry found that EDI adoption led to increased inventory turns and reduced stock-outs. Hardgrave (2008) reached similar conclusions regarding increased effectiveness in his examination of RFID use at Wal-Mart.

In contrast, other studies have concluded insignificant relationships between LIT adoption and measures of effectiveness. For example, Crum et al.'s (1996) study concluded that EDI did not improve decision-making for firms in the motor carrier industry. Further, Leonard and Davis (2006) realized non-significant results when investigating the relationship between adoption of LIT and a variety of effectiveness measures, to include increased fill rates and reduced stock-outs. Thus, we seek to determine if these insignificant results are an anomaly by investigating whether or not:

H2: Organizational adoption of LIT increases business process effectiveness.

Our third hypothesis concerns the relationship between LIT adoption and business process flexibility. We define flexibility as the capacity to adapt. Although flexibility rarely translates into immediate increases in efficiencies, effectiveness, or short-term profits, flexibility facilitates an organization's preparation to encounter future, unknown events. This preparedness, then, often leads to an increase in (or at least a retention of) efficiency, effectiveness, and profit in the future. Flexibility captures performance outcomes that do not necessary associate with efficiency or effectiveness, but are still important to the long-term health of an organization.

Literature suggests that adoption of IT facilitates increased flexibility in the logistics setting. For example, Rogers, et al.'s (1992) study of EDI use in warehousing suggests that firms using EDI are significantly more able to accommodate special or abnormal requests and events than firms that do not use EDI. Choe's (2008) research in the Korean manufacturing industry corroborates the findings of Rogers, et al. (1992) and suggests that EDI facilitates increased speed and volume of new product creation and product changeover, thus increasing operational flexibility. Lim and Palvia (2001) posit that this increased flexibility is achieved primarily via reduction in paperwork and standardization of procedures. However, others have shown that EDI also leads to expansion of a firm's supplier base and increased market channel formalization, which also enhances a firm's capacity to adapt to market conditions (Manabe et al. 2005; Vijayasarathy & Robey 1997). On the other hand, conflicting research suggests that EDI does not benefit channel relationships and coordination (Johansson & Palsson 2009; Nakayama 2003). Thus, we investigate whether or not:

H3: Organizational adoption of LIT increases business process flexibility.

2.4 Buyer-Supplier Relationships

In order to transfer products from the point of origin to the point of consumption, inter- and intra-organizational collaboration is inherently a key component of the supply chain. As with any collaborative effort, the relationship between participants may dramatically impact the performance outcomes sought by each party. The buyer-supplier relationship may be identified via eight key dimensions: (1) communication and information sharing, (2) cooperation, (3) trust, (4) commitment, (5) relationship value, (7) adaptation, (6) power imbalance and interdependence, and (8) conflict (Boeck and Wamba, 2008). In this study, we consider relationships consisting of the characteristics of (1) communication and information sharing, (2) cooperation, (3) trust, (4) commitment, (5) relationship value, and/or (6) willingness to adapt as being positive relationships. Conversely, we consider a relationship lacking these attributes or consisting of (7) power imbalance or (8) conflict to be non-positive.

A variety of studies have demonstrated the positive outcomes derived from buyer-supplier co-operation in the supply chain. For example, Larson (1994) found that supply chain relationships consisting of greater levels of trust, respect, cooperation, teamwork, unified purpose, and communication resulted in higher levels of product quality and lower total costs for both the buyer and supplier. Additionally, Klein and Rai's (2009) study of strategic information flows within the supply chain suggests that positive supply chain relationships marked by increased strategic information flows between partners yields significant financial and operational performance outcomes. In their study, both buyers and suppliers realized

improved management of assets, reduced operations costs, enhanced productivity, and improved planning, flexibility, and control of resources.

These positive outcomes derived from positive buyer-supplier relationships may be explained by social exchange theory, which views the exchange relationship between specific actors as being contingent upon rewarding reactions from others (Blau 1964). As discussed above, the adoption of LIT is an inherently collaborative venture. For example, for EDI to work effectively, both organizations must agree to adopt and utilize the technology in a manner that benefits both parties. Thus, when buyer-supplier relationships are characterized in accord with Boeck and Wamba's (2008) dimensions of a positive relationship, both the buyer and supplier should realize increased levels of efficiency, effectiveness, and flexibility from the adoption of LIT. As such, we propose that a positive buyer-supplier relationship moderates the relationship between LIT adoption and measures of performance. Accordingly, we propose:

> *H4a: The relationship between LIT adoption and business process efficiencies will intensify with the presence of a positive buyer-supplier relationship.*
>
> *H4b: The relationship between LIT adoption and business process effectiveness will intensify with the presence of a positive buyer-supplier relationship.*
>
> *H4c: The relationship between LIT adoption and business process flexibility will intensify with the presence of a positive buyer-supplier relationship.*

Figure 1 illustrates this study's research model. To examine the relationships suggested in this model, this study utilizes data derived from existing empirical studies and meta-analytic techniques to investigate the relationship between popular LIT innovations and the hypothesized performance outcomes realized by adoption of these technologies. These specific methods are discussed in the following section.

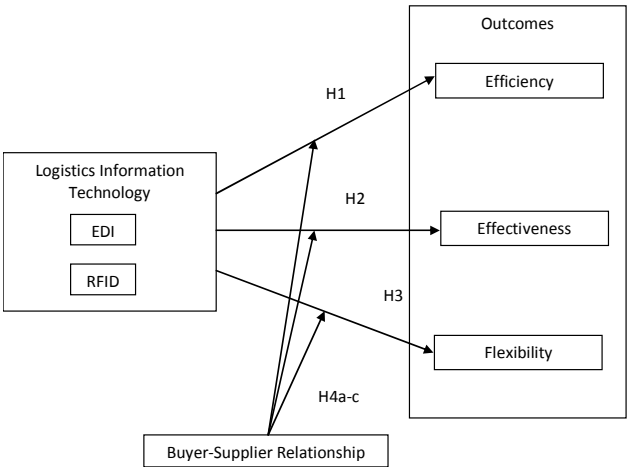

Figure 1. Research Model.

3 METHOD

3.1 Search for Empirical Articles

This study employs a meta-analysis method. To begin, relevant manuscripts reporting empirical research findings were sought. To be included in the analysis, the research effort must report the subjective or objective measure of an actual outcome that could be logically attributed to the adoption of EDI or RFID.

No date or discipline restrictions were applied to our search; however, due to the nature of the artifacts under investigation, very few studies before 1990 were uncovered and the majority of articles were found in MIS and SCM journals. In addition, the literature search was conducted in October 2010, thus 2010 literature made available on or before this time period was used. Finally, many trade magazines report performance outcomes resulting from LIT adoption. However, we limited our search to academic publications so as to use articles that are the result of rigorous academic research.

We searched the EBSCO Business Source Premier and ProQuest databases for articles that met the selection criteria. Two separate searches were conducted, using the same procedure for each LIT. Abstracts were searched using the keywords: EDI OR "electronic data interchange"; RFID OR "radio frequency identification." If cursory reading of the title and abstract suggested any possibility that the article met the criteria, then it was downloaded and printed. The printed articles were thoroughly reviewed to extract adoption outcomes and commensurate correlations. In sum, 48 unique articles were used for analysis. A listing of articles used for this analysis is available upon request.

3.2 Meta-Analysis

To investigate hypotheses one through three (the relationship between LIT and efficiency, effectiveness, and flexibility), the mean correlation coefficients (Pearson's r) across studies were calculated. To begin, we extracted outcomes of LIT adoption and their associated effect size from each article. Some articles investigated only one outcome from a single sample while others investigated greater than ten outcomes from multiple samples. This data and the appropriate article descriptives were recorded in a spreadsheet.

Each performance outcome was then categorized into its commensurate category: efficiency, effectiveness, or flexibility. Adoption outcomes that were not related to performance were not categorized, and thus not included in the meta-analysis. Example of non-performance outcomes of adoption included such measured outcomes as credit cards use by buyers or changes to training programs. In sum, 336 performance outcomes were recorded and used for analysis. We categorized each performance outcome with regard to the definition of each category, as provided in the "Expected Performance Outcomes of LIT" section of this paper. Given these definitions, most performance outcomes were easily categorized. Performance outcomes that were thought to possibly fit more than one category were discussed among two additional raters until consensus was reached regarding which category was most appropriate. To enhance the reliability of the entire categorization process, two additional raters independently categorized a sample of the outcome variables. Fleiss' Kappa for the categorization was calculated to be .93. In sum, 111 outcomes were categorized as efficiency, 129 outcomes were categorized as effectiveness, and 96 outcomes were categorized as flexibility.

After categorizing the performance outcomes, we used meta-analysis procedures outlined by Hunter and Schmidt (2004) to correct for sampling error and obtain corrected mean correlations. In addition to calculating the corrected mean correlation for efficiency, effectiveness, and flexibility, we calculated the standard error of the corrected mean correlations in order to present appropriate confidence intervals. The formulae used to calculate the corrected mean correlations and standard error are:

$$\bar{r} = \sum N_i r_i / \sum N_i$$

$$SE_{\bar{r}} = SD_{\bar{r}} / \sqrt{k}$$

where $\bar{r}$ is the corrected mean correlation, N is the combined sample size, $SE_{\bar{r}}$ is the standard error of the corrected mean correlation, $SD_{\bar{r}}$ is the standard deviation of the uncorrected mean correlation, and k is the number of correlations.

Next, we began our analysis of the proposed moderator, positive buyer-supplier relationships, by categorizing each study in terms of the relationship. Each study was examined to determine if the article offered any indication of a positive relationship between buyers and suppliers. We found that authors of EDI and RFID studies often go into great detail regarding the context of the implementation and use of

the LIT. Although buyer-supplier relationships are dynamic by nature, many of the studies we reviewed were careful to discuss the nature of the relationship throughout the implementation and use of the LIT. Information regarding the relationship between buyers and suppliers was found in various areas of each manuscript, to include the literature review, hypothesis development, and methods sections where the research setting or sample is discussed. Information was sometimes found in the results section if the study incorporated some measure of the relationship. Using the eight dimensions outlined by Boeck and Wamba (2008) as a guide, studies that indicated relationships consisting of (1) communication and information sharing, (2) cooperation, (3) trust, (4) commitment, (5) relationship value, or (6) willingness to adapt were labeled as "positive relationship." If these six dimensions were indicated in a negative sense or if indications of (7) power imbalance or (8) conflict were present, the article was labeled as "non-positive relationship." Similarly, if the relationship was not addressed in the article, it was labeled as "non-positive relationship."

Although the buyer-supplier relationship is often measured via scales that capture the varying degree of the relationship (e.g. Larson 1994), this study is concerned with the moderating effect of positive relationships. Therefore, we employed a dichotomous rating scheme; any other type of relationship other than positive, to include poor or not reported relationships, was simply categorized as non-positive. Thus, most studies were easily categorized in regard to the relationship between buyers and suppliers; either the study highlighted the positive relationship or it did not. Any study that was not clearly categorized was discussed with two additional raters until consensus was reached. Reliability of this categorization method was tested via use of two additional raters who examined and categorized a sample of the articles. Fleiss' Kappa was calculated as .97 for this categorization process.

To account for different sample sizes between studies, Hunter and Schmidt (2004) suggest using weighted least squares regression to test for moderating relationships. However, using two-sample, weighted t-tests will yield the exact same results because we examine only a single dichotomous independent variable (Nichols 1995). Thus, for parsimony and ease of interpretation, we conducted three separate t-tests, one for each performance category.

Because we extracted multiple performance outcomes from many of the research articles used for meta-analysis, we must address interdependence of data as a possible validity threat to this study. The assumption of independence is critical to many statistical analyses; therefore, Lipsey and Wilson (2001) posit that multiple data points from a single publication should only be used when they may be treated as independent. In our study, the multiple effect sizes extracted from individual research articles were often the product of multiple samples or multi-method techniques (e.g. Kim et al. 2008; Manabe, et al. 2005). However, in some cases, we extracted multiple effect sizes from studies employing a single sample or method. Thus, we used an empirical method employed by Sharma et al. (2009) to test for any effect of the violation of the independence assumption. We completed the same analysis procedures used to test the study's four hypotheses, but instead used only effect sizes derived from studies that contributed only one correlation. The results of this analysis led to the same conclusions regarding our hypotheses as when all data points were employed. All point estimates of corrected effect sizes were within the 95% confidence intervals reported for the full sample. We therefore conclude that inclusion of multiple effect sizes from a single publication does not threaten the validity of our findings.

4 RESULTS

Our analysis began by comparing the performance outcomes of EDI with the outcomes of RFID. As stated previously, we feel it is theoretically appropriate to combine EDI and RFID into one unit of analysis. However, we tested the appropriateness of this theoretical rationale via statistical means. Thus, we completed a series of t-tests to determine if the performance outcomes realized by EDI and RFID are statistically homogeneous. Results t-test results suggest no difference in efficiency ($t_{127} = 1.54$, $p = .120$), effectiveness ($t_{109} = .55$, $p = .583$), or flexibility ($t_{94} = 1.0$, $p = .326$) outcomes between EDI and RFID.

Next, we conducted our meta-analysis in accordance with the method prescribed by Hunter and Schmidt (2004) to test for relationships between LIT adoption and performance outcomes. We find evidence to support hypotheses 1 through 3. Results are shown in Table 2.

Outcome	k	n	Mean r	SDr	Corrected Mean r	SEr	95% CI
Efficiency	129	9,911	.41	.28	.40	.02	.37, .42
Effectiveness	111	9,514	.39	.29	.34	.03	.31, .37
Flexibility	96	7,807	.23	.33	.18	.03	.15, .21

Note: k = number of correlations, n = total sample size, Mean r = uncorrected mean correlation, SDr = standard deviation of mean uncorrected correlation, Corrected Mean r = mean corrected correlation, SEr = standard error of corrected correlation, 95% CI = lower and upper limits of 95% confidence interval

Table 2. Meta-Analysis of Relationship between Performance Outcomes and LIT Adoption.

Finally, t-test analyses for the moderating effect of positive buyer-supplier relationships indicated significant results for efficiency ($t_{127} = 2.83$, $p = .005$) and flexibility ($t_{94} = 2.56$, $p = .012$). However, the moderating effect of a positive buyer-supplier relationship was found to be insignificant for effectiveness ($t_{109} = 1.16$, $p = .249$). Thus, we find partial support for hypothesis 4. Comparison of these effect sizes are reported in Table 3.

	Corrected Mean r		
Outcome	Non-Positive Relationship	Positive Relationship	Difference
Efficiency	.34	.43	.09*
Effectiveness	.34	.35	.01
Flexibility	.13	.31	.18*

* Significant at $p < .01$

Table 3. Effect Size Comparisons.

5 DISCUSSION

The purpose of meta-analysis is to consolidate a large collection of analysis results for the purpose of integrating findings (Glass 1976). Thus, given the results of our analysis, we feel comfortable in concluding that, in general, LIT adoption leads to positive performance outcomes. We also conclude that conflicting results are likely caused by unaccounted for moderating variables or artifacts specific to a particular study. Indeed, studies that indicate a positive buyer-supplier relationship tend to yield, on average, larger effect sizes than studies that indicated a non-positive relationship. These findings suggest theoretical and practical implications.

5.1 Implications for Theory and Future Research

As suggested in this study, positive buyer-supplier relationships induce larger effect sizes for the relationships between LIT adoption and measures of efficiency and flexibility. Given these results, we suggest that Grawe's (2009) logistics innovation model be expanded. Figure 2 illustrates our proposed updated logistics innovation model. Components in bold constitute our additions to Grawe's (2009) original model.

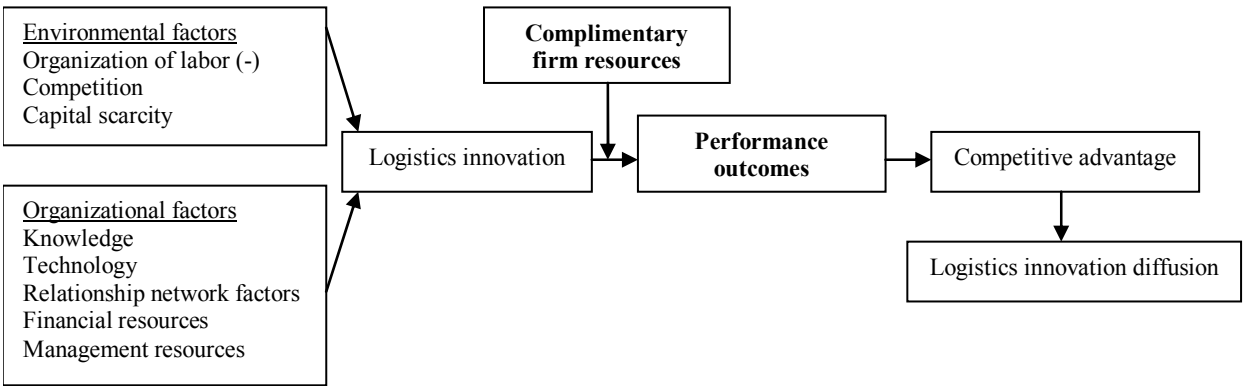

Figure 2. Updated Logistics Innovation Model (adapted from Grawe 2009).

Our proposed model adds two components to Grawe's (2009) original logistics innovation model. First, consistent with literature regarding RBV (e.g. Barney 1991), we posit that the adoption of a logistics innovation leads to generally positive outcomes in lieu of leading directly to competitive advantage as it does in the original model. Most logistics innovations are not necessarily a resource that can directly invoke sustained competitive advantage because they most often do not embody the necessary criteria of such a resource; they are not valuable, heterogeneously distributed across firms, and imperfectly mobile (Mata, et al. 1995). Being an innovation used for logistics purposes makes meeting these requirements especially difficult given the collaborative nature of the discipline and the subsequent requirement for multiple firms to employ similar technologies in order to work in unison. However, as demonstrated in our study, when complimentary resources are combined with logistics innovations, performance outcomes are enhanced. This significant increase in performance may, in turn, provide an opportunity to realize competitive advantage. This idea is congruent with past literature that suggests resource complementarity may play an important role in RBV theory because of its ability to create competitive advantage via combining two otherwise non-competitive advantage-inducing resources (Wade & Hulland 2004). Accordingly, the second component added to Grawe's (2009) model is a moderator: complimentary firm resources.

We recommend additional research continue to hone the logistics innovation model. Specifically, we suggest exploring avenues that may facilitate the realization of competitive advantage via logistics innovation. The results of our study suggest that positive buyer-supplier relationships induce larger effect sizes for the relationships between LIT adoption and measures of efficiency and flexibility. This larger effect size may imply a competitive advantage for firms who adopt LIT and possess a complimentary firm resource. However, additional research must further investigate the inferences of our findings to justify the inclusion of competitive advantage in the logistics innovation model. If empirical support cannot demonstrate how logistics innovation may eventually evoke competitive advantage for the adopting firm, then removal of the competitive advantage construct from the model may be warranted.

Next, the results suggest that a positive buyer-supplier relationship does not moderate the relationship between LIT adoption and effectiveness outcomes. Measures of effectiveness observed in the literature may not be as dependent on relationships with buyers and suppliers as measures of efficiency and flexibility. This may be because effectiveness measures (e.g. improved internal decision making, etc.) often address internal processes that are somewhat insulated from external organizations or events, whereas measures of efficiency and flexibility (e.g. reduced transaction error rates and improved inter-organizational data sharing, respectively) encompass processes that are generally more affected by external relationships. Thus, a positive buyer-supplier relationship may not necessarily serve as a complimentary resource to LIT to increase measures of effectiveness. As such, we other complementary

firm resources may moderate the relationship between LIT adoption and measures of effectiveness. Future logistics innovation studies should identify and test additional complementary resources. Given our review of the literature, we posit that additional moderating variables may include market position, time since adoption, firm size, industry, organizational learning abilities, and absorptive capacity. However, we did not find sufficient existing data in our meta-analysis to analyze these possible effects. We instead recommend new studies be designed to specifically test these relationships.

5.2 Implications for Practice

This study provides two primary implications for practitioners. First, this study found that, in most cases, adoption of RFID or EDI led to positive results for the adopting firm. However, our study also demonstrates how other circumstances specific to the adopting firm (e.g. relationships with trading partners) may help or hinder the achievement of positive outcomes via LIT adoption. Most importantly, this study reaffirms the idea that organizations and technology adoption do not operate in a vacuum. Thus, firms looking to adopt LIT should carefully examine the possible interaction effects between their firm, their partners, the LIT, and the unique circumstances in which the LIT is to be employed.

Second, this study emphasizes the importance of fostering positive buyer-supplier relationships in the supply chain. Given our definition of LIT and the nature of the supply chain, LITs are inherently collaborative technologies. However, some firms have undoubtedly adopted these technologies without first building positive relationships or even despite poor relationships with their partners. Although some firms may have enough clout and influence in the market or supply chain to nullify the importance of fostering positive relationships (e.g. Wal-Mart), our study suggests that it would behoove most firms interested in using any LIT to first work on building positive relationships with their trading partners if they hope to achieve maximum benefits from the employment of the adopted technology. The benefits of collaboration and building positive relationships have been demonstrated in a variety of situations in the supply chain literature (e.g. Klein & Rai 2009; Larson 1994). Our study provides additional empirical evidence that should motivate firms to foster positive relationships with their trading partners.

5.3 Limitations

The primary limitation of this study is common to most studies that rely on assimilation of others' research, which is the omission of relevant research studies in our analysis. In addition, publication bias may have artificially inflated the number of studies we found that report significant and/or positive results. To address this potential limitation, we used a series of analyses based on Rosenthal's (1979) file drawer analysis. These analyses estimate the number of unpublished or otherwise omitted studies required to challenge the significance of our findings. Results of these analyses suggest that our findings regarding the relationships tested in this study are robust to the omission of contradictory research.

We assume that our sampling strategy led us to use LITs that are representative of the population of LIT. However, caution must be used when generalizing our findings to all LITs, and especially to LITs that may serve a greatly different purpose than EDI and RFID, such as decision support systems. Future studies could test the generalizability of our findings by investigating additional LITs.

6 CONCLUSION

This research corroborates the findings of past empirical research and the assumptions of business practitioners by demonstrating that the implementation of LIT innovations generally produces positive performance outcomes for the adopting organization. We also provide evidence as to the moderating effect of positive buyer-supplier relationships on the relationship between LIT adoption and performance outcomes. This finding offers one possible explanation for the incongruent findings of past research addressing the outcomes of LIT adoption while also providing support for our extension of Grawe's (2009) logistics innovation model, which presents a foundation for future research.

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