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Electronic Data Interchange: Research Review and Future Directions*

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ABSTRACT

For nearly two decades, electronic data interchange (EDI) has been widely viewed as a technology pivotal to supply chain management that has also provided benefits to firms on multiple levels. Despite a substantial body of literature, there are a number of conflicting and inconclusive research results in this field. In this study, we synthesize the diverse body of research in EDI by organizing the literature into an initial theoretical framework. Based on a meta-analysis of results from the empirical literature, we seek to clarify conflicting results from the literature in order to develop a more unified theoretical framework of contextual variables associated with EDI adoption factors and outcomes. From a managerial standpoint, our literature-based framework offers a set of guidelines for making successful EDI adoption and implementation decisions.

Subject Areas: Electronic Data Interchange (EDI), Electronic Linkages, Meta-Analysis, and Supply Chain Collaboration.

INTRODUCTION

For over two decades, electronic data interchange (EDI) has been one of the primary enabling technologies for conducting business-to-business (B2B) transactions. EDI-based transactions enabled more than $2 trillion of trade among various firms in 2001, with as many as 55% of all North American large and mid-size companies reporting the use of an EDI network (Kanakamedala, King, & Ramsdell, 2003). While the economics associated with EDI has long been a concern for many companies, the arrival of the Internet has made the technology feasible even for small firms. International Data Corporation (IDC) estimated the total value of

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EDI—traditional and Internet—grew from $1.99 trillion in 2003 to $ 2.68 trillion in 2007, with 45.9% of EDI commerce revenue attributable to Internet EDI (IDC, 2004). Far from becoming a legacy technology, EDI continues to be a preferred platform for sharing business documents in many supply chain–based transactions.

While practitioners and academics agree that EDI is an important and beneficial interorganizational communication technology, Ahmad and Schroeder (2001, p. 16) summarize the state of academic research on EDI and note: "even after more than 25 years of use of EDI in various industries, the literature is still inconclusive regarding the benefits gained from its usage." This observation may seem surprising, considering the length of time the technology has been in use. Over the last 25 odd years, a rich literature base in electronic interorganizational systems (IOSs) has developed. This literature has been insightful in examining the role of IOSs as a vehicle for information sharing, process redesign, and better coordination among supply chain partners, which can lead to higher performance and competitive advantage for the firm (Venkatraman & Kambil, 1991; Zaheer & Venkatraman, 1994; Frohlich, 2002; Mukhopadhyay & Kekre, 2002). Within this context, EDI has proven to be somewhat of an anomaly in the IOS literature with some studies reporting that EDI adoption has produced benefits (particularly in procurement and logistics), while other studies have found instances where adoption resulted in few, if any, benefits (Handfield, 1995).

Because of its longevity, EDI has sparked the interest of researchers from nearly all the management disciplines, including operations management, purchasing, logistics, marketing, information systems and economics, strategic management, organizational behavior, and accounting/financial management. Each discipline has studied the role of EDI from its own perspective, using different theoretical foundations, research designs, and methodologies. In some cases, different studies have produced conflicting results. In this research, we specifically examine empirical studies where conflicting results have arisen due to differences in sampling designs that vary with respect to industrial setting, sample size, and primary respondent. Given the diversity of theoretical lenses, research designs, and methodologies used in the academic literature, our research seeks to determine if any discernible patterns exist across this set of apparently conflicting empirical conclusions in the EDI literature.

Selected examples of conflicting results from the EDI literature illustrate the challenges associated with this endeavor. For instance, the impact of supplier coercion on EDI adoption has been heavily studied. Some studies find that pressure from a customer is a significant driver influencing the supplier's adoption decision (e.g., Chwelos, Benbasat, & Dexter, 2001; Gavidia, 2001; Kuan & Chau, 2001), yet others do not (e.g., O'Callaghan, Kaufmann, & Konsynski, 1992). In studying the barriers to EDI adoption, both Iskandar, Kurokawa, and Leblanc (2001a) and Premkumar, Ramamurthy, and Nilakanta (1994) find that the size of the initial investment is a significant barrier to EDI adoption, while Murphy, Daley, and Hall (1998) find no statistically significant relationship. Perhaps the most compelling conflicts are those regarding the benefits that firms have realized from the use of EDI. Riggins and Mukhopadhyay (1994) find that EDI integration leads to reduction in the overall error rates in document transaction; while Truman (2000) does not find any support for reduced errors. Lim and Palvia (2001) find that EDI

integration is associated with a decrease in inventory levels; yet, Teo, Tan, Wei, and Woo (1995) find no significant relationship. Finally, Ahmad and Schroeder (2001) find that EDI use significantly improves delivery performance, but Walton and Marucheck (1997) find no significant support for that benefit.

This patchwork of conflicting findings has created challenges in assessing the validity of industry claims regarding the benefits of EDI on supply chain performance. They signal the need for the development of a model of EDI adoption grounded in the current literature that can serve as a basis for building a renewed theoretical base upon which to reconcile the disparity of results in the literature. From a research standpoint, such a model is vital to building a theory of virtual collaboration in the supply chain, a common theme in the emergent literature (Frohlich, 2002). From a managerial standpoint, conflicting findings, particularly those regarding the benefits of EDI, can discourage practitioners from using the research as a basis for making decisions involving EDI investment, adoption, and use.

In this article, we review selected empirical studies from the EDI literature, seeking to establish an understanding of key patterns and conflicts, thereby facilitating the development of a richer set of theoretical models. Our fundamental research question is guided by Davis, Bagozzi, and Warshaw's (1989) technology acceptance model (TAM): is there a consistent set of antecedents and realized benefits associated with EDI adoption that is supported by the empirical research in multiple streams of research in the field? This question is explored in the following manner: (i) we provide a general discussion of findings in the empirical literature related to EDI adoption and its impact; (ii) we identify possible moderators that may explain some of the conflicting findings, applying meta-analysis as a tool to examine the relative level of consistency of results in the literature; and (iii) we synthesize the current literature on EDI adoption and implementation and outline areas of future research.

Further sections of this article are organized as follows. First, we introduce the research framework for our analysis. This framework presents relationships that have been hypothesized in the literature regarding the determinants of EDI adoption and integration as well as realized outcomes. Second, we briefly describe the methodology used for selecting the studies to be included in our review and the meta-analysis methodology. Third, we present the results of our literature review and meta-analysis. Fourth, we provide a discussion of our results and expand our research model to incorporate contingent effects and a configurational perspective of EDI adoption. Finally, we present limitations of the research methodology and conclude with a brief discussion of the implications of our work for both scholars and managers.

RESEARCH FRAMEWORK

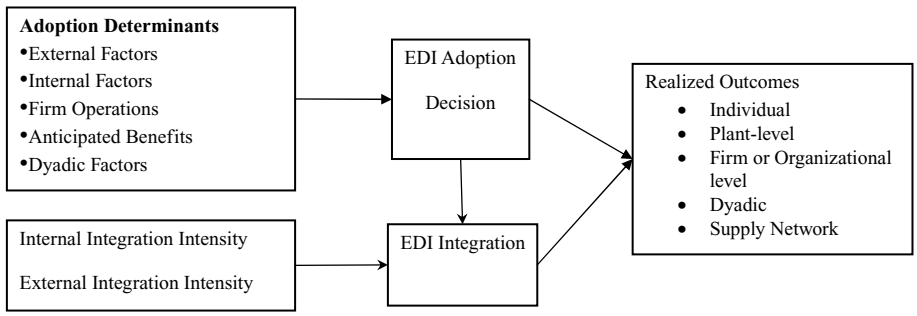
An operational definition for EDI in this research is the "process of computer to computer, business to business data transfer of repetitive business processes involving direct routing of information from one computer to another without human interference, according to predefined information formats and rules" (Holland, Lockett, & Blackman, 1992, p. 539). Note that this definition precludes human

interference in transaction processing and emphasizes those business processes that are repetitive and high volume. This definition also underscores the role of EDI as a platform that supports business processes that span organizational boundaries as well as its role in business process improvement (Riggins & Mukhopadhyay, 1994; Clark & Hammond, 1997; Walton & Marucheck, 1997). Much of the scholarly work on EDI focuses on the following research questions, which are fundamental to technology acceptance: (i) why do firms adopt and integrate EDI into their processes? (ii) what are the key issues in a successful EDI implementation? and (iii) what is the impact of EDI adoption on the firm? We focus our discussion on reconciling the conflicting results in the empirical literature addressing questions (i) and (iii) only. With regard to question (ii), Handfield (1995) observed that EDI has been relatively immune to the technical implementation problems that plagued other information technologies. The literature reveals that many of the determinants associated with successful implementation projects and organizational change, including top management support, presence of a champion, and adequate resource support, communication, and training, are significantly associated with successful EDI adoption and implementation (Premkumar & Ramamurthy, 1995; Chwelos et al., 2001; Iskandar et al., 2001a; Kuan & Chau, 2001; Min & Galle, 2003). Thus, the research addressing EDI technology implementation is well established and consistent with the general technology management literature.

A Theoretical Framework for EDI Adoption

Figure 1 represents an initial parsimonious view of our initial interpretation of the existing literature on EDI. The model provides insights into the question of why firms adopt EDI and what the impact of EDI is on performance. Note that this model was derived primarily from the theoretical assumptions/hypotheses posited in the research reviewed in this study, but does not reflect the combined empirical outcomes of the research (which is depicted later in this article). Figure 1 is also similar in structure to the model of e-business adoption and its impact on performance studied by Wu, Mahajan, and Balasubramanian (2003). Given the breadth of the parameters explored in the EDI literature, we made the decision to classify key explanatory variables into five general categories: (i) external factors,

Figure 1: Initial conceptual model



EDI = Electronic Data Interchange.

(ii) internal factors, (iii) firm operations, (iv) anticipated benefits, and (v) dyadic factors. Our categorization illustrates how thorough the research literature has been in specifying numerous possible explanatory variables and determinants to EDI adoption.

External factors characterize the environment in which an organization competes. Prior literature has suggested that many of these factors are contextual with a basis in socio-political theory in explaining why a firm might adopt EDI as a response to environmental factors. Specifically, determinants such as industry pressure, industry structure and concentration, environmental uncertainty, and other competitive market influences can impact a firm's EDI adoption decisions (Premkumar & Ramamurthy, 1995; Ahmad & Schroeder, 2001; Chwelos et al., 2001; Gavidia, 2001; Teo, Wei, & Benbasat, 2003). In industries characterized by a few large customers using EDI, members of the supply base may feel that EDI adoption is mandatory (whether coerced or not) in order to retain the business of an influential customer. EDI may be the only way to provide the customer with the service it demands in order to retain or increase that share of the business. Widespread industry use of EDI, such as in the automotive, retailing, grocery, and health care industries, can also create a climate where EDI use is considered necessary for remaining competitive in the industry (Handfield, 1995).

Internal factors hypothesized to impact the adoption decision relate to how the managerial, technological, and organizational resources possessed by the firm influence the readiness for adoption. Many of these factors have appeared in the technology management literature, and include systems technical compatibility, availability of technical and professional staff, managerial competencies, size of the organization, financial support, proactiveness, and organizational readiness for EDI adoption (Iacovou, Benbasat, & Dexter, 1995; Premkumar & Ramamurthy, 1995; Lee & Han, 2000b; Ahmad & Schroeder, 2001; Chwelos et al., 2001; Teo et al., 2003). The presence of these resource-based factors are hypothesized to facilitate EDI adoption; on the other hand, the absence of these factors can also constitute barriers to adoption (Frohlich, 2002).

Firm operations refer to hypothesized determinants at the plant or production facility level. Ahmad and Schroeder (2001) argue that EDI adoption at the plant level is the appropriate unit of analysis for study, not the enterprise level. Yet despite its important role, very few studies have actually considered EDI from the perspective of the plant. Some of the relevant factors in EDI adoption include just-in-time (JIT) practices, product customization, product variety, and business process improvement (Germain & Dröge, 1995; Premkumar & Ramamurthy, 1995; Ahmad & Schroeder, 2001; Iskandar, Kurokawa, & LeBlanc, 2001b). These drivers are plant specific because they impact the degree of variability and uncertainty experienced in managing production processes to meet forecasted customer demand. Product volume and variety can greatly impact both the accuracy and timeliness of demand forecasts, which affects not only the manufacturer's performance but also the performance of the entire supply chain. Forecasts of customer demand drive the production management function and impact many activities such as inventory management, production scheduling, manufacturing process efficiency, and delivery frequency from suppliers. In particular, JIT practices advocate the use of EDI as a vehicle for supply chain collaboration and the sharing of linked

planning information including forecasts, production schedules, inventory levels, and scheduled/in-transit deliveries to stabilize the production environment (Ahmad & Schroeder, 2001; Handfield, 1995). The role of EDI in enabling JIT is more than just a means of improving operational efficiency by squeezing time and waste out of manufacturing operations. EDI can also be a basis for information sharing through collaborative forecasting to help combat the bullwhip effect, thus leading to stabilization of manufacturing schedules (Lee, Padmanabhan, & Whang, 1997).

The fourth category, anticipated benefits, is an important motivator for EDI adoption (Frohlich, 2002). Many of the anticipated benefits attributed to EDI are derived from information-processing theory and/or transaction-cost economics (TCE). Information-processing theory suggests that reducing information uncertainty and time delays in EDI-based business transactions will reduce costly buffers in the form of higher inventory levels and longer delivery lead times while improving resource utilization (Srinivasan, Kekre, & Mukhopadhyay, 1994; Iacovou et al., 1995; Walton & Marucheck, 1997; Ahmad & Schroeder, 2001). A TCE perspective suggests that EDI facilitates closer coordination between suppliers and customers and leads to reduced transaction costs for both parties (Saeed, Malhotra, & Grover, 2005; Srinivasan et al., 1994). TCE also shows how business processes can be streamlined through the automation of information exchange (Mukhopadhyay & Kekre, 2002). Process improvement can lead to lower costs, improved order accuracy, shorter lead times, and enhanced responsiveness for both supply chain partners.

These two theories are complementary in shaping the organization's expectations for the benefits from EDI adoption. Frohlich (2002), using Lewin's (1959) classical change model and Cooper and Zmud's (1990) related stage model of information technology implementation, argues that the initiation or "unfreezing" stage in the implementation of a technology (such as EDI) requires that both supply chain partners understand the technology's benefits and drawbacks as a foundation for building consensus for the adoption decision. Anticipated benefits of EDI are greatest when the technology is viewed as a solution to specific problems that both organizations face in their dyadic business relationship.

Dyadic antecedents involve determinants that are specifically related to the characteristics of the relationship between a specific buyer and supplier that can impact both the design and adoption of the EDI system. The sourcing literature has specified antecedents, including the nature and level of trust in the relationship (arm's-length association versus coordinated relationship), the longevity of the relationship (long term versus contractual), relative power differences, imposition or coercion, and the technical ability to externally integrate two disparate systems. These elements are further complicated by the fact that firms may have a number of supply chain partner-specific subsystems for EDI operating independently of one other (Hart & Saunders, 1997, 1998; Frohlich & Westbrook, 2001; Hill & Scudder, 2002; Saeed et al., 2005). Walton and Marucheck (1997) found that a single firm could simultaneously have a number of different types of EDI relationships with different supply chain partners. The EDI relationship can vary with respect to the levels of external integration and information sharing and is often dependent on the characteristics of different supply chain partners. As such, EDI benefits may vary dramatically across different dyadic relationships, depending on the willingness of each supply chain partner to commit to EDI adoption.

The depiction of posited relationships in the EDI literature in Figure 1 demonstrates the multidisciplinary nature of the EDI adoption decision and the large number of dependent parameters complicating these hypothesized relationships. Consequently, we recognize that determinants of EDI adoption reside at many different levels—from the strategic to the tactical, from internal manufacturing parameters to external boundaries and beyond. *The very general nature of our hypothesized relationships between the determinants and the adoption decision underscores the fact that no single generally accepted model of EDI adoption in the literature exists.* Each research study presents its own research model, focusing on different sets of hypothesized determinants and antecedents, often to the exclusion of others. Many of the studies are distinct in the sense that the hypothesized determinants or explanatory variables are representative of only one level or category in our research model.

Determinants and Results of EDI Integration

Although the EDI adoption decision has been heavily researched, the number of studies addressing EDI integration is a small set indeed. By integration we refer to the degree to which EDI technology is used in current internal and external business processes, applications, and transactions. The distinction between the two terms is important because our definition of EDI precludes manual intervention in transaction processing. Our framework suggests that EDI adoption may precede integration, but that integration benefits may be quite different from adoption benefits. Based on our analysis of the literature, we characterize two different second-order integration constructs. These are (i) internal integration intensity and (ii) external integration intensity. The former refers to the integration among various applications internal to the firm so that both incoming and outgoing EDI data handling is automated. The latter refers to the diversity of transactions, connectivity to the diverse stakeholders of the firm, such as customer and supply chain partners, and the depth of process interconnectivity to suppliers.

Internal integration intensity consists of three dimensions. First, the percentage of transactions processed using EDI is a proxy measure for the level of EDI usage within the company (Massetti & Zmud, 1996). While this measure may be useful in comparing EDI use across different firms, it lacks specificity in measuring how and where the EDI system is integrated. A more targeted measure of internal integration is the degree to which an EDI transaction is integrated with the internal business systems of the firm, eliminating the need for manual processing and data entry redundancy (Premkumar et al., 1994; Premkumar & Ramamurthy, 1995; Massetti & Zmud, 1996; Truman, 2000). This measure of "internal integration" is the most prevalent in the literature. Likewise, further reference to internal integration in this work will refer to this definition. Finally, the degree to which EDI-based transactions can be integrated across the different functional departments within the firm is a third dimension of integration. Studies examining this integration are scarce (Truman, 2000).

Many firms have integrated EDI with their order-processing and inventory-management systems. Handfield (1995) states that more innovative integrations include electronic funds transfer where funds are electronically remitted to suppliers and electronic graphic interchange where visuals and drawings are

electronically transmitted to support new product development and bidding processes (Thachenkary, 1992; Takac, 1993). Many of the antecedents of EDI adoption are also shared with EDI integration (Premkumar et al., 1994; Bergeron & Raymond, 1997; Ramamurthy, Premkumar, & Crum, 1999). Integration is also affected by the adoption process itself, including the elapsed time since EDI adoption, success of the implementation, system complexity, integration cost, and business process standardization (Premkumar et al., 1994; Premkumar & Ramamurthy, 1995). Anticipated benefits specific to the internal integration decision include cost efficiencies (through decreased paperwork and reduced staff requirements), increased quality (fewer errors and improved data accuracy), improved productivity by eliminating redundancy in processing, and better customer service (better planning of shipments, fewer stock-outs, and better planning of shipments and deliveries) (Arunachalam, 1997; Lim & Palvia, 2001; Lee & Lim, 2003; Manabe, Fujisue, & Kurokawa, 2005).

External integration intensity also consists of three dimensions. One measure is the number of external partners connected to the firm's EDI system. Again we adopt this definition for our research because this is the most prevalent measure of "external integration." A second dimension is the diversity of transaction sets converted into EDI (Bergeron & Raymond, 1997; Iskandar et al., 2001b). This measure is also referred to as EDI diversity by several authors (Hart & Saunders, 1998; Lee & Lim, 2003). A third dimension is EDI depth as proposed by Massetti and Zmud (1996). This measure refers to the integration of supply chain–related business processes between buyer and supplier through EDI; however, it is currently understudied.

Many of the same factors hypothesized to be determinants of internal integration are likewise expected to impact external integration (Handfield, 1995). We recognize that another set of dyadic factors also facilitates or encumbers the integration effort, including the degree of commitment, interdependence, and trust between partners in the buyer–supplier relationship (Lee & Lim, 2003). Anticipated benefits with respect to external integration include increased communications, information sharing, increased collaboration, and improved buyer–supplier relationships (e.g., Bergeron & Raymond, 1992; Premkumar & Ramamurthy, 1995; Ramamurthy et al., 1999).

Realized Benefits of EDI

The realized benefits of EDI adoption and integration can also be categorized by their impact at multiple levels. We note that realized benefits may be quite different from anticipated benefits. Handfield (1995) observes that often the anticipated benefits from EDI were more modest in scope and more tactical than actual realized benefits, and surprisingly, anticipated benefits were in many cases never realized. For example, anticipated staff reductions in purchasing often are not realized, but procurement staff may find that their job duties are reallocated from clerical tasks to more strategic activities related to managing and negotiating with suppliers. Table 1 provides a summary of specific EDI benefits identified in the literature. Each of these outcome variables has been modeled as a dependent (independent) variable in at least one EDI study. With no single generally accepted model of EDI use, Table 1 displays the broad set of EDI outcome variables that have surfaced in

Table 1: Anticipated electronic data interchange (EDI) benefits: Level and impact

Construct	Selected References	Construct	Selected References
Competitive Benefits		**Benefits Impacting Supply Chain Partners**	
Expand customer base	Crum, Premkumar, & Ramamurthy (1996).	Reduce response times to customers	Vijayasarathy & Tyler (1997); Arunachalam (1997); Reekers (1994); Iskandar, Kurokawa, & LeBlanc (2001a); Banerjee & Golhar (1994).
Gain competitive advantage	Vijayasarathy & Tyler (1997); Arunachalam (1997); Reekers (1994); Iskandar (2001a); Banerjee & Golhar (1994).	Help reduce inventory levels	Vijayasarathy & Tyler (1997); Arunachalam (1997); Reekers (1994); Iskandar et al. (2001a); Banerjee & Golhar (1994); Kekre & Mukhopadhyay (1992); Lee, Clark & Tam (1999); Droge & Germain (2000); Jiménez-Martinez & Polo-Redondo (2004).
Greater sales volume	Vijayasarathy & Tyler (1997); Reekers (1994); Banerjee & Golhar (1994); Crum et al. (1996).	Increase inventory turnover	Vijayasarathy & Tyler (1997).
Keep pace with competitors using EDI	Vijayasarathy & Tyler (1997); Murphy & Daley (1996); Crum et al. (1996).	Reduce stock outs	Vijayasarathy & Tyler (1997).
Improve gross margin	Vijayasarathy & Tyler (1997).	Improve customer service	Vijayasarathy & Tyler (1997); Arunachalam (1997); Reekers (1994); Iskandar et al. (2001a); Banerjee & Golhar (1994).
Improve product/service quality	Reekers (1994); Crum et al. (1996).	Comply with vendors' requests and demand	Vijayasarathy & Tyler (1997); Arunachalam (1997); Reekers (1994); Banerjee & Golhar (1994).
Improve customer loyalty	Reekers (1994); Banerjee & Golhar (1994).	Meet customer requirement	Arunachalam (1997).
Increase our market share	Iskandar et al. (2001a).	Improve planning of shipment cycles	Reekers (1994).

Continued

Table 1: Continued

Construct	Selected References	Construct	Selected References
Cost-Saving Benefits		**Supply Chain Transaction Benefits**	
Lower cost of general management activities	Vijayasarathy & Tyler (1997); Reekers (1994); Iskandar et al. (2001a); Murphy & Daley (1996); Crum et al. (1996).	Enhance data accuracy	Vijayasarathy & Tyler (1997); Arunachalam (1997); Reekers (1994); Murphy & Daley (1996); Crum et al. (1996); Riggins & Mukhopadhyay (1994).
Lower cost of delivering products to customers	Reekers (1994).	Reduce procurement lead time	Vijayasarathy & Tyler (1997); Iskandar et al. (2001a).
Help reduce/eliminate paper work	Arunachalam (1997); Reekers (1994); Murphy & Daley (1996).	Increase efficiency of clerical staff	Aruhachalam (1997); Iskandar et al. (2001a).
Staff reductions	Arunachalam (1997); Reekers (1994).	Reduce clerical errors	Iskandar et al. (2001a); Reekers (1994); Banerjee & Golhar (1994).
Decrease inventory costs	Reekers (1994); Iskandar et al. (2001a).	Make accounting and billing easier	Arunachalam (1997); Murphy & Daley (1996).
Reduce transaction cost	Arunachalam (1997); Sriram & Banerjee (1994).	Delivery performance/shipment performance	Walton & Marucheck (1997); Ahmad & Schroeder (2001); Srinivasan, Kekre, & Mukhopadhyay (1994).
		Improve control over data	Reekers (1994); Banerjee & Golhar (1994).
		Improve productivity	Arunachalam (1997); Murphy & Daley (1996); Reekers (1994); Crum et al. (1996).
Communication & Coordination Benefits in Supply Chain			
Improve channel relations with vendors	Vijayasarathy & Tyler (1997); Reekers (1994); Banerjee & Golhar (1994); Bergeron & Raymond (1997).	Better data sharing with buyers/suppliers or Coordination	Reekers (1994); Hill & Scudder (2002).
Improve communication with shipper	Arunachalam (1997); Reekers (1994); Banerjee & Golhar (1994); Murphy & Daley (1996).	Helps track shipments more easily	Arunachalam (1997); Murphy & Daley (1996); Lim & Palvia (2001).
Enable integration of information database	Iskandar et al. (2001a); Arunachalam (1997).		

the literature. Some studies identified multiple benefits from EDI use, while others use a single perceptual measure of EDI success. The literature as a whole displays a rather incoherent theoretical basis for study.

Notwithstanding this issue, we sought to synthesize the literature, assuming that EDI impacts organizations at multiple levels: (i) the individual level; (ii) the plant level (including procurement, operations, and logistics); (iii) the enterprise level; (iv) the buyer–supplier dyad; and (v) the supply chain network. While our analysis will focus on impacts at the plant, firm, and dyadic level, we include the other two levels to complete the model, but caution that these are areas where the research is underdeveloped. This caveat becomes all the more important when we address the implications for future research in EDI as an IOS.

Although the information sciences literature has examined the impact of information technology at the individual level, much of the EDI literature has used the organization or plant as the unit of analysis. Handfield (1995) provides examples of EDI adoption where the impact was felt not only by individuals in the purchasing department who were direct users of the EDI system, but also by customer service staff, who did not use the EDI system, but whose workloads were impacted by EDI. Jones and Beatty (2001) examine the impact of change in the work environment on user satisfaction with EDI. They find that "change in tasks" had no impact on user satisfaction. Venkatesh (2006) argues that, although the dyad may be the appropriate unit of analysis for supply chain technologies, the perceptions, beliefs, and behaviors of individuals operating at the boundaries of the dyad can determine the outcomes realized by the organization. Important managerial parameters that impact EDI success include training, system design, and socialization.

At the plant level, Table 1 displays outcome-related dependent variables in several studies. Within the production function, key outcomes include productivity-based metrics such as reduced lead times, fewer shipment discrepancies, reduced safety stock levels, higher inventory turns, increased data accuracy, and improved efficiency, as well as customer-facing outcomes (e.g., meeting customer requirements for the right product at the right time). Outcomes include increased responsiveness, better delivery performance, fewer stock-outs, and better fill rates. At the organization level, outcomes are more strategic and address improved ability to reduce costs, grow the customer base, and improve competitiveness and profitability (Ahmad & Schroeder, 2001; Frohlich, 2002; Mukhopadhyay & Kekre, 2002).

At the dyadic level, soft benefits include increased trust and cooperation between partners, increased information sharing, collaborative planning, and improved sourcing relationships (Hill & Scudder, 2002; Saeed et al., 2005; Sahin & Robinson, 2002). Finally, at the network level, the size of a buyer's network of electronic linkages may influence the outcomes realized from EDI (Holland et al., 1992; Saeed et al., 2005; Wang & Seidmann, 1995). However, the literature is inconclusive on the effect of the overall size of the supplier network on EDI adoption. Iskandar et al. (2001b) find that the total number of customers does not significantly impact EDI adoption in their study of the automotive industry. Yet, a case study conducted in the office products industry found that the number of customers using EDI significantly impacted the benefits that a single firm gained from EDI (Jelassi & Figon, 1994).

The emergence of Internet EDI has caused a shift in the conceptualization of EDI as an electronic dyad integrating a single buyer and supplier, to a system that supports a single firm's linkages with a large number of supply chain partners. Wal-Mart is an example of a major firm that has long used a traditional EDI system, but is now requiring many of its suppliers to use Internet EDI (Bednarz, 2004). The research is still in its infancy in exploiting the implications and risks of such an electronic "arborescence" structure with Saeed et al. (2005) among the first to empirically study the trade-offs and benefits in such a relationship.

METHODOLOGY

As noted earlier in our discussion, Figure 1 represents set of hypothesized relationships that prevail in the epistemological and theoretical foundations of EDI research. When viewed from a meta-analytical perspective, however, there is a dismaying lack of clarity that emerges regarding many of these relationships. In such cases, there is a need to reconstruct the theoretical basis for future research, to resolve conflicts, and build a basis for future research in the field of IOSs (Handfield & Melnyk, 1998). One of the research methodologies for accomplishing this goal is meta-analysis. Meta-analysis is a technique that "enables combining of numerical results from few of many studies . . . and the explanation of consistencies as well as the discovery of moderators and mediators in bodies of research findings" (Rosenthal & DiMatteo, 2001, p. 61). Meta-analysis is increasingly being applied to business problems—including manufacturing strategy (White, 1996), new product performance (Montoya-Weiss & Calantone, 1994), and purchasing (Das & Handfield, 1997)—where empirical research has been inconclusive regarding the significance, direction, and magnitude of hypothesized relationships. Because these conditions also characterize the EDI literature, a meta-analysis is needed to help guide future researchers in EDI, particularly as EDI becomes more prominent in e-business. The meta-analysis methodology is described in detail in Appendix A. Below we describe our methodology in selecting empirical studies for the inclusion in our analysis.

We examined the EDI literature from 1991 to 2005 as published in refereed academic journals. The year 1991 was chosen as the start date because it corresponded to the presentation of Wrigley's (1991) summary of existing EDI literature at that time. Although over 900 EDI articles had appeared in both academic and practitioner journals prior to 1991, surprisingly, only 32 of these articles even mentioned the word research. We identified only 12 research articles published prior to 1991 that had used empirical methodology in studying EDI. A search of online databases such as ABI-Informs and EBSCO using the key words "Electronic Data Interchange" or "EDI" produced numerous articles appearing in 45 academic journals in diverse research domains, such as information systems, operations management, logistics/supply chain, and technology management. To complement our literature search, we contacted 50 authors who have published in EDI and requested each to provide a list of the academic studies, both published and working papers, that he/she felt were most important in the EDI literature. We received 15 responses with 43 nominated research articles. All nominated

research articles referred to published articles already in our database. Overall, these methods yielded 182 articles.

We classified the selected studies into four methodological groups: (i) conceptual or discussion-based articles, (ii) survey-based articles that involved collection and analysis of primary and/or secondary data, (iii) case studies involving the application of EDI within a single organization or a small sample of firms, and (iv) analytical models addressing EDI effects in a stylized setting. Of the 182 published articles, we identified 90 survey-based studies, 50 conceptual articles, 33 case studies, and 9 analytical studies. (A tabulation of each article and its categorization is available on request from the authors.) These findings confirmed our belief that the majority of the EDI research involved empirical methodologies. Five of these 90 studies were eliminated from consideration as they were nearly identical to previously published studies by the same authors and used the same data sets. To avoid bias in the meta-analysis by including only published studies, we examined all dissertations listed in the UMI Proquest Digital Dissertation Database and identified 42 relevant theses and dissertations completed between the years 1986 and 2006. Among these, 29 were survey-based, 10 contained collections of case studies, and 3 were analytical studies. Of the survey-based dissertations, 11 had already been published and were already in our database at the time of this study. Finally, we searched conference proceedings, including the Institute of Electrical and Electronics Engineers (IEEE) conference proceedings and the Association for Computing Machinery (ACM) database, but failed to find any articles with usable empirical data. A table listing all the empirical studies in our database is presented in Appendix B. Although we initially started with 103 studies that presented empirically based results, only 39 studies (6 dissertations and 33 published articles) could be included in our meta-analyses; each is identified with an asterisk in Appendix B.

Despite the number of studies in the database, a full-scale meta-analysis of the EDI literature proved difficult for several reasons. First, we found very few common research hypotheses among the various empirical studies we investigated, reflecting a fundamental paucity of theoretical foundations for many of the research studies. Second, we could not identify a single dependent variable that was consistently measured and applied across different empirical studies. Some studies used multiple measures in reporting their results, as opposed to a single dependent variable, making data synthesis even more difficult. Third, despite a rich body of empirical research, there seemed to be a lack of generally accepted construct definitions and standard scales used in the EDI research. Various studies used different terminologies and items in defining similar constructs, making synthesis difficult. Finally, several studies either did not report correlation coefficients or failed to provide sufficient detail in their analyses to allow a meta-analysis. For these reasons, the lack of a required sample size for meta-analysis of specific relationships among defined sets of variables/constructs proved challenging. Current literature suggests that at least four studies are needed for a meta-analysis (Alavi & Joachimsthaler, 1992), which limited the number of relationships that could be consistently validated through this rigorous approach. Despite these barriers, we were able to identify several important patterns of results, which provide a formative structure for ongoing research in EDI and IOS.

RESULTS

Table 2 presents a selected summary of the significance of the statistical relationships between the five categories of determinant factors depicted in Figure 1 and EDI adoption. Meta-analysis was performed in cases when four or more studies for a particular variable were available. Table 3 presents the results of the meta-analyses, including the effect size as determined by the weighted correlation value, the significance level of the chi-square statistic used to test for the homogeneity of the effect size among various studies, the range of the correlation coefficients used, and the computed post hoc power.

External Factors

In examining the relationships between external factors and EDI adoption, the literature suggests that pressure by government agencies, environmental uncertainty, and previous adopters do not significantly affect EDI adoption (O'Callaghan et al., 1992; Germain & Dröge, 1995; Ahmad & Schroeder, 2001; Kuan & Chau, 2001). However, the literature has reported conflicting results associated with the effects of both industry influence and competitor influence on EDI adoption. We performed meta-analyses on both these explanatory factors with results reported in Table 3. The analysis revealed effect sizes in the medium to high range (as indicated by the weighted r), for both factors. However, very low p values combined with significant variance in effect size across studies led us to believe that the presence of moderating variables may have a major role in this body of research, as we describe in more detail below.

One of the most important potential moderating effects in EDI adoption studies not explicitly controlled for is industry variance. Moreover, industries such as retail, health care, automotive, and grocery are highly competitive, have a high number of transactions, and are more likely to adopt EDI to drive efficiencies and reduce lead times. Two of the studies in the sample considered for the meta-analysis were conducted in the automotive industry with respondents who were primarily suppliers to the large automobile manufacturers (Rassameethes, 1999; Iskandar et al., 2001a). Neither of these studies finds that competitive pressure significantly affects EDI adoption. The remaining studies used samples consisting of a mixture of industries, with two of these studies concluding that the influence of industry competitors significantly impacts adoption decisions (e.g., Chwelos et al., 2001; Teo et al., 2003). The average effect size of studies conducted in the automotive industry ($r = .070$, S.E. $= .075$) was significantly lower with samples representing a mix of industries ($r = .313$, S.E. $= .035$) suggesting that automotive industry firms could be a potential moderating variable.

A possible moderating factor here is that automotive companies typically single source by product platform (Handfield & Krause, 1999). Also, EDI adoption within the automotive industry is typically driven by mandate from a few influential Original Equipment Manufacturers (OEMs), in contrast to firms in other industries where multiple customers exist in a competitive market structure (Min & Galle, 2003). This effect is most closely related to the research addressing partner dependency. When there are a few dominant buyers in an industry, a single buyer may represent a major share of a supplier's business, which creates the condition

Table 2: Selected conflicting results from electronic data interchange (EDI) literature*

	Significant	Insignificant
EXTERNAL ENVIRONMENT		
Competitive Pressure	Chwelos, Benbasat, & Dexter (2001); **RAMAMURTHY, PREMKUMAR, & CRUM (1999)**; Teo, Wei, & Benbasat (2003).	Iskandar, Kurokawa, & LeBlanc (2001b).
Industry Pressure	Chwelos et al. (2001); Gavidia (2001); Kym (1991); Teo et al. (2003).	O'Callaghan, Kaufmann, & Konsynski (1992).
INTERNAL FACTORS		
Technical Compatibility with Systems	Iskandar et al. (2001b); O'Callaghan et al. (1992); Premkumar, Ramamurthy, & Nilakanta (1994); ***Premkumar et al. (1994)***.	Gavidia (2001); **Iskandar et al. (2001b)**; ***Premkumar & Ramamurthy (1995)***; Premkumar & Ramamurthy (1995); **Premkumar et al. (1994)**.
Size of the Company	Ahmad & Schroeder (2001); Allen, Crum, & Braunschweig (1992); Germain & Dröge (1995); Gavidia (2001); Iskandar et al. (2001b).	Lee & Han (2000a); Rassameethes, Kurokawa, & LeBlanc (2000).
Cost of Implementation (negative)	Iskandar, Kurokawa, & LeBlanc (2001a); Premkumar et al. (1994).	Crum, Premkumar, & Ramamurthy (1996); **PREMKUMAR & RAMAMURTHY (1995)**; **PREMKUMAR ET AL. (1994)**.

Continued

Table 2: Continued

	Significant	Insignificant
ANTICIPATED BENEFITS		
Benefit Expectations	**Arunachalam (1997)**; ***Bergeron & Raymond (1992)***; Chwelos et al. (2001); Gavidia (2001); Kuan & Chau (2001); **Lee & Lim (2003)**; **Lim & Palvia (2001)**; **Manabe et al. (2005)**; O'Callaghan et al. (1992); **Premkumar et al. (1994)**; **Premkumar & Ramamurthy (1995)**; **Ramamurthy et al. (1999)**; **Rassameethes, Kurokawa, & LeBlanc (2000)**; Son (2001).	Kuan & Chau (2001) (Indirect Benefits); ***Premkumar et al. (1994)*; *Premkumar & Ramamurthy (1995)*; *Ramamurthy et al. (1999)***.
DYADIC		
Source Firm Dependency (Interdependency)	Lee & Lim (2003); Hart & Saunders (1998); Chwelos et al. (2001); Iskandar et al. (2001b); **Lee & Lim (2003)**.	Premkumar & Ramamurthy (1995); **Iskandar et al. (2001b)**; Ramamurthy et al. (1999).
Trust (with Volume of EDI Use)	**Lee & Lim (2003)**.	Hart & Saunders (1998).
Firm's Influence on Partners	***Premkumar & Ramamurthy (1995)***.	**Premkumar & Ramamurthy (1995)**.
Trust (Transaction Diversity)	***Hart & Saunders (1998)***.	***Lee & Lim (2003)***.

Notes: *Plain font indicates EDI adoption; bold font indicates internal EDI integration; bold with italics indicates external EDI integration; and bold with capital indicates same direction of internal and external integration variables in the same study.

Table 3: Meta-analysis of relationships in Figure 1*

Explanatory Variable	Sample Size	Weighted r	p value	Effect Size Range	Power
Industry Influence*	4	.416	.019	0.341–0.510	1.000
Competitor Influence*	6	.27	.000	0.002–0.457	0.954
Dependency on Source Firm*	6	.187	.000	0.044–0.600	0.732
Environmental Uncertainty	4	.097	.148	0.020–0.436	0.253
Technical Compatibility	6	.166	.141	0.090–0.308	0.743
Organizational Size	7	.219	.351	0.147–0.380	0.856
Imposition by Source Firm*	8	.251	.001	0.100–0.500	0.937
Perceived Benefits	6	.302	.521	0.240–0.420	0.994
Reduces Inventory Levels*	4	−.102	.017	−0.265 to 0.169	0.255
Increases Productivity*	4	.052	.017	−0.144 to 0.225	0.121
Reduces Paper work*	4	.013	.050	−0.154 to 0.209	0.063
Improves Data Accuracy*	5	.134	.023	0.018–0.476	0.344
Improves Communication with Trading Partner	4	.199	.796	0.138–0.281	0.551
Improves Customer Service	5	.188	.053	0.033–0.450	0.533
Quick Response to Market Trends*	4	.102	.000	−0.157 to 0.503	0.255
Internal Integration on Benefits	10	.280	.901	0.190–0.390	0.948
External Integration on Benefits	4	.259	.821	0.180–0.290	0.835

*_Note:_ An asterisk indicates significant variation in effect size evaluated at the 0.05 significance level.

of de facto coercion for EDI adoption. Other examples include Wal-Mart, Best Buy, Dell, Cardinal Health, and other large industry players. We divided the six studies in this area into those that sampled automotive suppliers only and those that sample a mix of industries. We hypothesized that the automotive suppliers would face greater business dependency on their customers than the suppliers from a mix of industries. Our results support this hypothesis. Samples consisting only of automotive suppliers differed significantly ($r = .35$ and S.E. $= .059$) from those that sampled a mix of industries ($r = .106$ and S.E. $= .042$). While these results are exploratory, they suggest that membership in the automotive supply base may be a moderator in the relationship between competitive and industry pressure and EDI adoption.

EDI integration

While the number of studies addressing EDI integration is limited, we offer comment on the literature. Current research suggests that competitive pressure is a significant determinant of both internal and external EDI integration (Ramamurthy et al., 1999), while a firm's influence on its market structure is a significant determinant of internal integration, but not external integration (Premkumar & Ramamurthy, 1995).

Internal Factors: Compatibility, Firm Size, and Implementation Cost

While many internal factors have been hypothesized to impact the EDI adoption decision, we turn our attention to conflicting results associated with three factors: technical compatibility, organizational size, and the cost of implementation. A meta-analysis on the effect of technical compatibility of the firm's systems on EDI adoption reveals a small to moderate effect size, with greater consistency that reduces the likelihood of moderating effects. Two related variables are overall readiness (Chwelos et al., 2001) and organizational proactiveness (Premkumar & Ramamurthy, 1995; Iskandar et al., 2001b), which were both statistically significant variables associated with EDI adoption and integration. However, the limited number of studies investigating these determinants did not lend themselves to a meta-analysis.

Despite conflicting findings in the research, our meta-analysis reveals that the relationship between organizational size and EDI adoption has a moderate effect size, with little evidence of moderating variable inputs. Some of the salient predictors of adoption include the level of financial and management resources available to the firm (Premkumar et al., 1994; Premkumar & Ramamurthy, 1995; Ramamurthy et al., 1999). Further clouding the picture of the impact of organizational attributes on EDI adoption are conflicting findings regarding organizational compatibility, both as an insignificant enabler in one case (O'Callaghan et al., 1992; Premkumar et al., 1994) and as a significant determinant in another (Chwelos et al., 2001). The small number of studies precludes performing a meta-analysis, but suggests that there is at best limited support for organizational size and resources as significant determinants of EDI adoption.

Likewise, the overall impact of EDI implementation cost on adoption is inconclusive. Some studies find that cost is a significant barrier to EDI adoption

(Premkumar et al., 1994; Iskandar et al., 2001a; Min & Galle, 2003), while others find that cost presents no significant effect (Crum, Premkumar, & Ramamurthy, 1996; Murphy et al., 1998). A meta-analysis could not be conducted due to parameter disparity.

EDI integration

In general, the literature has failed to establish any organizational factors as significant drivers of EDI integration. The relationship between technical compatibility as a driver of internal integration is characterized with conflicting results from multiple studies (Premkumar et al., 1994; Premkumar & Ramamurthy, 1995). Implementation cost also has apparently no impact on internal and external integration of EDI (Premkumar et al., 1994; Premkumar & Ramamurthy, 1995). Thus, the literature related to EDI integration fails to shed additional light on the effect of selected internal or organizational factors on EDI adoption. Other results examining the effect of internal factors, including the impact of EDI experience on integration, are also inconclusive (Iskandar et al., 2001b; Premkumar & Ramamurthy, 1995). The limited number of studies for many of these variables precludes any meta-analysis or examination of moderating effects.

An astonishing observation in these studies is that conflicting results are produced in studies conducted by the same set of authors, possibly even using the same data sets. These conflicting results are likely the result of (i) inconsistent scales (i.e., combination or separation of scales from one article to another in case of the same data set; (ii) failure to use multimethod, multirespondent, and multitrait sampling frames; or (iii) inconsistent application of EDI adoption and integration explanatory factors in different data sets. Outside of the limited effect of firm size and resources on EDI adoption, the literature is so fragmented that it fails to identify possible moderating or mediating variables.

Operational Factors: Is JIT a Driver for EDI Adoption?

Although the number of studies examining the relationship between operations-related variables and EDI adoption is too small to conduct a meta-analysis, this literature is relatively free of the conflicting findings that have plagued the other categories of explanatory variables. Adoption of JIT ("lean manufacturing") initiatives has consistently risen as an important driver of EDI adoption (Germain & Dröge, 1995; Ahmad & Schroeder, 2001; Nicolaou, 2002). Lean manufacturing systems are predicated on the concept of more frequent deliveries from suppliers to point of use, and the research is unequivocal in finding that transaction frequency is a significant determinant of EDI adoption (Sriram & Banerjee, 1994; Germain & Dröge, 1995; Iskandar et al., 2001b). A second attribute of lean manufacturing is the need to standardize products, which is also found to be significantly associated with EDI adoption (Dröge & Germain, 2000; Ahmad & Schroeder, 2001; Iskandar et al., 2001b; Nicolaou, 2002) and is also consistent with the predictor of higher, more frequent transaction volume. Third, product variety is an insignificant driver of EDI adoption (Germain & Dröge, 1995), which is not necessarily contradictory in nature. For instance, in one facility we visited, a first-tier supplier's production line had an EDI link to an OEM's assembly operation, such that vehicle

identification numbers of vehicles passing through assembly were transmitted electronically to the beginning of the line. Line operators would initiate a model assembly, and as assemblies were completed, they were shipped directly to the point of use at the OEM's location in a three-hour window. This arrangement depended on high transaction frequency and standardized products; production models were assembled using a mixed model schedule.

Another initiative associated with JIT is process simplification. The literature has established that business process improvement efforts are associated with both EDI adoption and integration. In particular, business process standardization has a significant effect on both internal and external integration (Premkumar & Ramamurthy, 1995). Several authors have cited the importance of EDI as part of any process improvement initiative (Riggins & Mukhopadhyay, 1994; Clark & Hammond, 1997; Walton & Marucheck, 1997; Walton & Gupta, 1999). In particular, Walton and Marucheck (1997) found no significant relationship between EDI integration and delivery performance, but also discovered that, when procurement and receiving processes were improved, higher delivery performance did occur as a result of EDI adoption (Walton & Gupta, 1999). In summary, this literature review suggests that EDI has been used to manage and reduce transaction costs, particularly in procurement activities, at the plant level rather than as an element of a strategy to mitigate supply risk and manage product variety.

Anticipated Benefits

The fourth class of antecedents is the anticipated benefits organizations expect to gain from EDI adoption. Although many studies have concluded that anticipated benefits are a significant driver for EDI adoption and integration (e.g., O'Callaghan et al., 1992; Premkumar et al., 1994; Iacovou et al., 1995; Premkumar & Ramamurthy, 1995; Crook & Kumar, 1998; Chwelos et al., 2001; Kuan & Chau, 2001), there are conflicting results with several studies not finding a significant relationships. Our meta-analysis in Table 3 reveals that anticipated benefits have a medium to strong effect on EDI adoption, and the p value suggests that there is no moderating variable. Overall the meta-analysis suggests that anticipated benefits are a driver of EDI adoption, despite the conflicting results.

Dyadic Factors

Dyadic factors studied fall into two groups: power asymmetries and relational factors. Power asymmetries are most often mentioned in the context of small suppliers coerced into adopting EDI by their more powerful customers (e.g., Banerjee & Golhar, 1994; Chwelos et al., 2001). Our meta-analysis suggests that, despite a moderate effect size and a high post hoc power for coercion by supply chain partners as a factor in EDI adoption, there is significant variation of effect size across the studies in this area. To investigate whether firm size was a moderating variable, we divided the studies into those that explicitly sampled only small firms and those that sampled a mix of firms of different sizes. Results suggest that effect sizes for studies with mixed firm samples (Premkumar & Ramamurthy, 1995: $r = .205$; Gavidia, 2001: $r = .510$) are higher than studies that sampled only small suppliers (e.g., Chwelos et al., 2001: $r = .189$). A test of difference of weighted

average effects between the two groups yielded statistically insignificant results. Contrary to common wisdom, Kuan and Chau (2001) find that influence exerted by business partners actually reduces the likelihood of EDI adoption by small companies. This lack of statistical support in the empirical literature suggests that other factors are more important than firm size and coercion in determining rates of EDI adoption. Another problem may be that there is a lack of clarity around what constitutes a "small supplier," which is alternatively defined as less than $1 billion in sales (Chwelos et al., 2001), fewer than 100 employees (Kuan & Chau, 2001), fewer than 540 suppliers (Raymond & Blili, 1997), and fewer than 10 employees (Murphy & Daley, 1996).

A more salient parameter that may have more explanatory power is the relative dependency of the supplier (customer) on a particular customer (supplier), which could establish a position of power in the negotiation process (Premkumar & Ramamurthy, 1995; Hart & Saunders, 1998; Iskandar et al., 2001b; Lee & Lim, 2003). Our meta-analysis reveals a low to moderate effect size and high variation among studies. While the high cost of EDI adoption may be prohibitive for smaller firms (Mackay, 1993; Arunachalam, 1997; Vijayasarathy & Tyler, 1997), researchers also found that supplier incentives in the form of additional business, price premiums, and technical support/training may induce suppliers to adopt EDI and absorb the initial investment cost (Riggins, Kriebel, & Mukhopadhyay, 1994; Wang & Seidmann, 1995; Barua & Lee, 1997; Nakayama, 2000). Findings on incentive-based approaches to EDI adoption were also inconsistent. Although O'Callaghan et al. (1992) find that EDI is associated with an increased share of supplier business, other researchers do not find support for incentive-based approaches (Nakayama, 2000; Mukhopadhyay & Kekre, 2002).

A dominant research paradigm in the literature examines "pure coercion" and "pure incentive" as distinct policies to encourage EDI adoption. Some studies have begun to examine a more balanced approach, involving a mix of coercive and incentive policies as a means to promote EDI adoption on the part of a supply chain partner (Riggins et al., 1994). Barua and Lee (1997) find that a supplier will join a network in anticipation of the overall benefits that can be gained from the relationship regardless of its internal cost structure. There is clearly a gap in the IOS research here to further establish the interrelationships between EDI adoption costs, degree of dependency in supply chain relationships, and coercive/incentive policies.

Buyer–supplier relational factors that spur adoption include the presence of a high level of trust between the buyer and the supplier, the need to gain better communication and coordination, and the degree of partnership and interdependence between the buyer and the supplier (Vijayasarathy & Robey, 1997; Hart & Saunders, 1998; Lee & Han, 2000a; Lee & Lim, 2003). Commitment and trust refer to the role of EDI in nurturing the business relationship and the perceived sense of fairness in business transactions. While the number of studies is limited, conflicting results also prevail in this area. For example, Lee and Lim (2003) find support for the hypothesis that improved trust between business partners leads to EDI use, while Hart and Saunders (1998) do not. Lee and Lim (2003) find support for the effect of commitment on EDI use, while Hart and Saunders (1998) do not. Further, the research displays insignificant effect sizes between conflict and

cooperation in dyads and EDI use. While the electronic dyad is increasingly cited as the unit of analysis in EDI studies, our review indicates the effects of dyadic relationship variables on EDI adoption is inconclusive, piecemeal, and fragmented. One possible explanation is that the structured formats required in EDI exchanges are inconsistent with the more informal and interpersonal interactions that characterize dyadic relationships.

Although the research base is currently inconclusive on the role of EDI in enhancing the dyadic relationship, our opinion is that further work is needed to determine if EDI use can lead to more timely information, improved supply chain coordination, and improved forecasting. Currently, there is little support for making that case, and given the increasing role of technology in global supply chains, there is certainly a need for research in this area.

Realized Outcomes of EDI Adoption and Integration

Much of the empirical literature is devoted to an examination of the benefits realized from EDI as listed in Table 1. Yet our analysis of the current literature finds that the realization of specific individual benefits from EDI has not been conclusively established. Although our meta-analyses sought to resolve these inconsistencies, the number of relationships that lend themselves to meta-analysis are limited by small sample sizes, inconsistent construct development, and a general lack of well-developed theory. As shown in Table 4, the outcomes associated with EDI adoption are inconsistent as well. Outcome results are inconsistent with conventional beliefs regarding EDI: data accuracy exhibits a low effect size while inventory reduction, reduced paperwork, and increased productivity all exhibit

Table 4: Conflicting findings on realized benefits attributed to electronic data interchange

Benefits	Significant	Insignificant
Reduces inventory levels	Banerjee & Golhar (1994).	Reekers (1994); Elbaz (1999); Iskandar, Kurokawa, & LeBlanc (2001a).
Improves customer service	Reekers (1994); Iskandar et al. (2001a); Murphy, Daley, & Hall (1998).	Banerjee & Golhar (1994); Elbaz (1999).
Quick response to market trends	Reekers (1994); Iskandar et al. (2001a).	Banerjee & Golhar (1994); Elbaz (1999).
Improves communication with trading partner	Reekers (1994); Sriram & Banerjee (1994); Iskandar et al. (2001a).	Murphy et al. (1998).
Reduces paperwork		Reekers (1994); Banerjee & Golhar (1994); Murphy et al. (1998); Elbaz (1999).
Increases productivity		Murphy et al. (1998); Banerjee & Golhar (1994); Reekers (1994); Elabz (1998).
Data accuracy	Reekers (1994).	Murphy et al. (1998); Banerjee & Golhar (1994); Elbaz (1999).

insignificant effect sizes. Note here that inventory reduction displays a negative relationship. We first comment on data accuracy.

Although the literature posits that EDI adopters benefit from improved data accuracy (Banerjee & Golhar, 1994; Reekers, 1994; Murphy et al., 1998; Elbaz, 1999; Iskandar et al., 2001a), the meta-analysis reveals that the effect size is not high. We found no possible moderating variables in this case, suggesting that EDI adoption alone is unlikely to have a major impact on data accuracy.

The posited negative relationship between EDI adoption and inventory reduction also displays conflicting results. Kekre and Mukhopadhyay (1992) and Dröge and Germain (2000) found significant inventory reductions with EDI adoption while Mackay (1993) and Jiménez-Martinez and Polo-Redondo (2004) note the lack of outcomes for this variable. Several studies compare the differences in perceptions of benefits between EDI adopters and nonadopters. Results of three studies are inconclusive. On the one hand, nonadopters reported higher expected inventory reductions due to EDI as compared to adopters (Banerjee & Golhar, 1994; Reekers, 1994; Elbaz, 1999), while, on the other hand, adopters fared better in a third study (Iskandar et al., 2001a). The p value suggests moderating influences, which might include organizational size, with smaller organizations experiencing greater improvement in inventory (Teo et al., 1995), JIT adoption (Germain & Dröge, 1995; Clark & Hammond, 1997; Lee et al., 1999), continuous replenishment programs (Raghunathan & Yeh, 2001), and sophistication of the EDI system. Inventory reduction as a benefit of EDI will be further discussed as a result of EDI integration.

With regard to increased productivity, the findings are inconclusive, which leads to the very low effect size. Truman (2000) suggests that EDI reduces both administrative and professional staff. In contrast, Sriram and Banerjee (1994) found no significant reduction in staffing levels at the purchasing department due to adoption of EDI. Likewise, the meta-analysis reveals that the effect of EDI adoption on reducing paperwork is also insignificant. This particular effect size was the lowest in the entire analysis, and the computed power was very low. Improved delivery performance due to EDI adoption deserves further discussion. Although EDI is hypothesized to improve delivery performance in general (Galliers, Swatman, & Swatman, 1995), empirical studies on EDI's role in improving delivery performance are scarce, precluding a meta-analysis. Yet Ahmad and Schroeder (2001) find that EDI adoption is related to significant improvement in delivery performance after controlling for the effects of JIT.

In general, the highest average effect sizes were demonstrated for benefits related to customer-facing activities, including improved communication with a trading partner and improved customer service. Both exhibited a moderate effect size, with improved communication showing no hint of a moderator. Quick response to market trends also exhibits a low effect size, but the p value suggests possible moderating variables. We must caution that the definitions of customer service and quick response were not well specified in these studies. An open question is whether EDI adoption leads to an improvement in the services that firms can offer their customers. Inconclusive results prevail, as Rogers, Daughtery, and Stank (1992) found that warehouses that adopt EDI can provide a broader array of services, while Nakayama (2000) finds that increased value-added services are negatively correlated with increased EDI usage.

Our analysis fails to find support for many of the conventional beliefs regarding the realized benefits from EDI adoption. The surprising result from the meta-analysis is that the strongest effect sizes were reported for improved customer service and improved communication with supply chain partners, which are frequently collaborative downstream activities in a supply chain.

EDI integration

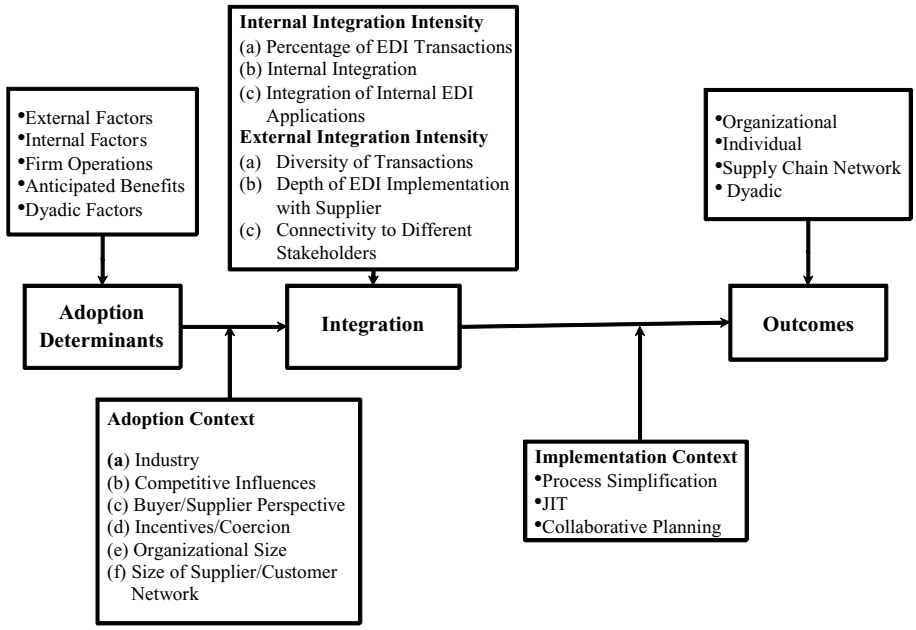
While the literature has found conflicting evidence in several cases for the overall benefits from EDI adoption, the benefits from EDI integration seem more consistent, although the limited number of studies precludes a full-scale meta-analysis. Many of the anticipated benefits from EDI are realized only when the EDI system is internally integrated. These include a significant reduction in inventory (Clark & Hammond, 1997; Lee et al., 1999; Lim & Palvia, 2001). Conflicting results also prevail in areas of data accuracy, processing times, and error rates (Riggins & Mukhopadhyay, 1994; Truman, 2000; Lim & Palvia, 2001; Anderson & Lanen, 2002). Yet the literature seems to be more consistent in linking integration to more strategic outcomes such as customer and financial performance (Ramamurthy et al., 1999; Dröge & Germain, 2000; Mukhopadhyay & Kekre, 2002).

Even the often-cited relationship between EDI integration and delivery performance is clouded by conflicting results. A majority of the studies find that integrated EDI improves delivery performance (Srinivasan et al., 1994; Ahmad & Schroeder, 2001; Lim & Palvia, 2001), particularly when EDI integration is an element of JIT adoption. Yet Walton and Marucheck (1997) do not find any support for this relationship when they defined delivery performance as a multidimensional measure, including on-time delivery, correct quantities of ordered items, and quality of incoming goods. There are two possible explanations for this discrepancy. First, process improvement through initiatives such as lean manufacturing may overshadow the effect of EDI integration on delivery performance (Germain & Dröge, 1995; Clark & Hammond, 1997; Lee et al., 1999). This result suggests that EDI may simply act as an enabling factor for supply chain excellence, as documented in the Supply Chain Operating Reference model. Second, from a measurement point of view, the construct delivery performance has not been precisely measured across studies of EDI outcomes. This is certainly a problem in academic research, where we discovered that delivery performance was defined as on-time delivery (Ahmad & Schroeder, 2001), reduced shipment discrepancies (Srinivasan et al., 1994), or both (Walton & Marucheck, 1997). Delivery performance is also a nebulous metric in practice. Our discussions with a manager in the consumer packaged goods industry reveals: "on-time can mean a number of things, including arrive final destination—POD, received into inventory, arrive load port, arrive destination port, unloaded from container, outgate to consignee, wheels down, portion of shipment received, or last item of shipment received."

A MODERATED MODEL OF EDI DEPLOYMENT

Our initial motivation for this study, derived from Davis et al.'s (1989) TAM sought insight into the following question: is there a consistent set of antecedents

Figure 2: Expanded conceptual model



EDI = Electronic Data Interchange, JIT = Just-in-Time.

and realized benefits associated with EDI adoption that is supported by multiple streams of research in the field? Our review and meta-analysis of the EDI research could be interpreted as disappointing in these terms. In general, we found a lack of consistent results, disparate linkages to organizational benefits, and a general inconclusive set of theoretical foundations, constructs, and effect sizes in the EDI literature. Despite these limitations and in the spirit of theoretical development, we remind readers that the objective of meta-analytic studies is to derive insights and lessons learned from prior research and to establish guidelines for future research (Hunter, Schmidt, & Jackson, 1982). We believe that our meta-analyses of EDI adoption patterns provide some important guidelines for future researchers that seek insights into IOSs, supply chain collaboration, and lean supply chain management. These guidelines are summarized in an interpretive framework established in Figure 2.

Many firms have become suspicious of promised benefits from IOS applications, due to massive investments with little return from many enterprise resource planning implementations, forays into B2B technologies, on-line portals, and other IOS applications. Thus, the assertion that adoption of new IOSs is driven by the expectation of positive benefits in the short term is perhaps not as valid as in the past. Our meta-analysis results suggest that the adoption of EDI is more likely tied to direct incentives and/or market-share/business continuity requirements, as opposed to any direct benefits. A good example of this type of behavior is the mandate by retailers that all suppliers attach radio frequency identification (RFID) tags

to their products. Suppliers generally expect few benefits from this requirement, but comply ("slap and ship" with an RFID tag) in order to maintain a business relationship.

Second, it is apparent that many variables moderate the relationship between new technology adoption, derived benefits, technical compatibility, and organizational size (see Table 2). Each of these variables has roots in different theoretical bases as described in the section titled "Research Framework." Our analysis suggests that external pressure (from competition, trading partners, and industry) is not a consistent driver of EDI adoption in all cases. While there is broad support that EDI generates positive benefits, the nature of these impacts is not the same given different levels of EDI integration. In this context, factors such as product standardization and adoption of lean manufacturing may play a role as well.

A model that is more parsimonious and consistent with the results of our meta-analyses is shown in Figure 2. This model provides guidelines for future research in IOS and suggests that contextual factors play an important role in the successful adoption of IOS technologies such as EDI. Indeed, given the multiple contingent factors at each stage of adoption, variables such as industry effects, the strength of the buyer–supplier relationship, organizational size, power asymmetries, JIT adoption, process improvements, and types of incentives, among others, play an important moderating role and, as such, need to be controlled for in empirical models. Contingencies at the adoption stage also include integration, diversity, depth, intensity, and application integration. Further, the nature and quality of EDI adoption and the scale of adoption may drive the overall benefits as outlined earlier. Other moderating factors that may influence the nature of adoption outcomes include overall size of the network and scale of adoption. We summarize the key research questions and gaps in Table 5, which are consistent with the overall framework in Figure 2.

Clearly, the ability to control for all of these factors in any given sample represents a challenge for researchers. As such, we believe that future researchers would be better served with a research design that seeks to understand general configuration approaches to successful adoption of IOS. A configuration can be defined as commonly occurring clusters of strategy, structure, process, or context (Miller, 1981; Neher, 2005). We believe that, despite the diversity of factors driving EDI adoption, the multitude of adoption dimensions, and the multiple impacts found in the literature, researchers could instead identify approaches that are more successful for configurational types. Examples here might include configurations of powerful buyers with small suppliers in retail or powerful manufacturers dealing with a network of smaller distributors. These sampling frames can provide more tightly defined theoretical bases that control for the multiple forms of moderating variables that might otherwise drive inconsistent results and conclusions. Through a consistent set of sampling frames that examine different forms of configurations while utilizing a more theoretically sound and consistent set of constructs and outcomes, future meta-analytical studies would be more productive in deriving meaningful cross-industry comparisons of EDI adoption.

Finally, we believe that information system adoption does not occur in a vacuum, but is increasingly related to the strength and resilience of collaborative buyer–supplier relationships. Systems in and of themselves do not drive

Table 5: Summary of findings and key research questions proposed

Section	Findings of Support	Key Research Questions Proposed
Antecedents of EDI adoption	• External factors: industry influence and competitive pressures on EDI positively affect EDI adoption with possible moderators, such as membership in the automotive industry supply bases. • Internal factors: technical compatibility and organizational size seem to impact EDI adoption. The impact of cost is inconclusive. • Plant factors: JIT adoption, transaction frequency and standardization of both product and processes positively affect EDI adoption. • Anticipated benefits significantly affect EDI adoption. • Dyadic factors: source firm imposition affects EDI adoption although there is a possible moderator.	• Does membership in other industries, as contextual variables, also moderate EDI adoption? • How does the size of supply base/customer base affect EDI adoption? • Can EDI help in managing product variety? • Can the use of EDI help mitigate supply risk and supplier disruptions? • Does process change play a mediating or moderating role in EDI adoption? • Do contingency factors affect the specific benefits that a firm anticipates with EDI adoption? • How do imposition, incentives, and dyadic relationship factors affect EDI adoption?
Antecedents of EDI integration	• External factors: competitive pressure significantly affects EDI integration. • Internal factors: Inconclusive findings for factors in the study. • Plant factors: inconclusive. • Perceived benefits: inconclusive. • Dyadic factors: inconclusive.	• Is there an optimal sequence in integrating an EDI system both externally and internally? • How do the various measures of EDI integration relate to one another? • How should incentives be aligned to promote sustained EDI integration among suppliers? • What is the effect of ERP on EDI integration?

Continued

Table 5: Continued

Section	Findings of Support	Key Research Questions Proposed
Outcomes of EDI adoption	• The effect sizes of a majority of the cost-savings benefits (data accuracy, inventory reduction, and productivity) realized are not consistent, across the different studies and the effect sizes are insignificant. • Customer-facing activities such as improved communications and better customer service are outcomes of EDI adoption.	• How does EDI drive individual job profiles and performance? Does it vary by function? • How does the role of management change with increasingly sophisticated EDI systems? • When does EDI imposition yield positive benefits and when does it yield negative benefits? • What is the role of network size in realizing various benefits from EDI?
Outcomes of EDI integration	• EDI integration is significantly associated with overall benefits. • EDI integration shows consistently higher effects for key benefits including inventory reduction. • The overall effect of integration on delivery performance is inconclusive.	• As EDI is rolled out across the supply network, do early adopters realize different benefits from later adopters?
Outcomes channel coordination and channel relationships	• The impact of EDI on improving relationships, resolving conflicts, and inducing cooperation among the stake holders in the supply chain has been inconclusive.	• Does the type and sensitivity of information shared through EDI affect the dyadic benefits? • How is security and privacy of information assured in an EDI dyad? • What relationship variables affect whether EDI can facilitate collaborative forecasting and planning? • How does EDI affect the structure of the supply chain?

EDI = Electronic Data Interchange, JIT = Just-in-Time, ERP = Enterprise Resource Planning.

collaboration—people do. As such, we urge future researchers to integrate future research of IOS/EDI adoption with measures of collaborative relationship behavior, as we believe this will provide a more functional theoretical foundation and higher explanatory power. For instance, Saeed et al. (2005) find evidence for the idea that firms can gain sourcing leverage through increased IOS breadth and depth. They note that "the fit between the technology and supply chain processes is important to yield better outcomes" (p. 369). We strongly agree with this statement and add that realistic expectations regarding adoption requirements and benefits are more likely to result in a more efficient adoption process, a smoother transition, and a quicker path to successful collaboration.

METHODOLOGICAL ISSUES AND LIMITATIONS

A number of other guidelines arise from our research that future researchers should consider in IOS/EDI research. First, there is a need for greater consistency among construct names and item wording in measurement scales used in the EDI research. Many of the studies we examined employed different construct titles, despite using similar or identical items in their scales. Despite the consistency of models depicting that perceived benefits are related to EDI adoption, there was an alarming insistency in construct development. For example, O'Callaghan et al. (1992) applied the terms "relative service advantage" and "customer service advantage," while Kuan and Chau (2001) used the terms "direct benefits" and "indirect benefits." Chwelos et al. (2001), Bergeron and Raymond (1992, 1997) and Ramamurthy et al. (1999) all use a single construct of EDI benefits that aggregates all the variables. Consistent application of scales and constructs will drive greater reliability of measures and can facilitate a more robust body of research going forward.

Many studies also failed to report correlation values or results that could be converted into correlation scores and thus could not be included in our analyses. Reporting of correlations is fundamental for developing a body of empirical research to build improved theory and replication of results (Handfield & Melnyk, 1998). Only 39 studies reported results that could be converted into correlation scores and many of them were not usable because the constructs examined were inconsistent. In certain cases where interconstruct correlations were reported, we applied our best judgment on the equivalency of constructs despite differing item scales. Despite the effort, we dropped several observations that did not meet our criteria of a minimum of four studies (Alavi & Joachimsthaler, 1992).

CONCLUSIONS

EDI remains a technology that is widely used, and which forms the basis for many IOSs. The emergence of internet-based communications has positively affected EDI use, but, more importantly, it signals the need for scholars to better inform managers on the benefits of EDI use within a supply chain. Despite a substantial literature base, our analysis suggests that EDI research is highly fragmented with no overarching theoretical perspective in explaining the conflicts and insignificant effects within the current literature. Through the course of this article, we identify

gaps and suggest research questions that will promote a better understanding of how best to gain the benefits of EDI and offer a framework on which future research can be built.

We believe that this analysis is not only useful for researchers but it is also helpful for managers who make EDI adoption decisions. From a managerial perspective, an understanding of the demonstrated results from EDI can help to plan resource allocations in the adoption process to maximize returns from EDI. From a research perspective, we believe that configured theoretical models can drive researchers to better understand the impact of EDI and other IOS technologies. [Received: November 2007. Accepted: November 2008.]

REFERENCES

Ahmad, S., & Schroeder, R. G. (2001). The impact of electronic data interchange on delivery performance. *Production and Operations Management, 10*(1), 16–30.

Alavi, M., & Joachimsthaler, E. (1992). Revising DSS implementation research: A meta-analysis of the literature and suggestions for researchers. *MIS Quarterly, 16*(1), 95–116.

Allen, B. J., Crum, M. R., & Braunschweig, C. D. (1992). The US motor carrier industry: The extent and nature of EDI use. *International Journal of Physical Distribution & Logistics Management, 22*(8), 27–34.

Anderson, S. W., & Lanen, W. N. (2002). Using electronic data interchange (EDI) to improve the efficiency of accounting transactions. *The Accounting Review, 77*(4), 703–729.

Angeles, R., Corritore, C. L., Basu, S. C., & Nath, R. (2001). Success factors for domestic and international electronic data interchange (EDI) implementation for US firms. *International Journal of Information Management, 21*(5), 329–347.

Angeles, R., & Nath, R. (2000). An empirical study of EDI trading partner selection criteria in customer-supplier relationships. *Information & Management, 37*(5), 241–255.

Angeles, R., & Nath, R. (2001). Partner congruence in electronic data interchange (EDI)-enabled relationships. *Journal of Business Logistics, 22*(2), 109–128.

Angeles, R., Nath, R., & Hendon, D. W. (1998). An empirical investigation of the level of electronic data interchange (EDI) implementation and its ability to predict EDI system success measures and EDI implementation factors. *International Journal of Physical Distribution & Logistics Management, 28*(9), 773–793.

Arunachalam, V. (1997). Electronic data interchange: Issues in adoption and management. *Information Resources Management Journal, 10*(2), 22–31.

Banerjee, S., & Golhar, D. Y. (1993). EDI implementation in JIT and non-JIT manufacturing firms: A comparative study. *International Journal of Operations & Production Management, 13*(3), 25–38.

Banerjee, S., & Golhar, D. Y. (1994). Electronic data interchange: Characteristics of users and nonusers. *Information & Management, 26*(2), 65–74.

Banerjee, S., & Sriram, V. (1995). The impact of electronic data interchange on purchasing: An empirical investigation. *International Journal of Operations & Production Management, 15*(3), 29–39.

Barua, A., & Lee, B. (1997). An economic analysis of the introduction of an electronic data interchange system. *Information Systems Research, 8*(4), 398–422.

Bednarz, A. (2004). Internet EDI: Blending old and new. *Network World, 21*(8), 29–30.

Bergeron, F., & Raymond, L. (1992). The advantages of electronic data interchange. *Database, 23*(4), 19–31.

Bergeron, F., & Raymond, L. (1997). Managing EDI for corporate advantage: A longitudinal study. *Information & Management, 31*(6), 319–333.

Chwelos, P., Benbasat, I., & Dexter, A. S. (2001). Research report: Empirical test of an EDI adoption model. *Information Systems Research, 12*(3), 304–321.

Clark, T. H., & Hammond, J. H. (1997). Reengineering channel reordering processes to improve total supply-chain performance. *Production and Operations Management, 6*(3), 248–265.

Cohen, J. (1977). *Statistical power analysis for behavioral sciences*. New York, NY: Academic Press.

Cooper, R. B., & Zmud, R. W. (1990). Information technology implementation research: A technological diffusion approach. *Management Science, 36*(2), 123–139.

Crook, C. W., & Kumar, R. L. (1998). Electronic data interchange: A multi-industry investigation using grounded theory. *Information & Management, 34*(2), 75–89.

Crum, M. R., Premkumar, G., & Ramamurthy, K. (1996). An assessment of motor carrier adoption: Use and satisfaction with EDI. *Transportation Journal, 35*(4), 44–57.

Das, A., & Handfield, R. B. (1997). A meta-analysis of doctoral dissertations in purchasing. *Journal of Operations Management, 15*(2), 101–121.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8), 982–1003.

Dröge, C., & Germain, R. (2000). The relationship of electronic data interchange with inventory and financial performance. *Journal of Business Logistics, 21*(2), 209–231.

Drury, D. H., & Farhoomand, A. (1996). Administrative innovation applied to systems adoption. *International Journal of Technology Management, 12*(1), 45–59.

Elbaz, D. (1999). *Electronic data interchange: An assessment of the factors leading to EDI adoption*. Master's Thesis, Concordia University, Montreal, Canada.

Ferguson, D. M., Hill, N. C., & Hansen, J. V. (1990). Electronic data interchange: Foundations and survey evidence on current use. *Journal of Information Systems, 4*(2), 81–91.

Frohlich, M. T. (2002). e-Integration in the supply chain: Barriers and performance. *Decision Sciences, 33*(4), 537–556.

Frohlich, M. T., & Westbrook, R. (2001). Arcs of integration: An international study of supply chain strategies. *Journal of Operations Management, 9*(2), 185–200.

Galliers, R. D., Swatman, P. M. C., & Swatman, P. A. (1995). Strategic information systems planning: Deriving comparative advantage from EDI. *Journal of Information Technology, 10*(3), 149–158.

Gavidia, J. V. (2001). *Determinants of electronic data interchange adoption in international buyer supplier communications*. Doctoral Dissertation, The University of Texas – Pan American, Edinburg, Texas.

Germain, R., & Dröge, C. (1995). Just-in-time and context: Predictors of electronic data interchange technology adoption. *International Journal of Physical Distribution & Logistics Management, 25*(1), 18–33.

Handfield, R. B. (1995). *Re-engineering for time-based competition*. Westport, CT: Quorum Books.

Handfield, R. B., & Krause, D. (1999). Think globally, source locally. *Supply Chain Management Review, 35*(1), 36–46.

Handfield, R. B., & Melnyk, S. (1998). The scientific theory-building process: A primer using the case of TQM. *Journal of Operations Management, 16*(4), 320–339.

Hart, P., & Saunders, C. (1997). Power and trust: Critical factors in the adoption and use of electronic data interchange. *Organization Science, 8*(1), 23–42.

Hart, P. J., & Saunders, C. S. (1998). Emerging electronic partnerships: Antecedents and dimensions of EDI use from the supplier's perspective. *Journal of Management Information Systems, 14*(4), 87–111.

Hill, C. A., & Scudder, G. D. (2002). The use of electronic data interchange for supply chain coordination in the food industry. *Journal of Operations Management, 20*(4), 375–387.

Holland, C., Lockett, G., & Blackman, I. (1992). Planning for electronic data interchange. *Strategic Management Journal, 13*(7), 539–550.

Howells, J., & Wood, M. (1995). Diffusion and management of electronic data interchange: Barriers and opportunities in the UK pharmaceutical and healthcare industries. *Technology Analysis & Strategic Management, 7*(4), 371–387.

Hunter, J. E., Schmidt, F. L., & Jackson, G. B. (1982). *Meta-analysis: Cumulating research findings across studies*. Beverly Hills, CA: Sage.

Iacovou, C. L., Benbasat, I., & Dexter, A. S. (1995). Electronic data interchange and small organizations: Adoption and impact of technology. *MIS Quarterly, 19*(4), 465–485.

International Data Corporation. (2004). *Worldwide traditional and Internet EDI commerce forecast*, *2002–2007*. Framingham, MA: Author.

Iskandar, B. Y., Kurokawa, S., & LeBlanc, L. J. (2001a). Adoption of electronic data interchange: The role of buyer-supplier relationships. *IEEE Transactions on Engineering Management, 48*(4), 505–517.

Iskandar, B. Y., Kurokawa, S., & LeBlanc, L. J. (2001b). Business-to-business electronic commerce from first- and second-tier automotive suppliers' perspectives: A preliminary analysis for hypotheses generation. *Technovation, 21*(11), 719–731.

Jelassi, T., & Figon, O. (1994). Competing through EDI at Brun Passot: Achievements in France and ambitions for the single European market. *MIS Quarterly, 18*(4), 337–352.

Jimenez-Martinez, J., & Polo-Redondo, Y. (1998). International diffusion of a new tool: The case of electronic data interchange (EDI) in the retailing sector. *Research Policy, 26*(7–8), 811–827.

Jiménez-Martinez, J., & Polo-Redondo, Y. (2001). Key variables in the EDI adoption by retail firms. *Technovation, 21*(6), 385–394.

Jiménez-Martinez, J., & Polo-Redondo, Y. (2004). The influence of EDI adoption over its perceived benefits. *Technovation, 24*(1), 73–79.

Johnson, D. A., Allen, B. J., & Crum, M. R. (1992). The state of EDI usage in the motor carrier industry. *Journal of Business Logistics, 13*(2), 43–68.

Jones, M. C., & Beatty, R. C. (2001). User satisfaction with EDI: An empirical investigation. *Information Resources Management Journal, 14*(2), 17–26.

Kanakamedala, K., King, J., & Ramsdell, G. (2003). The truth about XML. *McKinsey Quarterly, 2003*(3), 9–12.

Kekre, S., & Mukhopadhyay, T. (1992). Impact of electronic data interchange technology on quality improvement and inventory reduction programs: A field study. *International Journal of Production Economics, 28*(3), 265–281.

Kuan, K. K. Y., & Chau, P. Y. K. (2001). A perception-based model for EDI adoption in small businesses using technology–organization–environment framework. *Information & Management, 38*(8), 507–521.

Kym, H. (1991). *An evaluation of adoption and implementation strategies for customer-oriented electronic data interchange*. Doctoral Dissertation, University of Pittsburgh, Pittsburgh, PA.

Lancioni, R. A., Smith, M. F., & Schau, H. J. (2003). Strategic Internet application trends in supply chain management. *Industrial Marketing Management, 32*(3), 211–217.

Larson, P. D., & Kulchitsky, J. D. (2000). The use and impact of communication media in purchasing and supply chain management. *Journal of Supply Chain Management, 36*(3), 29–39.

Lee, H. G., Clark, T., & Tam, K. Y. (1999). Research report. Can EDI benefit adopters? *Information Systems Research*, *10*(2), 186–195.

Lee, H. L., Padmanabhan, V., & Whang, S. (1997). Information distortion in a supply chain: The bullwhip effect. *Management Science, 43*(4), 546–558.

Lee, S., & Han, I. (2000a). The impact of EDI controls on the relationship between EDI implementation and performance. *Information Resources Management Journal, 13*(4), 25–33.

Lee, S., & Han, I. (2000b). The impact of organisational contexts on EDI controls. *International Journal of Accounting Information Systems, 1*(2), 153–177.

Lee, S., & Lim, G. G. (2003). The impact of partnership attributes on EDI implementation success. *Information & Management, 41*(2), 135–148.

Lewin, K. (1959). Group decision and social change. In E. E. Maccoby, T. M. Newcomb, & E. L. Hartley (Eds.), *Readings in social psychology* (3rd ed.). London, UK: Methuen, 197–211.

Lim, D., & Palvia, P. C. (2001). EDI in strategic supply chain: Impact on customer service. *International Journal of Information Management, 21*(3), 193–211.

MacDonald, J. B., & Smith, K. (2004). The effects of technology-mediated communication on industrial buyer behavior. *Industrial Marketing Management, 33*(2), 107–116.

Mackay, D. R. (1993). The impact of EDI on the components sector of the Australian automotive industry. *The Journal of Strategic Information Systems, 2*(3), 243–263.

Mackay, D. R., Altmann, G. L., & McMichael, H. (2003). How intimate are Australian e-business retail supply chains? *Logistics Information Management, 6*(1), 48–55.

Manabe, S., Fujisue, K., & Kurokawa, S. (2005). A comparative analysis of EDI integration in US and Japanese automobile suppliers. *International Journal of Technology Management, 30*(3/4), 389–414.

Massetti, B., & Zmud, R. W. (1996). Measuring the extent of EDI usage in complex organizations: Strategies and illustrative examples. *MIS Quarterly, 20*(3), 331–345.

McGowan, M. K., & Madey, G. R. (1998). The influence of organization structure and organizational learning factors on the extent of EDI implementation in U.S. firms. *Information Resources Management Journal, 11*(3), 17–28.

Millen, R. A. (1992). Utilization of EDI by motor carrier firms: A status report. *Transportation Journal, 32*(2), 5–13.

Millen, R. A., & Ukena, J. (1995). EDI usage in the motor carrier industry: A comparison of practice from 1991 to 1994. *International Journal of Physical Distribution & Logistics Management, 25*(6), 23–40.

Miller, D. (1981). Toward a new contingency approach: The search for organizational gestalts. *Journal of Management Studies, 18*(1), 1–26.

Min, H., & Galle, W. P. (2003). e-Purchasing: Profiles of adopters and nonadopters. *Industrial Marketing Management, 32*(3), 227–233.

Montoya-Weiss, M., & Calantone, R. (1994). Determinants of new product performance: A review and meta-analysis. *Journal of Product Innovation Management, 11*(5), 397–417.

Mukhopadhyay, T., & Kekre, S. (2002). Strategic and operational benefits of electronic integration in B2B procurement processes. *Management Science, 48*(10), 1301–1313.

Mukhopadhyay, T., Kekre, S., & Kalathur, S. (1995). Business value of information technology: A study of electronic data interchange. *MIS Quarterly, 19*(2), 137–156.

Muncer, S. J., Craigie, M., & Holmes, J. (2003). Meta-analysis and power: Some suggestions for use of power in research synthesis. *Understanding Statistics, 2*(1), 1–12.

Murphy, P. R., & Daley, J. M. (1996). International freight forwarder perspectives on electronic data interchange and information management issues. *Journal of Business Logistics, 17*(1), 63–85.

Murphy, P. R., Daley, J. M., & Hall, P. K. (1998). EDI issues in logistics: A user and carrier perspective. *Journal of Business Logistics, 19*(2), 89–103.

Nakayama, M. (2000). e-Commerce and firm bargaining power shift in grocery marketing channels: A case of wholesalers' structured document exchanges. *Journal of Information Technology, 15*(3), 195–211.

Nakayama, M. (2003). An assessment of EDI use and other channel communications on trading behavior and trading partner knowledge. *Information & Management, 40*(6), 563–580.

Neher, A. (2005). The configurational approach in supply chain management. In H. Kotzab, M. Westhaus, M. Müller, & G. Reiner (Eds.), *Research methodologies in supply chain management*. Heidelberg, Germany: Physica-Verlag, 75–89.

Nicolaou, A. I. (2002). Adoption of just-in-time and electronic data interchange systems and perceptions of cost management systems effectiveness. *International Journal of Accounting Information Systems, 3*(1), 35–62.

O'Brien, C., & Head, M. (1995). Developing a full business environment to support just-in-time logistics. *International Journal of Production Economics, 42*(1), 41–50.

O'Callaghan, R., Kaufmann, P. J., & Konsynski, B. (1992). Adoption correlates and share effects of electronic data interchange systems in multichannels. *Journal of Marketing, 56*(2), 45–56.

Pawar, K. S., & Driva, H. (2000). Electronic trading in the supply chain: A holistic implementation framework. *Logistics Information Management, 13*(1), 21–32.

Philip, G., & Pedersen, P. (1997). Inter-organisational information systems: Are organisations in Ireland deriving strategic benefits from EDI? *International Journal of Information Management, 17*(5), 337–357.

Poole, R. R. (1997). *The impact on the buyer-seller relationship of firms using electronic data interchange*. Doctoral Dissertation, University of North Texas, Denton, TX.

Premkumar, G., & Ramamurthy, K. (1995). The role of interorganizational and organizational factors on the decision mode for adoption of interorganizational systems. *Decision Sciences, 26*(3), 303–336.

Premkumar, G., Ramamurthy, K., & Nilakanta, S. (1994). Implementation of electronic data interchange: An innovation diffusion perspective. *Journal of Management Information Systems, 11*(2), 157–186.

Prosser, A., & Nickl, A. (1997). The impact of EDI on interorganizational integration. *International Journal of Production Economics, 52*(3), 269–281.

Raghunathan, S., & Yeh, A. B. (2001). Beyond EDI: Impact of continuous replenishment program (CRP) between a manufacturer and its retailers. *Information Systems Research, 12*(4), 406–419.

Ramamurthy, K., & Premkumar, G. (1995). Determinants and outcomes of electronic data interchange diffusion. *IEEE Transactions on Engineering Management, 42*(4), 332–351.

Ramamurthy, K., Premkumar, G., & Crum, M. R. (1999). Organizational and interorganizational determinants of EDI diffusion and organizational performance: A causal model. *Journal of Organizational Computing & Electronic Commerce, 9*(4), 253–286.

Raney, M. A., & Walter, C. K. (1992). Electronic data interchange: The warehouse and supplier interface. *International Journal of Physical Distribution & Logistics Management, 22*(8), 21–26.

Rassameethes, B. (1999). *The role of electronic data interchange (EDI) in automotive supply chains*. Doctoral Dissertation, Vanderbilt University, Nashville, TN.

Rassameethes, B., Kurokawa, S., & LeBlanc, L. J. (2000). EDI performance in automotive supply chain. *International Journal of Technology Management, 20*(3/4), 287–303.

Raymond, L., & Bergeron, F. (1996). EDI success in small and medium-sized enterprises: A field study. *Journal of Organizational Computing & Electronic Commerce, 6*(2), 161–173.

Raymond, L., & Blili, S. (1997). Adopting EDI in a network enterprise: The case of subcontracting SMEs. *European Journal of Purchasing & Supply Management, 3*(3), 165–175.

Reekers, N. (1994). Electronic data interchange use in German and US organizations. *International Journal of Information Management, 14*(5), 344–356.

Riggins, F., Kriebel, C. H., & Mukhopadhyay, T. (1994). The growth of interorganizational systems in the presence of network externalities. *Management Science, 40*(8), 984–998.

Riggins, F., & Mukhopadhyay, T. (1994). Interdependent benefits from interorganizational systems: Opportunities for business partner engineering. *Journal of Management Information Systems, 11*(2), 37–57.

Rogers, D. S., Daugherty, P. J., & Stank, T. P. (1992). Enhancing service responsiveness: The strategic potential of EDI. *International Journal of Physical Distribution and Logistics Management, 22*(8), 15–20.

Rosenthal, R., & DiMatteo, M. R. (2001). Meta-analysis: Recent developments in quantitative methods for literature reviews. *Annual Review of Psychology, 52*(1), 59–82.

Saeed, K. A., Malhotra, M. K., & Grover, V. (2005). Examining the impact of interorganizational systems on process efficiency and sourcing leverage in buyer–supplier dyads. *Decision Sciences, 36*(3), 365–396.

Sahin, F., & Robinson, E. P. (2002). Flow coordination and information sharing in supply chains: Review, implications, and directions for future research. *Decision Sciences, 33*(4), 505–536.

Scala, S., & McGrath, R. (1993). Advantages and disadvantages of electronic data interchange an industry perspective. *Information & Management, 25*(2), 85–91.

Soliman, K. S., & Janz, B. D. (2003). An exploratory study to identify the critical factors affecting the decision to establish Internet-based interorganizational information systems. *Information & Management, 41*(6), 697–706.

Son, J. Y. (2001). *Explaining EDI-based electronic cooperation in customer-supplier interfirm relationships: An empirical study*. Doctoral Dissertation, Georgia Institute of Technology, Atlanta, GA.

Son, J. Y., Narasimhan, S., & Riggins, F. J. (2005). Effects of relational factors and channel climate on EDI usage in the customer-supplier relationship. *Journal of Management Information Systems, 22*(1), 321–353.

Srinivasan, K., Kekre, S., & Mukhopadhyay, T. (1994). Impact of electronic data interchange technology on JIT shipments. *Management Science, 40*(10), 1291–1304.

Sriram, R. S., Arunachalam, V., & Ivancevich, D. M. (2000). EDI adoption and implementation: An examination of perceived operational and strategic benefits, and controls. *Journal of Information Systems, 14*(1), 37–53.

Sriram, V., & Banerjee, S. (1994). Electronic data interchange: Does its adoption change purchasing policies and procedures. *International Journal of Purchasing and Materials Management, 30*(1), 31–40.

Suzuki, Y., & Williams, L. R. (1998). Analysis of EDI resistance behavior. *Transportation Journal, 37*(4), 36–44.

Takac, P. F. (1993). EDI, EFT and implications for banks. *Logistics Information Management, 6*(1), 8–15.

Teo, H. H., Tan, B. C. Y., Wei, K. K., & Woo, L. Y. (1995). Reaping EDI benefits through a pro-active approach. *Information & Management, 28*(3), 185–195.

Teo, H. H., Wei, K. K., & Benbasat, I. (2003). Predicting intention to adopt interorganizational linkages: An institutional perspective. *MIS Quarterly, 27*(1), 19–49.

Thachenkary, C. S. (1992). COINLink: The impacts of an EDI network on the automobile dealership and lending industries. *IEEE Transactions on Engineering Management, 39*(4), 386–393.

Truman, G. E. (2000). Integration in electronic exchange environments. *Journal of Management Information Systems, 17*(1), 209–245.

Venkatraman, N., & Kambil, A. (1991). The check's not in the mail: Strategies for electronic integration in tax return filing. *Sloan Management Review, 32*(2), 33–43.

Venkatesh, V. (2006). Where to go from here? Thoughts on future directions for research on individual-level technology adoption with a focus on decision making. *Decision Sciences, 37*(4), 497–518.

Vijayasarathy, L. R., & Robey, D. (1997). The effect of EDI on market channel relationships in retailing. *Information & Management, 33*(2), 73–86.

Vijayasarathy, L. R., & Tyler, M. L. (1997). Adoption factors and electronic data interchange use: A survey of retail companies. *International Journal of Retail and Distribution Management, 25*(9), 286–292.

Walton, L. W. (1994). Electronic data interchange (EDI): A study of its usage and adoption within marketing and logistics channels. *Transportation Journal, 34*(2), 37–45.

Walton, S. V., & Gupta, J. N. D. (1999). Electronic data interchange for process change in an integrated supply chain. *International Journal of Operations & Production Management, 19*(4), 372–388.

Walton, S. V., & Marucheck, A. S. (1997). The relationship between EDI and supplier reliability. *International Journal of Purchasing and Materials Management, 33*(3), 30–35.

Wang, E. T. G., & Seidmann, A. (1995). Electronic data interchange: Competitive externalities and strategic implementation policies. *Management Science, 41*(3), 401–418.

White, G. P. (1996). A meta-analysis model of manufacturing capabilities. *Journal of Operations Management, 14*(4), 315–331.

Williams, L. R., Magee, G. D., & Suzuki, Y. (1998). A multidimensional view of EDI: Testing the value of EDI participation to firms. *Journal of Business Logistics, 19*(2), 73–88.

Wrigley, C. D. (1991). Research on EDI: Present and future. *Proceedings of the 4th International Electronic Data Interchange Conference*. Bled, Slovenia.: Moderna Organizacija Kranj, 352–367.

Wu, F., Mahajan, V., & Balasubramanian, S. (2003). An analysis of e-business adoption and its impact on business performance. *Journal of the Academy of Marketing Science, 31*(4), 425–447.

Zaheer, A., & Venkatraman, N. (1994). Determinants of electronic integration in the insurance industry: An empirical test. *Management Science, 40*(5), 549–566.

APPENDIX A: STUDY METHODOLOGY

Our data analysis follows the method suggested by Hunter et al. (1982). We use a random effects approach that assumes that the effect sizes in the population vary from study to study and the variation in the effect sizes can be accounted for by possible moderators or study characteristics. We started our analysis by compiling the survey items from individual studies. This compilation resulted in more than 650 items corresponding to more than 200 unique constructs. Because the categorization of variables and constructs in our research framework is fairly broad, we grouped similar constructs by examining their definitions in different studies to determine if there was enough commonality to warrant aggregation. The only items that were included in the analysis were ones where there was complete consensus on the part of the raters with regard to how they should be categorized. We then extracted the correlation coefficients, where available, from the individual studies corresponding to the selected items to calculate a weighted correlation coefficient in order to measure the effect size. Montoya-Weiss and Calantone (1994) state that, when studies operationalize and use different definitions of the explanatory factors and dependent variables, the correlation coefficient is the appropriate metric for assessing the effect size.

In calculating the weighted correlation coefficient, we first adjusted the correlations coefficients for negative item wordings wherever required (Montoya-Weiss & Calantone, 1994). When negative wording was not a problem, we used reported *t* scores and the *F* scores with a single degree of freedom and transformed them into correlation coefficients based on the method of Rosenthal and DiMatteo (2001). We then combined the different correlation coefficients by computing the weighted average effect size $\bar{r} = \frac{\sum N_i r_i}{\sum N_i}$. Here, $\bar{r}$ is the weighted average correlation coefficient, N_i is the sample size of study i, and r_i is the correlation coefficient between the variables as reported in study i, $i = 1, \ldots, K$. A rule of thumb for interpreting effect sizes from the weighted correlation coefficients is small effect ($\bar{r} = .10$), medium effect ($\bar{r} = .20$), and large effect ($\bar{r} = .30$) (Cohen, 1977).

We next tested the significance of the variation across studies. Hunter et al. (1982) use the chi-square statistic to test for variation or heterogeneity in the correlation coefficients across studies. Significant heterogeneity across studies may be an indication that a moderator variable is present in the relationship between the explanatory variable and the outcome variable. To compute the chi-square statistic, we first estimated the variance in the correlation coefficient (σ_r^2), by computing $\sigma_r^2 = \frac{\sum N_i (r_i - \bar{r})^2}{\sum N_i}$. This variance σ_r^2 consists of two parts. The first is the variance due to sampling error (σ_e^2), and the second variance is due to population correlation (σ_ρ^2). We were able to compute an estimate of the population correlation σ_ρ^2 by first computing an estimate of the sampling error across the studies $\sigma_e^2 = \frac{(1-\bar{r}^2)^2}{\bar{N}-1}$ and then subtracting it from σ_r^2. To test for variation in population correlation, we performed a chi-square test to determine whether σ_ρ^2 significantly differs from zero using the formula

$$\chi^2_{K-1} = \frac{\sum (N_i - 1)(r_i - \bar{r})^2}{(1 - \bar{r}^2)^2}.$$

This test has very high statistical power and will cause the null hypothesis to be rejected even with a trivial amount of variation across the studies, particularly when the N_i's are large. Further, the standard errors of the overall effect sizes can be computed using $\sqrt{1/\sum w_i}$ where the weight w_i is the sample size of study i.

We also report the post hoc power for each meta-analysis based on the average sample size and the weighted average effect size reported (Muncer, Craigie, & Holmes, 2003). This measure is reported for the weighted average effect size and the average sample size across studies at a 0.05 significance level to provide an assessment of the power of individual effect sizes that were included in the study. These numbers may be useful to future researchers in determining an appropriate sample size for data collection given the effect sizes prevalent in current literature.

APPENDIX B: Selected empirical research studies*

Authors	Year	Authors	Year	Authors	Year	Authors	Year	Authors	Year
Ahmad & Schroeder*	2001	Germain & Dröge*	1995	Lim & Palvia*	2001	Philip & Pedersen	1997	Suzuki & Williams	1998
Allen, Crum, & Braunschweig	1992	Hart & Saunders*	1998	Macdonald & Smith	2004	Premkumar & Ramamurthy*	1995	Teo, Tan, Wei, & Wu*	1995
Anderson & Lanen	2002	Hill & Scudder*	2002	Mackay	1993	Premkumar, Ramamurthy, & Nilakanta*	1994	Teo, Wei, & Benbasat*	2003
Angeles, Nath, & Hendon	1998	Howells & Wood	1995	Mackay, Altmann, & McMichael	2003	Prosser & Nickl	1997	Truman*	2000
Angeles & Nath	2000	Iskandar, Kurokawa, & Leblanc*	2001a	Manabe, Fujisue, & Kurokawa*	2005	Ramamurthy & Premkumar*	1995	Vijayasarathy & Robey*	1997
Angeles & Nath	2001	Iskandar, Kurokawa, & Leblanc*	2001b	McGowan & Madey*	1998	Ramamurthy, Premkumar, & Crum*	1999	Vijayasarathy & Tyler	1997
Angeles, Corritore, Basu, & Nath	2001	Jimenez-Martinez & Polo-Redondo	1998	Millen	1992	Raney & Walter	1992	Walton*	1994
Arunachalam*	1997	Jimenez-Martinez & Polo-Redondo	2001	Millen & Ukena	1995	Rassameethes, Kurokawa, & Leblanc*	2000	Walton & Marucheck*	1997
Banerjee & Golhar	1993	Jimenez-Martinez & Polo-Redondo	2004	Min & Galle	2002	Raymond & Bergeron	1996	Williams, Magee, & Suzuki	1998
Banerjee & Golhar*	1994	Johnson, Allen, & Crum	1992	Mukhopadhyay & Kekre	2002	Raymond & Blili*	1997	Elbaz*	1999

Continued

APPENDIX B: Continued

Authors	Year	Authors	Year	Authors	Year	Authors	Year	Authors	Year
Banerjee & Sriram	1995	Jones & Beatty	2001	Mukhopadhyay, Kekre, & Kalathur	1995	Reekers*	1994	Gavidia*	2001
Bergeron & Raymond	1992	Kekre & Mukhopadhyay	1992	Murphy & Daley	1996	Riggins & Mukhopadhyay	1994	Kym*	1991
Bergeron & Raymond*	1997	Kuan & Chau*	2001	Murphy, Daley, & Hall*	1998	Rogers, Doherty, & Stank	1992	Poole*	1997
Chwelos, Benbasat, & Dexter*	2001	Lancioni, Smith, & Schau	2003	Nakayama*	2000	Scala & McGrath	1993	Rassameethes*	1999
Crum, Premkumar, & Ramamurthy	1996	Larson & Kulchitsky	2000	Nakayama	2003	Soliman & Janz	2003	Son*	2001
Clark & Hammond	1997	Lee, Clark, & Tam	1999	Nicolaou*	2002	Son, Narasimhan, & Riggins*	2005		
Dröge & Germain*	2000	Lee & Han	2000a	O'Brien & Head	1995	Srinivasan, Kekre, & Mukhopadhyay	1994		
Drury & Farhoomand	1996	Lee & Han	2000b	O'Callaghan, Kaufmann, & Konsynski	1992	Sriram & Banerjee	1994		
Ferguson, Hill, & Hansen	1990	Lee & Lim*	2003	Pawar & Driva	2000	Sriram, Arunachalam, & Ivancevich	2000		

*An asterisk indicates that the studies were used for purposes of meta-analysis.

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