Organizational Assimilation of Electronic Procurement Innovations

ARUN RAI, PAUL BROWN, AND XINLIN TANG

ARUN RAI is Regents' Professor and the Harkins Chair in the Center for Process Innovation and the Department of Computer Information Systems at Georgia State University. His research has been published in *Decision Sciences, European Journal of Operations Research, IEEE Transactions on Engineering Management, Information Systems Research, Journal of Management Information Systems, Management Science, MIS Quarterly,* and other journals. He serves as senior editor for *Information Systems Research* and associate editor for *Journal of Management Information Systems,* and has served as senior editor for the *Journal of Strategic Information Systems,* and on the editorial boards for *Decision Sciences, IEEE Transactions on Engineering Management, Information Systems Research, Journal of the AIS, Management Science, MIS Quarterly,* and others. His research has been sponsored by leading corporations, including A.T. Kearney, Bozell Worldwide, Daimler-Chrysler, Gartner, Georgia-Pacific, IBM, Intel, UPS, and SAP, among others.

PAUL BROWN is a Professor of Supply Chain Management and Decision Sciences at Clark Atlanta University. He is the founder and faculty director for CAU's Supply Chain Management program. His research focuses on supply chain management–related innovations and the implementation of information technology. His research has been published in *Information Management Journal* and *Project Management Journal* and he has presented research at the Institute of Supply Management Research and Teaching Symposium, Decision Sciences Institute National Meeting, INFORMS, and Information Resource Management Association. He is a member of Beta Gamma Sigma Honor Society, Alpha Iota Delta National Honor Society, Institute of Supply Management, and Decision Science Institute. He has worked in management positions with AT&T, Xerox, and the U.S. State Department.

XINLIN TANG is an Assistant Professor of Management Information Systems at Florida State University. She holds a Ph.D. from Georgia State University. Her current research focuses on digitally enabled business network management, strategic use of information technologies in the interorganizational context, and technology assimilation. Her research has been published in *Information and Management* and in proceedings of the International Conference on Information Systems and the Academy of Management Annual Meeting.

ABSTRACT: We investigate the assimilation of electronic procurement innovations (EPIs) and its impact on procurement productivity in buyer organizations. We identify online reverse auctions, electronic catalog management, electronic order fulfillment,

The second and third authors contributed to this paper equally and are listed alphabetically.

Journal of Management Information Systems / Summer 2009, Vol. 26, No. 1, pp. 257–296.

0742–1222 / 2009 $9.50 + 0.00.
DOI 10.2753/MIS0742-1222260110

and electronic payment and settlement as moderate complements for the performance of the procurement process. We develop a theoretical model that is informed by the literature on innovation assimilation and by structuration theory to explain the aggregated assimilation of EPIs. Our empirical study is based on survey data collected about EPIs from 166 buyer firms. Based on our analysis, we isolate the organizational, technological, and interorganizational factors that shape the meta-structures for the aggregated assimilation of EPIs. Our results also provide evidence of a substantial impact of the assimilation of these innovations on procurement productivity. Our post hoc analysis provides insights on differences across stages and across EPIs on the factors and meta-structures that enable assimilation.

KEY WORDS AND PHRASES: electronic procurement innovations, IT assimilation, productivity, structuration theory.

EFFICIENT AND EFFECTIVE MANAGEMENT OF SUPPLY CHAINS is an approach to enhance a firm's competitiveness [56, 65]. Manufacturers spend an average of $0.55 per dollar of revenue to administer the procurement of goods and services, which makes the procurement process a key area for cost savings [46]. Accordingly, firms are focusing on a related set of information technology (IT) innovations, which we refer to as electronic procurement innovations (EPIs), to improve procurement practices. These EPIs can collectively support the entire procurement process that encompasses catalog management, order fulfillment, payment and settlement, and reverse auctions.

Historically, little attention has been paid to improve the procurement process, as purchasing departments were considered to be buying functions and were not viewed to be strategic [51]. However, there has been mounting evidence on the inefficiency of procurement processes and their negative effect on firm performance [62]. The inefficiency levels are so high that many companies spend far more on managing the procurement cycle than on purchasing goods [3]. For example, on average, it takes as much as $107 of administration costs to process a paper-based purchase order [1]. Nonproduction goods account for a third or more of corporate expenditures and an astounding 95 percent of them are acquired using paper-based processes [17]. Moreover, fulfillment of purchase orders exhibit long and variable lead times that negatively impact downstream production and distribution [63].

To address these pathologies in procurement processes, firms have been undertaking initiatives to assimilate EPIs to obtain visibility into sourcing options and coordinate activities with suppliers. Despite the potential of EPIs, firms face significant challenges in assimilating these new technologies and in obtaining expected results [10]. Just like most classes of IT innovations that are applied to core business processes, EPIs exhibit assimilation gaps, where rates of use lag far behind rates of adoption [22]. Accordingly, there is growing interest in understanding how to manage the overall assimilation of a cluster of IT innovations that are targeted at a core business process [21]. This knowledge should enhance the management of the causal

chain of influence from organizational IT adoption to the impact of IT on business performance [19, 21].

Despite growing interest, there is limited scientific understanding about EPI assimilation due to four reasons. First, in general, there is scant theory-based research on the assimilation of classes of IT innovations for business processes [13, 67]. Second, past procurement studies have focused on a single innovation (e.g., reverse auctions) and factors specific to it (e.g., buyer–supplier relationships for reverse auctions) [28, 35]. While focusing on a single innovation helps us to understand issues that are specific to an innovation, it does not account for the complexities of managing the assimilation of multiple innovations, especially when they are moderately complementary. Indeed, the assimilation of moderately complementary innovations is much more challenging than the assimilation of those innovations that are unrelated or those that are full complements and must be concurrently adopted because of technical constraints [21]. Third, by focusing on one stage of the assimilation life cycle, such as the decision to adopt a specific innovation, past procurement studies have overlooked the fact that technology assimilation is an ongoing process. Fourth, and finally, a majority of past studies on procurement innovation have been anecdotal [43].

By developing and testing a general model, we aim to synthesize the factors that affect all stages of the assimilation process for EPIs that are moderately complementary and to determine their impact on productivity of the procurement process. Specifically, we focus on identifying the factors that can be generalized *across the class of electronic procurement innovations and their assimilation life cycle.* Consistent with observations made in past research on interorganizational systems, we consider organizational, interorganizational, and technical factors in our investigation. Our research questions are:

> *What organizational, technical, and interorganizational factors enable the aggregate assimilation of a set of moderately complementary EPIs? In turn, what is the impact of aggregate EPI assimilation on procurement productivity?*

By addressing these research questions, we contribute to the technology assimilation literature by isolating a parsimonious set of theoretically grounded factors that affect the aggregate assimilation of EPIs and by providing empirical evidence about the impact of aggregate EPI assimilation on procurement productivity. These results have significant practical implications for how firms should manage the assimilation of moderately complementary EPIs to streamline their procurement processes.

Aggregated EPI Assimilation

PREVIOUS RESEARCH IDENTIFIES THREE CLASSES of e-procurement: *e-sourcing,* such as online auctions, online bidding, and online tendering; *e-coordination,* such as electronic catalogs, electronic payment systems, and online fulfillment; and *e-communities,* such as public e-marketplaces, industry-sponsored e-marketplaces, and private exchanges [32, 34]. While e-sourcing and e-coordination are technologies to improve the procurement process, e-communities are alternate Internet-enabled channels for buyer–supplier

exchange that leverage e-sourcing and e-coordination technologies to facilitate this exchange. Given the importance of e-sourcing and e-coordination technologies to improve the procurement process and potentially serve as the building platform for e-communities, we focus on their assimilation in buyer firms.

Based on a review of the literature, we identify the major EPIs for sourcing and coordination to be *online reverse auctions, electronic catalog management, electronic order fulfillment,* and *electronic payment and settlement* [40, 72, 76]. Together, they represent a set of moderately complementary innovations that can be applied to support the identification of candidate suppliers, selection of a supplier, and execution of the physical and financial activities to complete the procurement transaction [57]. Thus, these four EPIs are neither unrelated innovations nor are they full complements, as the adoption of one EPI does not enforce adoption of another due to technical constraints. Specifically, online reverse auctions enable buyers to exchange information with sellers, and to solicit and accept bids from multiple sellers; electronic catalog management supports the generation, maintenance, and presentation of price and quality-related information associated with products and suppliers; electronic order fulfillment automates the ordering, shipping, reordering, and receiving processes; and electronic payment and settlement enables the billing, payment, and reconciliation of debits, credits, and invoices [40].

Given that these EPIs are moderate complements, their assimilation as a set is much more challenging than a set of unrelated innovations or a set of fully complementary innovations [21]. We draw on the literature on the assimilation of IT innovations to conceptualize the Aggregated EPI Assimilation construct. The assimilation of IT is the extent to which IT has diffused across organizational processes and is routinized in its use [21]. When investigating IT assimilation, a decision has to be made on whether a granular or aggregated conceptualization of innovation is appropriate. Although aggregated measures across innovations and assimilation stages enhance predictive validity[1] and can be generalized beyond a specific technology [21], the decision should be informed by the objectives of the research, the nature of the variables being investigated, and the form of aggregation that should be used.

As noted by Fichman [21], aggregation can take two basic forms: (1) aggregating innovative behaviors across specific innovations and (2) aggregating innovative behaviors across the *assimilation* life cycle (such as when behaviors that occur in both the early and late stages of *assimilation* are reflected in the measure). He notes that the decision on aggregation should be guided by six criteria: (1) the primary objective of the research, (2) the validity of generalization across assimilation stages, (3) the effects of organizational characteristic, (4) the effects of innovation characteristics, (5) the effects of innovation substitutes and complements, and (6) the effects of reporting errors and idiosyncratic adoption. Table 1 summarizes an evaluation of these six criteria for our investigation of EPI assimilation. Based on this assessment, we adopt an aggregated approach to assess EPI assimilation in a buyer firm and define Aggregated EPI Assimilation as the extent to which the four EPIs (i.e., electronic reverse auction, electronic catalog management, electronic order fulfillment, and electronic payment settlement) have diffused across a buyer firm's procurement process.

Table 1. Criteria Assessment for the Aggregated Treatment of EPI Assimilation

Description of circumstances of this investigation	Type of aggregation warranted: Across innovations	Type of aggregation warranted: Across stages	Rationale
1. The primary research objective is to identify determinants of organizational innovativeness with respect to the EPI technology class for the assimilation life cycle.	X	X	The investigative focus is on organizational, technological, and interorganizational determinants of organizational innovativeness that can be *generalized across the EPI technology class* for the assimilation life cycle.
2. Important theoretical factors generalize across stages of EPI innovation.		X	The objective to identify key organizational, technological, and interorganizational determinants that have the *same direction* of influence on EPI assimilation regardless of assimilation stage favors aggregation across stages.
3. The organizational characteristics included have the same value for each EPI in the set rather than varying across EPIs	X		The organizational, technological, and interorganizational factors being investigated are common to EPIs and assume the same value for each, which favors aggregation across innovations.

(continues)

Table 1. Continued

Description of circumstances of this investigation	Type of aggregation warranted: Across innovations	Type of aggregation warranted: Across stages	Rationale
4. The study does not control for the effects of EPI characteristics that vary across organizations.	X		The research does not theorize (or measure) differences in secondary innovation characteristics across organizations, which then favors aggregation across innovations. By using an aggregated design with multiple related EPIs, the omission of these secondary innovation characteristics should pose less of a problem. In contrast to a single innovation design, the aggregated design should smooth out noise across innovations making it easier to discern the effects of included predictor variables.
5. The EPIs in the set include mild complements (they are not substitutes, nor are they pure complements, as the adoption of one EPI, say, catalog management, does not require the adoption of another EPI, say, reverse auctions).	X		The four EPIs are considered imperfect complements because there are no technical constraints that force adoption of any two innovations, which favors aggregation across innovations. Overall innovativeness is assessed by aggregating across these imperfect complements.
6. There are concerns about the reliability of measurements in light of possible reporting errors with a survey research method or idiosyncratic adoption decisions on the part of some organizations.	X		Given that data were collected using surveys and single respondents, there are the usual concerns around measurement reliability that naturally derive from such an approach. Accordingly, aggregation across innovations and stages should reduce this noise by countering the effects of reporting errors.

Source: Adapted from [21, p. 436].

A Structuration Perspective for Aggregate EPI Assimilation

We draw on structuration theory of technology assimilation [47, 61] to inform our investigation. This theory base has been used to inform studies related to IT innovations for business processes such as the assimilation of computer-aided software engineering technology [54] and Web services [13]. The theory focuses on the relationship between social structure and human actions and suggests that assimilation of innovations is a cumulative consequence of individual actions, which are shaped by institutional meta-structures [23]. These meta-structures reinforce established structures and patterns of action that reproduce established behavior or enable the emergence of new structures and actions that generate innovation behavior.

In our context, EPI assimilation represents the aggregate innovation that emerges from the structuring actions of individuals, whose cognitions and behaviors are influenced by institutional meta-structures. Specifically, meta-structures for *signification, legitimization,* and *domination,* the three key meta-structures that have been identified [47, 61], influence the cognitions and behaviors of individuals. Signification is established by meta-structures that provide meaning and promote understanding, and serve as cognitive guides for individual action and behavior; legitimization is established by those meta-structures that validate behaviors as desirable and congruent with the goals and values of the organization; and domination is provided by the meta-structures that enforce established institutional rules to regulate actions and behaviors of individuals.

Drawing on structuration theory and based on a review of the literature on interorganizational diffusion of IT, we identify the organizational, interorganizational, and technological factors that represent the meta-structures of signification, legitimization, and domination for EPI assimilation (Table 2). We now elaborate on our rationale for mapping causal factors to particular meta-structures.

1. Meta-structures for signification are provided by the *strategic, relational,* and *technological* context in which EPIs must be interpreted and used. Accordingly, we identify Top Management Support for EPI (organizational factor), Trusting Beliefs About Suppliers (interorganizational factor), and Security Safeguards for EPI (technological factor) as meta-structures of signification. Top Management Support provides the strategic rationale for a firm's EPI initiatives, Trusting Beliefs captures the nature of the relationships in which EPIs must be used, and Security Safeguards focuses on the match between requirements for safeguards and protection and perceptions of those offered by EPI.
2. Meta-structures for domination are provided by the political support and financial commitment for EPI assimilation, and the extent to which IT innovativeness, in general, is desirable and pursued in a firm. Accordingly, we identify Top Management Support (an organizational factor) and Organizational Readiness (a composite construct of Financial Resources and IT Sophistication in a buyer firm) as the causal factors through which the meta-structures of domination operate to validate actions and behaviors for EPI assimilation. Top Management Support directs political support for EPI actions and Organizational Readiness

Table 2. A Structuration Perspective for Aggregated EPI Assimilation

	Definition	Mapping to constructs	Explanation
Structures of signification	Meta-structures related to the *strategic, relational, and technological context* yield meaning and understanding, serving as cognitive guides to understand appropriate behavior/actions with respect to EPI assimilation.	Top management support for EPI	Senior management articulates the *strategic context* for EPI deployment, which informs cognition on the business need of EPI.
		Trusting beliefs about suppliers	Perceptions about the benevolence, competence, and integrity of suppliers provide the *relational context* in which EPI innovations are interpreted and used.
		Benevolence	Perception about whether suppliers act in the buyer's interests.
		Competence	Perception about whether suppliers have expertise and knowledge.
		Integrity	Perception about whether suppliers are honest and keep their promise.
		Security safeguards of EPI	Perceptions about the safeguards and protection of EPI for procurement transactions provide the *technological context* in which EPI innovations are interpreted and used.
Structures of domination	Meta-structures related to *political, financial, and technological resources* validate behaviors associated with EPI assimilation as being appropriate and consistent with the goals and values of the organization.	Top management support for EPI	Senior management signals *political support* for the initiative and legitimizes actions and behaviors related to EPI assimilation, by their active involvement in the deployment of EPI.
		Organizational readiness	The technological and financial resources for EPI assimilation.
		Financial resources	The general base of financial resources available to be invested in organizational improvement and innovation, such as EPI assimilation.
		IT sophistication	The sophistication of IT resources and capabilities in the organization is an aggregate signal of the desirability and importance of IT-related innovations for core organizational processes, in this case, EPI assimilation for procurement.
Structures of legitimization	Meta-structures related to goals and electronic procurement standards *regulate* actions and behaviors for EPI assimilation.	Top management support for EPI	Senior management regulates actions and behaviors for EPI assimilation, by establishing goals for initiatives and standards to monitor them.
		EPI standards efficacy	Perceptions about electronic procurement standards relative to the requirements of the work processes of the organization.
		Comprehensiveness	Comprehensive standards provide positive feedback for broader deployment of EPIs, by accommodating for the scope of procurement activities.
		Flexibility	Flexible standards provide positive feedback for broader deployment of EPIs, by accommodating for required deviations.

provides financial resources and technological capabilities that should promote EPI assimilation behaviors.

3. Meta-structures for legitimization are established by top management imperatives for EPI and behavioral regulations associated with EPI usage. Accordingly, we identify Top Management Support (organizational factor) and EPI Standards Efficacy (technological factor) as the causal factors through which the meta-structure of legitimization operates to regulate EPI assimilation behaviors.

Top Management Support: A Key Role in All Three Institutional Meta-Structures

In general, Top Management Support is important for information systems (IS) innovations that are resource-intensive and require substantial material and managerial resources [13, 69]. Actions by senior management can modify prevailing structures, introduce complementary structures to facilitate technology use, and reinforce norms that value the use of the technology [38]. For EPI assimilation, we suggest that Top Management Support plays a key role in each of the three meta-structuring actions—signification, legitimization, and domination. By articulating a vision and establishing a strategic plan for electronic procurement, top management can establish a context within which EPI actions and behaviors assume meaning. Moreover, top management can legitimize EPI assimilation by demonstrating their commitment and political support through participation in deployment initiatives. Finally, they can play a role in regulating the pace of EPI assimilation by establishing goals and targets for EPI assimilation. However, without strong ongoing backing from top management through the assimilation life cycle, it becomes difficult, if not impossible, for organizational members to see how EPIs are related to the firm's mission and strategic goals, to allocate valuable resources to support EPI initiatives, and to overcome inertial routines and establish new ones to actually use EPIs in daily work. Thus, we propose:

Hypothesis 1: Top Management Support has a positive effect on Aggregated EPI Assimilation.

Meta-Structure of Signification: Trusting Beliefs About Suppliers and Security Safeguards

Meta-structure of signification is the interpretive schemes of standardized, shared stocks of knowledge that humans draw on to interpret behavior and events, hence achieving meaningful interaction [48]. While senior management articulates the *strategic context* for EPI deployment, Trusting Beliefs About Suppliers and Security Safeguards provide the relational and technological context for employees to interpret behaviors and events related to EPI assimilation.

The role of trust in shaping cognitions and behaviors in online buyer–seller contexts has received significant attention in recent years. It has been identified as critical for e-commerce because vendors can more easily engage in opportunistic and harmful

behaviors in these situations [58]. Moreover, given the relatively impersonal nature of the online environment, more risks are involved [4, 12]. When purchasing online, buyers have to rely on electronic information provided by the supplier without necessarily being able to physically inspect the product. This makes buyers vulnerable to transaction risks because incomplete or distorted information may be provided [39]. In fact, opportunism can take a range of forms: unjustifiable delays in product delivery, unwillingness to share information related to order and shipment status, misrepresentation of product characteristics, the receipt of payment without delivering a product, and illegal activity and fraud [33]. Fears of such opportunistic behaviors should result in the negative framing of EPI by buyers and constrain actions and behaviors related to EPI assimilation.

Trusting Beliefs are one party's beliefs in and willingness to depend upon another party [44]. In our context, we are concerned with a buyer organization's trusting beliefs about its suppliers to conduct transactions using EPIs. There are three dimensions of Trusting Beliefs that have been identified— Competence, Benevolence, and Integrity [44]. As a set, these dimensions explain a major portion of the trusting beliefs held by one party about another. We expect that Trusting Beliefs About Suppliers plays a key meta-structuring role of signification by shaping the cognitions, actions, and behaviors of buyers with respect to their initial learning and experimentation with EPI, and then with respect to their limited and broader deployment of these new technologies.

Hypothesis 2: Trusting Beliefs About Suppliers has a positive effect on Aggregated EPI Assimilation.

Through security safeguards, EPIs provide a set of interpretive schemes for users to structure and understand how sensitive information can be protected for online transactions. Security has been identified as a major concern in Internet-enabled transactions [16, 26]. Because purchasing online usually involves sharing private information with sellers over the Internet, it is important that buyers not only trust suppliers, but also perceive the IT environment within which procurement processes occur to be safe and secure. These security issues range from system security to transactional security. At the system level, security refers to how successful the system is in preventing illegal access to confidential or sensitive company data. At the transaction level, security refers to the authenticity, integrity, confidentiality, and nonrepudiability of origin of electronic messages that are exchanged. Indeed, failure to address these security issues has been found to discourage the use of online technologies [26].

Based on the above discussion, we define Security Safeguards as the degree to which an organization perceives that EPIs provide safeguards to protect its users and to enable them to safely engage in online transactions. It represents an important causal factor through which the meta-structure of signification for EPI assimilation operates. To the extent that organizations perceive EPI processes to be safeguarded against key security concerns [27, 50], the forces of signification should result in higher levels of EPI assimilation. This leads to the following hypothesis:

Hypothesis 3: Security Safeguards has a positive effect on Aggregated EPI Assimilation.

Meta-Structure of Domination: Organizational Readiness

Meta-structure of domination is embedded in resource allocation as resources are the means through which "intentions are realized, goals are accomplished, and power is exercised" [48, p. 148]. While Top Management Support represents the political resources associated with EPIs, Organizational Readiness represents the financial and technological resources that can be used to support EPI assimilation. We focus on Organizational Readiness in terms of two subconstructs—Financial Resources and IT Sophistication of the buyer firm. The assimilation of complex IT innovation such as EPIs usually consumes significant resources. The availability of financial resources that can be used for EPI legitimizes and supports actions related to installation, integration with processes [15], enhancements, and ongoing expenses during usage [9, 60]. The second subconstruct, IT Sophistication, is concerned with the existing level of IT usage in an organization. Firms with high IT sophistication possess superior corporate data resources, information management practices, employees with high levels of IS knowledge, and resources for the organizational integration of IT innovations [15, 49, 68]. Thus, IT sophistication represents the institutional infrastructure of knowledge and information that a firm can use to support decisions and actions related to EPI assimilation [41]. Therefore, firms with high IT sophistication should have capacity to transform business processes (such as procurement) using IT innovations (such as EPIs). Thus, Organization Readiness, a composite construct of financial resources and IT sophistication, is a key causal factor of the meta-structure of domination as it represents the buyer firm's resources to act on intentions, pursue goals, and exert power related to EPI assimilation. Hence,

Hypothesis 4: Organizational Readiness has a positive effect on Aggregated EPI Assimilation.

Meta-Structure of Legitimization: EPI Standards Efficacy

Meta-structure of legitimization is defined by the norms or rules governing sanctioned or appropriate conduct. Process standards are formal rules or policies that govern conduct [24], and interorganizational business process standards can promote business-to-business integration [6, 71]. In our context, we define EPI Standards Efficacy in terms of two components: (1) Comprehensiveness, which is concerned with the scope of user requirements for the procurement process that can be governed by process standards, and (2) Flexibility, which is concerned with the range of user behavior in the procurement process that can be governed by process standards. By adopting certain EPI standards to govern the procurement process, the organization indicates that these standards represent how to execute tasks and that compliance to these standards is the approved mode of action. The routines embodied within the standards thus incorporate norms about the criteria and the priorities to conduct tasks, and the logic by which tasks are related, which collectively represent meta-structures of legitimization.

To elaborate, comprehensive standards act as coordination mechanisms that establish decision-making guidelines and common terms and languages, and identify responsibilities for tasks across entities [11, 42]. Such standards for procurement should facilitate the integration of processes and technology because they detail interdependent roles and actions [36]. In contrast to Comprehensiveness, Flexibility accommodates deviations from anticipated action. Indeed, there is recognition today that an effective IT infrastructure should be able to handle variation in requirements without substantially increasing costs [73]. As IT infrastructures with flexible standards allows for choices from a set of options [36], procurement standards flexibility extends the range of options that procurement managers have available to adapt to their organization's needs and that do not lock them into rigid routines.

Based on the above discussion, a buyer firm's comprehensiveness and flexibility of EPI standards, captured as Standards Efficacy, represent a meta-structure legitimization factor, which should regulate actions and behaviors related to EPI assimilation. Thus, we expect that if EPI standards are comprehensive and flexible, the cognitions, actions, and behaviors are positively reinforced, thereby promoting EPI assimilation.

Hypothesis 5: EPI Standards Efficacy has a positive effect on Aggregated EPI Assimilation.

Productivity Effects of Aggregated EPI Assimilation

Past research has examined the impact on operational efficiencies that result from interorganizational systems applied to buyer–supplier processes. Based on a longitudinal study on the implementation of electronic data interchange at Chrysler, Barua et al. [7] found that the company improved inventory turnover, lowered obsolete inventory costs, and increased transportation efficiency. Barua et al. [8] concluded that companies scoring higher on e-business measures of supplier and customer integration reported higher levels of operational efficiency. Given the improvements in sourcing and supplier coordination that should result from EPI assimilation, we posit that firms with higher levels of EPI assimilation will exhibit higher levels of procurement productivity.

Hypothesis 6: Aggregated EPI Assimilation has a positive effect on the productivity of the procurement process.

In this study, we control for industry type as the literature suggests that industry context affects a firm's performance [74], and thus may affect the level of procurement productivity of a buyer firm.

Research Method

Instrument Development

We developed our measures for constructs through successive stages of literature review, theoretical modeling, and refinement, as suggested by Churchill [14]. All constructs and measures are listed in Appendix A.

Measure for Productivity of the Procurement Process

Performance measures affected by IT innovations that have been investigated include intermediate process-level measures, such as inventory turnover and process productivity [7, 55], and organizational level measures, such as profitability improvement and competitive advantage [37]. Because EPIs aim to lower transaction costs through the procurement process from searching for goods to final financial settlement, we expect that process-level measures should better reflect the performance impact of EPI assimilation than organization-level measures. We measured Procurement Productivity as the total dollar value of goods procured by the organization divided by the total number of individuals employed in the procurement organization as this measure reasonably captures the relative efficiency and effectiveness of the procurement process [20].

Measure for Assimilation of EPI

A seven-item Guttman scale was used to capture assimilation of each of the four EPIs. This scale is similar to the one that Fichman [21] used to measure the assimilation of three software process innovations. We requested respondents to identify the stage that their organizations were in for each of the four EPIs (i.e., electronic reverse auction, electronic catalog management, electronic order fulfillment, and electronic payment settlement). Table 3 lists the survey items and the criteria for a firm to belong to an assimilation stage.

Measures for Independent Variables

The measures and their informing sources are shown in Appendix A. All independent variables were measured using a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

After the initial creation of our survey, we pursued a multistep process to obtain professional reviews of the survey instrument. We received feedback about the instructions, specific items used for constructs, and the clarity of the wording used for items. First, three faculty members that have extensive experience in survey development examined the instrument. In the next stage, three purchasing managers inspected it to comment on the clarity of questions and instructions. Finally, 35 purchasing managers from across the United States participated in the pilot study. At each stage, we used the feedback to revise and refine the instrument.

Data Collection

We are concerned with innovation and performance of procurement processes at the firm level. To develop a suitable sampling frame, we chose the membership database of the Institute for Supply Management™ (ISM) (www.ism.ws). As the world's largest supply management association, ISM has more than 40,000 supply management professionals involved in various industries. Four industries—industrial machinery and equipment, electronic equipment, wholesale trade–durable goods, and business

Table 3. Guttman Scale for the Assimilation of Electronic Procurement Innovation

Stage	Criteria to enter stage	Survey items
1. Awareness	Key decision makers are aware of technologies.	Informant is familiar with <XXX> technologies.
2. Interest	The organization is committed to actively learn more about <XXX> technologies.	Informant is aware of plans to use <XXX> technologies within the next 12 months.
3. Evaluation/ trial	The organization has acquired specific innovation-related products and has initiated evaluation or trial.	The location has acquired <XXX> technologies. The location is evaluating or trialing any <XXX> technologies.
4. Commitment	The organization has committed to use <XXX> technologies in a significant way for one or more products or suppliers.	Specific <XXX> technologies are planned, in progress, implemented, or cancelled.
5. Limited deployment	The organization has established a program of regular, but limited, use of <XXX> technologies for part of their procurement process.	Organization uses <XXX> technologies for between 5 percent and 25 percent of its purchases.
6. Partial deployment	The organization has established a program of regular, but limited, use of <XXX> technologies.	Organization uses <XXX> technologies for between 25 percent and 50 percent of its purchases.
7. General deployment	The organization has reached a state where <XXX> technologies are used on a substantial fraction of purchases.	Organization uses <XXX> technologies for more than 50 percent of its purchases.

Note: Four Guttman scales were specified; for each of these scales, <XXX> was replaced by a specific type of EPI: online reverse auction, electronic catalog management, electronic order fulfillment, and electronic payment and settlement.

services (represented by Standard Industrial Classification [SIC] codes, 36, 37, 50, and 73)—were selected. As procurement activities are of strategic importance to these industries, firms in these industries should be particularly interested in improving their procurement processes through the use of EPIs.

Twelve hundred senior procurement professionals belonging to unique organizations and working in the four industries listed above were randomly drawn from ISM's membership database. The survey and a cover letter stating the purpose of this research were sent to these individuals. They were requested to complete the survey if they were the most informed about EPI assimilation in their organization. Alternatively, they were requested to redirect the questionnaire to the most informed individual. A postcard reminder was mailed about three weeks after the initial mailing. A total of 166 responses were received, representing a response rate of about 14 percent. This response rate is comparable to other survey studies of a similar type and scale (e.g., [13]).

Table 4. Sample Characteristics ($N = 166$)

	N	Percent
Industry		
Industrial machinery and equipment	28	16.9
Electronic equipment	72	43.4
Wholesale trade–durable goods	46	27.7
Business services	20	12.0
Number of procurement employees		
< 10	91	54.8
10–50	46	27.7
50–300	15	9.0
> 300	11	6.7
Missing	3	1.8
Sales revenue		
< 10 million	27	16.3
10–100 million	47	28.3
100 million–1 billion	52	31.3
> 1 billion	38	22.9
Missing	2	1.2
Annual procurement expense		
< 10 million	46	27.7
10–100 million	65	39.2
100 million–1 billion	39	23.5
> 1 billion	12	7.2
Missing	4	2.4

Our respondents included presidents, vice presidents, and operations and purchasing managers. The characteristics of the sample are summarized in Table 4. This sample represents a broad range of firm size with different procurement requirements, and provides a good context to examine EPI assimilation and its impact.

Assessment of Nonresponse Bias

We conducted two tests to evaluate nonresponse bias. Based on Armstrong and Overton's [2] guidelines, respondents were classified into three groups, or waves, based on when they returned the survey. Analysis of variance (ANOVA) tests were used to evaluate if later respondents systematically differed from earlier respondents with regard to the number of employees in the buyer's organization. Another chi-square test was conducted to measure the difference between the expected and observed respondents in SIC code categories. Both tests revealed no significant nonresponse bias due to industry and firm size.

Safeguarding Against and Evaluating Common Method Bias

One of the major concerns with self-report data is common method bias. While this concern can be alleviated by collecting data from more than one respondent per firm,

it can be pragmatically difficult to do so due to the data attrition that occurs when only one of the contacted persons responds to their portion of the survey. Similarly, while the concern can be alleviated by collecting information about the dependent variable from a secondary source, it is difficult to obtain objective process-level performance data. Given these practical constraints, we took steps to design the instrument to safeguard against common method bias by using concise and clear items, employing a mix of Likert, Guttman, and ratio scales to measure independent and dependent variables, and controlling for scale length [53].

Once the data were collected, we conducted two tests to evaluate the presence of common method bias. First, Harmon's one-factor test was conducted to assess common method variance in the independent variables [52]. Aggregated EPI Assimilation was excluded from this analysis as it was measured using a Guttman scale for each EPI. All items used to measure the independent variables were entered into a single exploratory factor analysis. Nine factors with an eigenvalue around 1.0 were retained. In total, they accounted for over 74 percent of the variance, with the first factor accounting for about 27 percent of the total variance. These results suggest a lack of common method bias. Second, following Podsakoff et al. [53], we included a common method factor in a partial least squares (PLS) model. Items were allowed to load on their theoretical constructs, as well as on the common method factor. We calculated and compared each indicator's variance that is explained by its theoretical construct to that by the common method factor. The theoretical constructs explained, on average, over 71 percent of each indicator's variance, while the common method factor explained, on average, only 0.5 percent of their variance. Moreover, only five out of 35 loadings on the common method factor were marginally significant ($p < 0.10$). Given these findings, common method bias is not a serious concern.

Measurement Validation

Table 5 presents the descriptive statistics for the constructs. Some constructs were measured using reflective measures and others were measured using formative measures. We first assessed the properties of the multi-item measures for each subconstruct and then assessed the discriminant validity of the constructs in the structural model.

Phase I: Measurement Properties of Independent Subconstructs

As indicated in Appendix A, we identified the measures for the three subconstructs of Trusting Beliefs to be reflective. Following well-established guidelines, we assessed the unidimensionality, reliability, convergent validity, and discriminant validity for these three subconstructs (Table 6). The results suggest that all three subconstructs exhibit satisfactory measurement properties. For the formative measures, we examined the correlation between the measurement items and subconstructs, where subconstruct scores were computed as unit means of the items. This procedure is similar to that used by Rai et al. [56] and Smith et al. [64]. As seen in Table 7, all items correlated higher with their subconstruct than with others, suggesting discriminant validity.

Table 5. Descriptive Statistics

Number	Construct/dimension*	1	2	3	4	5	6	7	8	9	10	11
1	Top management support	—										
2	IT sophistication	0.40	—									
3	Financial resources	0.35	0.30	—								
4	Supplier competence	0.16	0.17	0.03	0.89							
5	Supplier benevolence	0.29	0.21	0.60	0.14	0.85						
6	Supplier integrity	0.28	0.22	0.56	0.66	0.14	0.88					
7	Security safeguards	0.16	0.09	0.44	0.52	0.53	0.03	—				
8	Standards flexibility	0.20	0.25	0.07	0.03	0.08	0.20	–0.03	—			
9	Standards comprehensiveness	0.49	0.29	0.30	0.26	0.39	0.32	0.23	0.35	—		
10	Aggregated EPI assimilation	0.39	0.24	0.18	0.06	0.13	0.15	0.06	0.04	0.31	—	
11	Procurement productivity	0.22	0.20	0.09	0.03	0.08	0.08	0.09	0.07	0.15	0.47	—
	Mean	4.78	5.94	4.33	5.32	5.29	5.37	5.13	4.61	4.41	4.78	0.68
	Standard deviation	1.65	0.91	1.29	0.90	0.90	0.97	0.95	1.07	1.05	2.11	0.24

Notes: Diagonal elements are the square root of average variance extracted (AVE), only reported for reflective measures. Correlations among supplier competence, supplier benevolence, and supplier integrity range from 0.56 to 0.66 and are below the 0.8 threshold suggested by Bagozzi et al. [5] for consolidation. * Range of scores for constructs 1–10 is 1–7; range for procurement productivity is 0–1.

Table 6. Validation of Reflective Measures

	Trusting beliefs about suppliers		
	Supplier competence	Supplier benevolence	Supplier integrity
Number of scale items	3	3	3
Unidimensionality (GFI)	0.94	0.94	0.94
Reliability	0.89	0.86	0.93
Convergent validity	0.98	0.98	0.98
Discriminant validity (AVE)	0.79	0.72	0.77

Phase 2: Discriminant Validity of Constructs in the Structural Model

In the structural model, we included three types of measures for the constructs:

1. *Composite indicators of subconstructs:* Organizational Readiness, Trusting Beliefs About Suppliers, and EPI Standard Efficacy are in this category. For each of them, the unit mean of items associated with a subconstruct was used as a composite indicator. Thus, the number of composite indicators equaled the number of subconstructs. There are three reasons for this aggregation choice. First, as the measurement items for the formative subconstructs are highly correlated, aggregation avoids multicollinearity problems. Second, the measures for the subconstructs exhibit high internal consistency. Third, the linear composite scores derived based on different weighting schemes are highly correlated when the indicators themselves are highly correlated [59], which is true for all the subconstructs. In such a situation, a unit mean offers the advantage of being easily interpretable and replicable across samples [25].
2. *Single composite indicator:* Top Management Support and Security Safeguards are in this category. Here again, for the same reasons as above, the unit mean of items was computed and used as a single composite indicator for the construct.
3. *Multiple noncomposite indicators:* Aggregated EPI Assimilation was measured using the assimilation of the four types of EPI as formative indicators. As these indicators did not highly correlate, they were retained as distinct formative indicators.

We examined the correlation of the composite indicators with the constructs. Construct scores were computed as unit means of their indicators. As seen in Table 8, these indicators exhibited higher correlations with their constructs in comparison to others, suggesting discriminant validity.

In summary, our measures satisfied various reliability and validity criteria and were used to test the structural model and hypotheses.

Results

We chose PLS and used PLS-Graph 3.00 Build 1126 to analyze the structural model and test our hypotheses. Because PLS does not directly provide significance tests,

Table 7. Correlation Matrix of Indicators and Subconstructs

Construct/item	TMS	ITS	FINA	SEC	FLEX	CPRH	AGG
Top management support (TMS)							
TMS1	**0.95**	0.37	0.33	0.18	0.19	0.42	0.37
TMS2	**0.96**	0.35	0.34	0.17	0.18	0.49	0.40
TMS3	**0.93**	0.35	0.33	0.13	0.21	0.48	0.43
TMS4	**0.76**	0.40	0.30	0.11	0.16	0.38	0.34
IT sophistication (ITS)							
ITS1	0.39	**0.80**	0.31	0.07	0.17	0.26	0.35
ITS2	0.36	**0.87**	0.29	0.06	0.19	0.27	0.25
ITS3	0.32	**0.73**	0.27	0.14	0.27	0.23	0.24
ITS4	0.29	**0.86**	0.21	0.07	0.18	0.17	0.18
ITS5	0.39	**0.89**	0.24	0.02	0.22	0.24	0.16
ITS6	0.21	**0.77**	0.16	0.14	0.20	0.26	0.15
Financial resources (FINA)							
FINA1	0.20	0.19	**0.83**	0.01	0.19	0.16	0.52
FINA2	0.14	0.13	**0.84**	0.05	0.15	0.15	0.47
Security safeguards (SEC)							
SEC1	0.13	0.12	0.05	**0.85**	0.17	0.23	0.10
SEC2	0.17	0.07	0.00	**0.87**	0.18	0.24	0.13
SEC3	0.10	0.04	0.02	**0.89**	0.18	0.25	0.06
SEC4	0.14	0.03	0.05	**0.88**	0.14	0.25	0.11
SEC5	0.15	0.09	0.08	**0.88**	0.16	0.30	0.15

(continues)

Table 7. Continued

Construct/item	TMS	ITS	FINA	SEC	FLEX	CPRH	AGG
Standards flexibility (FLEX)							
FLEX1	0.06	0.10	–0.12	0.09	**0.75**	0.06	0.12
FLEX2	0.23	0.25	0.05	0.19	**0.85**	0.40	0.08
Standards comprehensiveness (CPRH)							
CPRH1	0.48	0.20	0.21	0.19	0.40	**0.78**	0.33
CPRH2	0.30	0.23	0.06	0.39	0.24	**0.72**	0.19
CPRH3	0.33	0.23	0.23	0.19	0.16	**0.78**	0.32
Aggregated EPI assimilation (AGG)							
RA	0.30	0.13	0.39	0.16	0.06	0.22	**0.61**
CAT	0.30	0.26	0.38	0.01	0.14	0.27	**0.74**
ORD	0.33	0.22	0.33	0.14	0.09	0.36	**0.78**
PAY	0.30	0.15	0.47	0.05	0.13	0.22	**0.76**

Notes: RA = reverse auction; CAT = catalog management; ORD = order fulfillment; PAY = payment and settlement. Item correlations with their subconstructs are shown in boldface.

Table 8. Subconstruct Correlations

		TMS	OR	TBS	SEC	STD	AGG
Top management support (TMS)	TMS	**1.00**	0.14	0.09	0.05	0.03	0.15
Organizational readiness (OR)	ITS	0.26	**0.63**	0.17	–0.01	0.20	0.10
	FINA	0.23	**0.83**	–0.03	0.04	0.30	0.53
Trusting beliefs about suppliers (TBS)	COMT	0.06	0.03	**0.82**	0.24	0.01	0.01
	BENV	0.18	0.08	**0.76**	0.35	–0.11	0.05
	INTG	0.14	0.11	**0.74**	0.36	0.04	0.13
Security safeguards (SEC)	SEC	0.05	0.05	0.19	**1.00**	0.04	0.03
EPI standard efficacy (STD)	FLEX	0.16	0.17	–0.06	0.17	**0.82**	0.03
	CPRH	0.43	0.01	0.28	0.19	**0.68**	0.373
Aggregated EPI assimilation (AGG)	AGG	0.33	0.36	0.16	0.13	0.24	**1.00**

Notes: ITS = IT sophistication; FINA = financial resources; COMT = competence; BENV = benevolence; INTG = integrity; FLEX = flexibility; CPRH = comprehensiveness. Correlations with subconstructs and their higher-order constructs are shown in boldface.

bootstrap analysis with 500 subsamples was conducted to test the significance of path estimates. Based on these results, four path coefficients were found to be significant, supporting four of the six hypotheses (see Figure 1).

Weights and Standard Errors of Formative Indicators

Table 9 summarizes the weights and standard errors for the constructs for which multiple formative indicators were specified. The weights indicate the meaningfulness of formative indicators and their relative importance for a construct in a nomology. When *n orthogonal* formative indicators are specified, the ceiling on their average weight is $(1/n)^{1/2}$. This average standardized weight is achieved when the formative indicators explain all the variance in a construct. Given that four indicators were used for Aggregated EPI Assimilation, the theoretical maximum average weight of these indicators is 0.50. Similarly, as Organization Readiness and EPI Standards Efficacy were measured using two indicators each, the theoretical maximum for their average weight is 0.71. Finally, Trusting Beliefs was measured using three formative indicators, meaning that their maximum average weight is 0.58. However, formative indicators can be pragmatically expected to exhibit some level of correlation, though we detected no multicollinearity problems. In comparison to the theoretical maximum, the observed average weights for indicators are favorable: 0.34 for Aggregated EPI Assimilation, 0.52 for Organization Readiness, 0.54 for EPI Standards Efficacy, and 0.48 for Trusting Beliefs. These high average weights, in comparison to the theoretical maximum, are evidence of the importance of these indicators.

With the exception of the formative indicators for Trusting Beliefs, low standard errors were observed for all other indicators (Table 9). In the discussion, we elaborate on the implications of the high standard errors for Trusting Beliefs.

Discussion

THE RESULTS SUPPORT FOUR of the six hypotheses: Top Management Support significantly influences Aggregated EPI Assimilation (H1), Organizational Readiness has a positive effect on Aggregated EPI Assimilation (H4), and EPI Standards Efficacy has a positive effect on Aggregated EPI Assimilation (H5). Moreover, Aggregated EPI Assimilation has a positive effect on Procurement Productivity (H6). The model explains about 39 percent of the variance in Aggregated EPI Assimilation and 23 percent of the variance in Procurement Productivity.

Factors Influencing Aggregated EPI Assimilation

Our results suggest that Aggregated Assimilation of EPIs is significantly influenced by Top Management Support, Organizational Readiness, and Standards Efficacy. While the indicator for assimilation of electronic order fulfillment was not significant, as elaborated later, the same set of predictors were found to be important for its assimilation in a decomposed analysis where each EPI was considered individually. Thus,

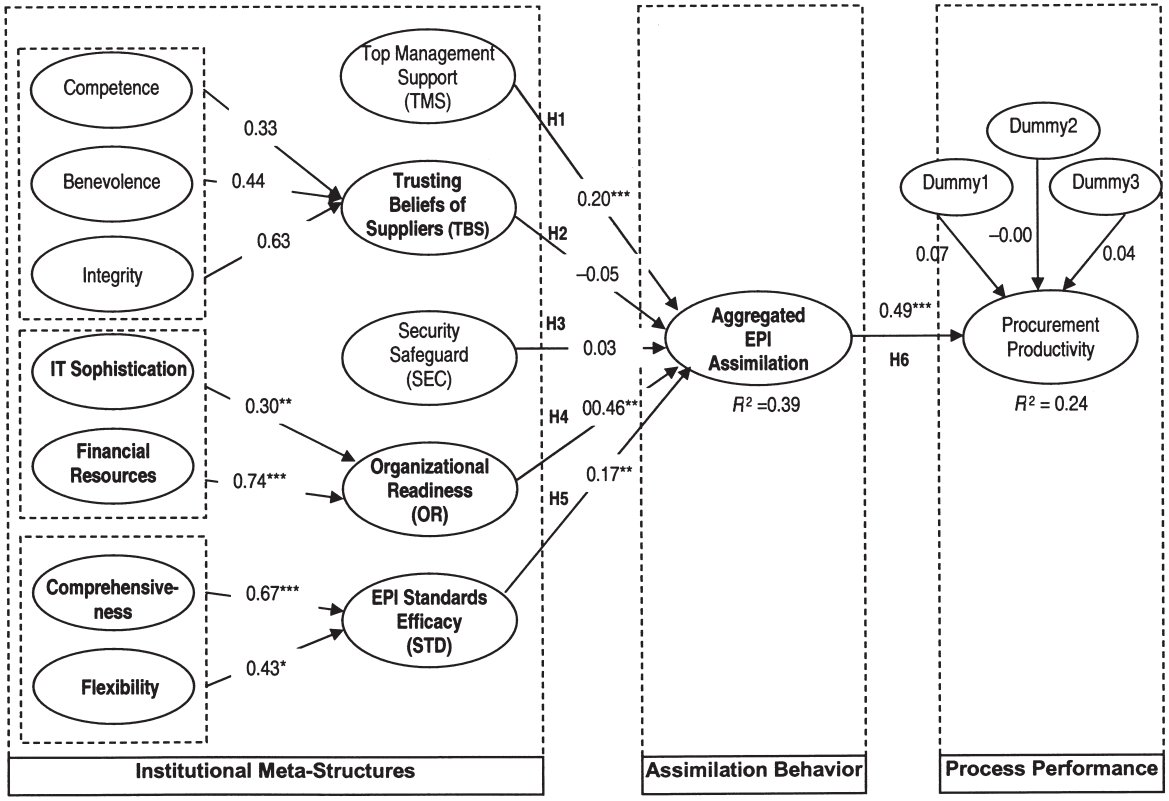

Figure 1. Results of PLS Analysis

Notes: Constructs names shown in boldface are measured formatively. Dummy variables represent the four industries. Appendix B presents the results related to the mediation role of Aggregated EPI Assimilation in the nomology. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Table 9. Indicator Weights and Standard Errors for Formative Constructs

	Weight	Standard error
Aggregated assimilation		
Reverse auction	**0.326**	0.106
Catalog management	**0.421**	0.115
Order fulfillment	0.080	0.116
Payment and settlement	**0.533**	0.108
Average	0.340	
Organizational readiness		
IT sophistication	**0.305**	0.106
Financial resources	**0.740**	0.048
Average	0.523	
Trusting beliefs about suppliers		
Competence	0.333	0.512
Benevolence	0.435	0.632
Integrity	0.632	0.521
Average	0.467	
EPI standards efficacy		
Flexibility	**0.429**	0.204
Comprehensiveness	**0.668**	0.069
Average	0.548	

Note: Boldface numbers are significant at $\alpha = 0.05$ level.

we can reasonably conclude that these factors generalize as important antecedents for the different EPIs.

Whereas Chatterjee et al. [13] studied the role of senior management in the context of assimilation of Web services, we extend their work by examining the effect of top management support on the assimilation of a set of moderately complementary EPIs. Our finding indicates that senior management's beliefs play a crucial role in promoting the assimilation of EPIs. Where top management believes in these innovations and communicates a clear vision about its role, a strong signal is sent to employees to evaluate, implement, and utilize them. The support of top management also provides essential political resources to overcome resistance that typically accompanies organizational innovation [29]. Purchasing managers and associates can exhibit inertia due to their entrenchment in legacy practices and in political and social influence networks. In effect, clear visioning and strategizing by top management not only legitimizes the use of EPIs but also establishes their significance. Moreover, to the extent that top management calibrates the goals for the organization, actions and initiatives related to EPI assimilation are regulated. Thus, by shaping the structures for signification, legitimization, and domination, top management support has a significant effect on EPI assimilation.

In terms of organizational readiness, past research reports that it has a positive effect on *intention to adopt EDI* [15]. We extend this research by providing evidence of a positive relationship between organization readiness and innovative behavior related to the ag-

gregated assimilation of EPIs. The two subconstructs of organization readiness—that is, IT sophistication and financial resources—have a significant effect on EPI assimilation. Effectively, sophisticated IT and financial resources provide key resources to enable decisions, promote actions, and support behaviors that legitimize the exploration and broad deployment of EPIs. Thus, these resources influence the structures of legitimization, which affect the actions and behaviors related to EPI assimilation.

The findings on the role of EPI standards indicate that Standards Efficacy is an important antecedent to EPI assimilation. Standards embody rules on how EPIs should be used and establish the institutional structures to regulate individual actions and behaviors related to the procurement process. If EPI standards are comprehensive and provide flexibility for day-to-day operations, they not only increase efficiency but also reduce complexity and uncertainty without establishing rigidity. In effect, they structure actions and regulate behaviors of individuals involved in procurement to favor the assimilation of EPIs.

Interestingly, Trusting Beliefs About Suppliers did not significantly relate to Aggregated EPI Assimilation. An inspection of the mean values for the three subconstructs related to Trusting Beliefs indicated that they were uniformly high across all stages of assimilation and across the four EPIs. For example, the mean of Competence of Suppliers, which can range from 1 to 7, had notably high values—it ranged from 5.22 to 5.92 across the assimilation stages for online reverse auction and from 5.12 to 5.39 across the four EPIs for the awareness stage. One explanation is that trusting beliefs gains importance at early stages in the assimilation process when firms evaluate online procurement and retain a high level of importance. This explanation is consistent with concerns about opportunism that impact decisions related to transaction exchange [75], including the use of technologies to support these exchanges. While we offer this theoretical interpretation, it should be noted that the standard errors for the weights associated with each of the three trusting belief constructs—that is, benevolence, integrity, and competence—were high. Thus, additional empirical investigation is needed on this relationship.

We did not observe a significant effect of Security Safeguards on Aggregated EPI Assimilation. The maturity of technology may be a factor that contributes to the lack of observed significance. Initially, there were many security concerns on transacting business over the Internet. However, with Internet technologies and applications becoming more robust and with the legal framework around Internet usage also developing, security concerns may be alleviated. Moreover, like Trusting Beliefs, it may be deemed to be a necessary condition to initiate assimilation, as the mean value for Security Safeguards was uniformly high across all levels of assimilation for the four EPIs.

The Effect of Aggregated EPI Assimilation on Procurement Productivity

The literature on IT business value argues that the effects of IT innovations usually surface at the intermediate level or core business processes [55]. Consistent with this perspective, we observe that Aggregated EPI Assimilation has a significant effect on

Procurement Productivity. To further evaluate the effect of Aggregated EPI Assimilation on Procurement Productivity, we examined the effect of individual EPI assimilation on Procurement Productivity (Table 10). Our findings suggest that compared to the assimilation of individual EPIs, the aggregated assimilation of IT innovations for major aspects of the procurement process—that is, catalog management, payment and settlements, and reverse auctions—improves procurement productivity substantially more.

In addition, we used an ANOVA test to compare the procurement productivity of four groups of firms: those that were not deploying any of the four EPIs, those that were deploying one or more EPIs to a limited extent, those that were broadly using some but not all EPIs, and those that were broadly deploying all four EPIs. As expected, procurement productivity increased across groups that represented increased usage levels of *all* EPIs ($p < 0.01$). Indeed, the last group exhibited significantly higher productivity than the other three, providing evidence that the EPIs complement each other in their impact on procurement productivity.

Post Hoc Analysis on the Transition Across Assimilation Stages of Individual EPIs

To explore the stability of the findings related to the impact of the causal factors across EPIs and across stages of assimilation, we conducted two sets of post hoc analyses. First, we examined the ability of the independent variables to explain the assimilation of each EPI considered separately (Table 11). A comparison of the results across five models—the aggregated model and the disaggregated models for the four EPIs—revealed that all independent variables similarly influenced Aggregated EPI Assimilation and the assimilation of each of the four EPIs when considered individually. In comparison to the four disaggregated models, the independent variables exhibited stronger path coefficients and explained a greater proportion of the variance in Aggregated EPI Assimilation. The ability of the independent variables to explain greater variance in Aggregated EPI Assimilation relative to disaggregated EPI assimilation is consistent with observations that the use of an aggregated measure of innovation has a positive effect on predictive validity [21]. It also supports the position that these causal factors enhance a buyer firm's innovation capability to assimilate a set of moderately complementary EPIs, which are more difficult to assimilate than unrelated or fully complementary innovations.

Second, we conducted a drill-down analysis and examined the mean differences of each subconstruct across stages of assimilation for each EPI. Because of sample size limitations, we consolidated the seven stages of the assimilation life cycle into three broad stages: *initial evaluation* (includes awareness, interest, evaluation, and commitment), *limited deployment,* and *general deployment* (includes partial and general deployment). As these stages are ordered, we conducted two pairwise comparisons—initial evaluation versus limited deployment, and limited deployment versus general deployment (Table 12).

While our primary objective is to understand the aggregated assimilation of EPIs, the drill-down analysis provides insights on how to address unique requirements to

Table 10. Comparison of Effects on Procurement Productivity

	Aggregated EPI assimilation	Assimilation of individual EPI			
		RA	CAT	ORD	PAY
Procurement productivity	0.49***	0.23**	0.39**	0.22**	0.40**
R^2	0.24	0.08	0.15	0.07	0.17

Notes: [a] RA = reverse auction; CAT = catalog management; ORD = order fulfillment; PAY = payment and settlement. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Table 11. Comparison of Models

	Aggregated EPI assimilation	Assimilation of individual EPI			
		RA	CAT	ORD	PAY
Top management support	0.20***	0.12**	0.10**	0.11**	0.09*
Organization readiness	0.46***	0.31***	0.325***	0.229**	0.39***
Trusting beliefs about suppliers	–0.05	–0.07	–0.06	0.01	0.02
Security safeguards	0.03	0.09	0.16*	0.02	0.02
EPI standards efficacy	0.17**	0.10*	0.14*	0.18**	0.17**
R^2	0.39	0.21	0.23	0.21	0.26

Notes: RA = reverse auction; CAT = catalog management; ORD = order fulfillment; PAY = payment and settlement. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

transition between stages and to assimilate each of the four EPIs. We now discuss the findings from this exploratory analysis.

1. Top Management Support was observed to be higher at higher levels of assimilation for all four EPIs, which is consistent with the results for the Aggregated EPI Assimilation model and for the four disaggregated EPI assimilation models. Interestingly, the biggest increase in Top Management Support was observed between initial evaluation and limited deployment of reverse auctions. Conceivably, as reverse auctions can dramatically change the dynamics to select suppliers and award contracts [45], strong top management support is needed to transition from exploring the potential of the technology to adopting the practice. Thus, top management support, which is a causal factor for each of the meta-structures of signification, domination, and legitimization, is important for EPI assimilation across innovations and stages, and gains importance when the changes in work structures are more dramatic, as can be the case with reverse auctions.

Table 12. Post Hoc Analysis of the Influence of Factors on Different Stages of the Assimilation Life Cycle

		Domination		Signification				Legitimization	
		Organizational readiness		Trusting beliefs				Standards efficacy	
Construct/ Mean value	TMS	ITS	FINA	COMT	BENV	INTG	SEC	FLEX	CPRH
RA									
Initial exploration	4.479	5.887	4.803	5.248	5.207	5.275	5.034	4.629	4.295
Limited deployment[1]	5.908***	6.192	5.842***	5.403	5.474	5.754**	5.332	4.754	4.772***
General deployment[2]	5.833	6.067	5.467	5.889**	5.779	5.689	5.588	4.222	4.956
CAT									
Initial exploration	4.429	5.754	4.815	5.345	5.279	5.265	5.143	4.442	4.170
Limited deployment[1]	4.599	5.921	4.763	5.255	5.299	5.368	5.004	4.877**	4.474
General deployment[2]	5.824***	6.427***	5.676***	5.333	5.297	5.640	5.207	4.741	4.954**
ORD									
Initial exploration	4.342	5.775	4.724	5.252	5.170	5.208	5.069	4.500	4.109
Limited deployment[1]	5.184***	5.995	5.316**	5.352	5.290	5.421	5.022	4.825	4.702***
General deployment[2]	5.653**	6.397***	5.452	5.505	5.656	5.828	5.430	4.678	5.022
PAY									
Initial exploration	4.434	5.828	4.898	5.351	5.279	5.364	5.185	4.787	4.269
Limited deployment[1]	4.938**	5.963	5.031	5.177	5.146	5.281	4.862	4.500	4.500
General deployment[2]	5.550**	6.214**	5.200	5.391	5.448	5.505	5.442**	4.373	4.706

Notes: RA = reverse auction; CAT = catalog management; ORD = order fulfillment; PAY = payment and settlement; TMS = top management support; ITS = IT sophistication; FINA = financial resources; COMT = competence; BENV = benevolence; INTG = integrity; SEC = security safeguards; FLEX = flexibility; CPRH = comprehensiveness. [1] Asterisks represent significant differences between the initial exploration group and the limited deployment group. [2] Asterisks represent significant differences between the limited deployment group and the general deployment group. ** $p < 0.05$; *** $p < 0.01$ (one-tailed test).

2. In terms of Organizational Readiness, both IT Sophistication and Financial Resources were associated with the assimilation of three EPIs. Interestingly, IT Sophistication appears to be important to transition from limited deployment to general deployment for all EPIs except reverse auctions, suggesting that IT expertise and IT infrastructure resources are critical to infuse online catalogs, order fulfillment, and electronic payment and settlement into the work routines of procurement professionals. Similarly, Financial Resources were important to transition from limited deployment to general deployment for electronic catalogs, which suggests that slack resources are required to establish online catalogs for *all* parts and suppliers and that this conversion process is resource intensive. Moreover, Financial Resources significantly related to the transition from initial exploration to limited deployment for reverse auctions and order fulfillment, possibly because these EPIs are more complex to integrate into work processes in comparison to online catalogs and electronic payments and therefore require more resources to configure and stabilize them into work systems after initial experimentation. In general, these results suggest that the meta-structure of domination, as captured by Organization Readiness, plays an important role across all innovations and gains importance when work processes need to be changed more radically and when behavioral changes need to be broadly institutionalized.
3. For Standards Efficacy, the findings are consistent with the results for Aggregated EPI Assimilation and the assimilation of each EPI. Comprehensiveness significantly related to the transition from initial exploration to limited deployment for reverse auctions and order fulfillment. A possible reason is that the standards for auctions and order fulfillment are still emerging while the standards for payment and settlement are relatively mature and, therefore, unlikely to be a major issue for assimilation. Moreover, Flexibility was significantly related to the transition from initial exploration to limited deployment for online catalogs, possibly because the ability to represent product-related information continues to be a major requirement and a significant challenge for complex products. As we observed significant increases of Comprehensiveness and Flexibility between initial exploration and limited deployment, these causal factors of the meta-structure of legitimization appear to be more influential in facilitating the transition from initial exploration to limited deployment.
4. Security Safeguards was not found to affect Aggregated EPI Assimilation or the assimilation of individual EPIs in the disaggregated analysis. Interestingly, the drill-down analysis showed that Security Safeguards significantly related to the transition from limited deployment to general deployment for electronic payment and settlement. Electronic payment and settlement pertains to the financial exchange between the buyer and seller, and a high level of security appears to be important to its broad infusion into the procurement process. Thus, the meta-structure of signification operates through Security Safeguards to promote the general deployment of electronic procurement and settlement.

5. Trusting Beliefs about Suppliers, which is formed by Competence, Benevolence, and Integrity, was not found to significantly affect Aggregated EPI Assimilation or the assimilation of any of the EPIs. The drill-down results showed that Integrity was associated with the transition from initial exploration to limited deployment of reverse auctions and that Competence was associated with the transition from limited deployment to general deployment of reverse auctions. It appears that concerns about the integrity of suppliers can slow down the initial use of reverse auctions, suggesting that buyers may perceive greater risks of opportunism by suppliers in reverse auctions. Interestingly, the competence of suppliers may emerge as a consideration in the broad use of reverse auctions, possibly because of concerns of whether or not suppliers that win auctions can discharge their obligations and meet the needs of the buyers. The findings suggest that the meta-structure of signification operates in a nuanced manner through Trusting Beliefs About Suppliers to impact the assimilation of reverse auctions: integrity signifies lack of opportunism and is important in the early stages of the assimilation life cycle, and competence signifies an ability of the supplier to fulfill commitments and is important in later stages of the assimilation life cycle.

In summary, the drill-down results validated our earlier finding that the meta-structures of signification, legitimization, and domination operate through organizational, interorganizational, and technological factors to impact the assimilation of the EPIs. All three meta-structures operate through Top Management Support to impact the assimilation of each of the EPIs across the assimilation life cycle. The meta-structure of domination, operating through Organizational Readiness, gains importance in later stages of assimilation, while the meta-structure of legitimization, operating through Standards Efficacy, gains importance in the early stages of assimilation. The analysis also revealed that the meta-structure of signification operates though Security Safeguards and Trusting Beliefs to impact some aspects of EPI assimilation though this effect is not observed in the aggregate analysis. Specifically, the meta-structure of signification, operating through Security Safeguards, is important in later stages of assimilation for electronic payment and settlement, as this EPI is used to exchange finances where security is critical. Moreover, the meta-structure of signification, operating through Supplier Trusting Beliefs, is important for the assimilation of reverse auctions—integrity in early stages due to concerns about supplier opportunism, and competence in later stages due to concerns about suppliers' ability to meet commitments.

Limitations and Future Research

We collected data from a single informant to capture the view of purchasing professionals at a buyer organization. Suppliers may also influence EPI assimilation of buyers, especially if the buyer–supplier relationship and the supplier's legacy processes are hard to adjust to the revised online arrangements. The extent of such influence is

likely to also be a function of the personal nature of the relationships and negotiating tactics that form between buyers and suppliers over time. Therefore, including suppliers and buyers and employing a dyadic research design should generate additional insights about the role of their respective beliefs about EPIs in the assimilation process. Moreover, while we focused on the assimilation of EPIs for e-sourcing and e-coordination and excluded e-communities, future research should investigate the factors that generalize to, and those that are unique to, e-communities. Future research should also examine how procurement productivity is affected by economies of scale and market characteristics, such as supplier concentration and competitive intensity, for a firm's major product categories. This will develop our understanding on the relative impact of EPIs on procurement productivity under different market conditions for categories of products.

There are some shortcomings to the sampling approach that we used. First, we utilized a cross-sectional survey design. While this design is suitable to address the questions that we are interested in, a longitudinal research study on aggregated EPI assimilation can generate insights on how the different structuration factors change and interact over time to affect EPI assimilation. Second, though the ISM is the leading procurement organization in the world and represents a wide cross-section of procurement professionals from organizations of different sizes and in different industries, choosing informants from a single organization may still pose a threat to the generalizability of our results. Further research adopting a different sampling strategy will be useful to validate our findings.

Contributions

Given the strategic potential of electronic sourcing and coordination technologies for procurement innovation, we examined the impact of the assimilation of a set of moderately complementary EPIs on a buyer firm's procurement productivity and the factors that influence EPI assimilation. Drawing on structuration theory and the literature on interorganizational assimilation of IT, we identified a parsimonious set of factors for the meta-structures of signification, legitimization, and domination and examined their impact on EPI assimilation. Our study makes four major theoretical and practical contributions, each of which is elaborated below.

First, we examined the business value of assimilating a set of moderately complementary EPIs for sourcing and coordinating the procurement process. Most innovation diffusion studies, in contrast, have looked at a particular technology [15, 31], which overlooks the complementary nature of a set of related technologies, especially for core business processes such as procurement. Recent studies on the business value of EPIs have shown that high use of EPIs affects procurement performance [57]. Our results suggest that Aggregated EPI Assimilation has a stronger relationship with, and accounts for larger variation in, procurement productivity than the assimilation of each individual EPI. Indeed, firms that broadly deploy EPIs realize the greatest productivity benefit. Thus, we contribute to the IT business value literature by showing that the aggregate assimilation of EPIs for sourcing and coordination operate as moderate

complements to impact procurement productivity and create business value. Given our finding, senior managers should formulate their firm's EPI strategy so that process changes, technology integration, and personnel training focus on the complementarity among the EPIs for sourcing and coordination.

Second, we map the meta-structures of signification, legitimization, and domination to a set of organizational, interorganizational, and technical factors identified through an extensive review of the interorganizational IT diffusion literature. Our findings suggest that the meta-structures of signification, legitimization, and dominance operate through Top Management Support, Organizational Readiness, and EPI Standards Efficacy to impact Aggregated EPI Assimilation. Thus, each of the three meta-structures, and these three major factors through which they operate, play a significant role across innovations and stages.

Practically, senior managers can support EPI assimilation by signifying why the change is being undertaken and how it maps to the overall procurement strategy, by legitimizing the use of EPI in place of traditional approaches, and by exerting dominance to overcome inertial forces. Moreover, Organization Readiness, both in terms of financial resources and IT sophistication, provides essential resources that can be applied to direct assimilation and overcome resistance and inertia. Finally, practicing mangers can legitimize assimilation by enforcing a complete set of flexible standards for sourcing and coordination.

Third, our post hoc analysis provides initial insights on the relative emphasis of the three meta-structures at different stages of EPI assimilation. Our results suggest that the meta-structure of signification is important early in the process. This can be achieved through Top Management Support, Trusting Beliefs About Suppliers, and Security Safeguards. Subsequently, the meta-structure of legitimization gains in importance to transition from initial exploration to limited deployment of EPIs. Here, the support of top management to communicate that EPIs are not just exploratory technologies but represent a core technology for procurement, and that EPI standards are comprehensive and flexible to legitimately accommodate process requirements, plays a critical role. Finally, the meta-structure of domination gains importance to transition EPIs from limited deployment to general deployment. The support of top management to overcome inertial forces and the availability of IT knowledge and financial resources to integrate and routinize EPIs into work processes play important roles in this phase of the assimilation process. These results on how certain factors gain importance at different stages in the assimilation process should help practicing managers to place additional emphasis on selected factors based on the EPI assimilation life cycle.

Fourth, and finally, our study extends past research on IT-enabled process innovation, as it is one of the few to investigate the assimilation life cycle for a core business process. Most studies have focused on the adoption or implementation of a specific technology, such as EDI. Assimilation, however, is especially useful to understand process innovations, such as electronic procurement systems, that have not yet widely diffused. If a traditional approach such as capturing the time of adoption is used to measure innovation, important gradations in innovativeness will be missed. The approach introduced by Fichman [21] in the context of software process innovation

and applied by us for procurement innovation is more holistic. This measure can be adapted by others who are interested in investigating administrative and technological innovation for other business processes and understanding their impact on business value.

Acknowledgment: The authors thank the Editor-in-Chief and reviewers for their helpful comments.

NOTES

1. Damanpour's [18] meta-analysis found that studies using more aggregated measures have stronger statistical confirmation of expected theoretical relationships compared to studies using less aggregated measures.

2. The standard error of the mediated path is approximated as $(b^2s_a^{\ 2} + a^2s_b^{\ 2} + s_a^{\ 2}s_b^{\ 2})^{1/2}$, where a and b are the magnitudes of the paths between x, M, and y, and s_a and s_b are the standard deviations of a and b. The magnitude of the mediation effect is the cross-product of a and b.

REFERENCES

1. Aberdeen Group. Strategic procurement: The next wave of procurement automation. White Paper, Boston, July 1999.

2. Armstrong, S., and Overton, T. Estimating nonresponse bias in mail surveys. *Journal of Marketing Research, 14,* 3 (1977), 396–402.

3. Attaran, M. The coming age of online procurement. *Industrial Management & Data Systems, 101,* 3–4 (2001), 177–180.

4. Ba, S.; Whinston, A.B.; and Zhang, H. The dynamics of the electronic market: An evolutionary game approach. *Information Systems Frontiers, 2,* 1 (2000), 31–40.

5. Bagozzi, R.P.; Yi, Y.; and Phillips, L.W. Assessing construct validity in organizational research. *Administrative Science Quarterly, 36,* 3 (1991), 421–458.

6. Bala, H., and Venkatesh, V. Assimilation of interorganizational business process standards. *Information Systems Research, 18,* 3 (2007), 340–362.

7. Barua, A.; Kriebel, C.H.; and Mukhopadhyay, T. Information technologies and business value: An analytic and empirical investigation. *Information Systems Research, 6,* 1 (1995), 3–23.

8. Barua, A.; Konana, P.; Whinston, A.B.; and Yin, F. Driving e-business excellence. *MIT Sloan Management Review, 43,* 1 (2001), 36–45.

9. Bouchard, L. Decision criteria in the adoption of EDI. In J. DeGross, R.P. Bostrom, and D. Robey (eds.), *Proceedings of the Fourteenth International Conference of Information Systems.* New York: ACM Press, 1993, pp. 365–376.

10. Brews, P. The challenge of the Web-enabled business. *Financial Times* (November 27, 2000), 103–108.

11. Brown, C.V., and Sambamurthy, V. Linking intra-organizational stakeholders: CIO perspectives on the use of coordination mechanisms. Working Paper, Florida State University, Tallahassee, FL, 1998.

12. Brynjolfsson, E., and Smith, M. Frictionless commerce? A comparison of Internet and conventional retailers. *Management Science, 46,* 4 (2000), 563–585.

13. Chatterjee, D.; Grewal, R.; and Sambamurthy, V. Shaping up for e-commerce: Institutional enablers of the organizational assimilation of Web technologies. *MIS Quarterly, 26,* 2 (2002), 65–89.

14. Churchill, G.A., Jr. A paradigm for developing better measures of marketing constructs. *Journal of Marketing Research, 16,* 1 (1979), 64–73.

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

16. Cooper, L.K.; Duncan, D.J.; and Whetstone, J. Is electronic commerce ready for the Internet? *Information Systems Management, 13,* 3 (1996), 25–36.

17. Croom, S. The impact of Web-based procurement on the management of operating resources supply. *Journal of Supply Chain Management, 36,* 1 (2000), 4–13.

18. Damanpour, F. Organizational innovation: A meta-analysis of effects of determinants and moderators. *Academy of Management Journal, 34,* 3 (1991), 555–590.

19. DeLone, W.H., and McLean, E.R. Information systems success: The quest for the dependent variable. *Information Systems Research, 3,* 1 (1992), 60–95.

20. Dyer, J.H. Effective interfirm collaboration: How firms minimize transaction costs and maximize transaction value. *Strategic Management Journal, 18,* 7 (1997), 535–556.

21. Fichman, R.G. The role of aggregation in the measurement of IT-related organizational innovation. *MIS Quarterly, 25,* 4 (2001), 427–455.

22. Fichman, R.G., and Kemerer, C.F. The illusory diffusion of innovation: An examination of assimilation gaps. *Information Systems Research, 10,* 3 (1999), 255–275.

23. Giddens, A. *The Constitution of Society: Outline of the Theory of Structure.* Berkeley: University of California Press, 1984.

24. Gordon, S. Standardization of information systems and technology at multinational companies. *Journal of Global Information Management, 1,* 3 (1993), 5–14.

25. Hair, J.F.; Anderson, R.E.; Tathem, R.L.; and Black, W.C. *Multivariate Data Analysis.* Upper Saddle River, NJ: Prentice Hall, 1998.

26. Han, K.S., and Noh, M.H. Critical failure factors that discourage the growth of electronic commerce. *International Journal of Electronic Commerce, 4,* 2 (1999), 25–43.

27. Hannon, D. High-tech security becomes top priority in supply chain. *Purchasing, 131,* 11 (2002), 39–40.

28. He, Q.; Duan, Y.; Fu, Z.; and Li, D. An innovation adoption study of online e-payment in Chinese companies. *Journal of Electronic Commerce in Organizations, 4,* 1 (2006), 48–69.

29. Howell, J.M., and Higgins, C.A. Champions of technological innovations. *Administrative Science Quarterly, 35,* 2 (1990), 317–330.

30. Hoyle, R.H., and Kenny, D.A. Statistical power, reliability and tests of statistical mediation. In R.H. Hoyle (ed.), *Statistical Strategies for Small Sample Research.* Newbury Park, CA: Sage, 1999, pp. 197–219.

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

32. Jap, S.D., and Mohr, J.J. Leveraging Internet technologies in B2B relationships. *California Management Review, 44,* 4 (2002), 24–38.

33. Jarvenpaa, S.L., and Tractinisky, N. Consumer trust in an Internet store: A cross-cultural validation. *Journal of Computer-Mediated Communication, 5,* 2 (1999), 1–33.

34. Johnson, P.F., and Klassen, R.D. E-procurement. *MIT Sloan Management Review, 46,* 2 (2005), 7–10.

35. Kauffman, R.J., and Mohtadi, H. Proprietary and open systems adoption in e-procurement: A risk-augmented transaction cost perspective. *Journal of Management Information Systems, 21,* 1 (Summer 2004), 137–166.

36. Kayworth, T., and Sambamurthy, V. Facilitating localized exploitation and enterprise-wide integration in the use of IT infrastructures: The role of PC/LAN infrastructure standards. *DATA BASE for Advances in Information Systems, 31,* 4 (2000), 54–77.

37. Kohli, R., and Devaraj, S. Measuring information technology payoff: A meta-analysis of structural variables in firm-level empirical research. *Information Systems Research, 14,* 2 (2003), 127–145.

38. Kwon, T., and Zmud, R. *Unifying the Fragmented Models of Information Systems Implementation, Critical Issues in Information Systems Research.* New York: John Wiley & Sons, 1987.

39. Lee, H.G. Do electronic marketplaces lower the price of goods? *Communications of the ACM, 41,* 1 (1998), 73–80.

40. Lee, H.L., and Whang, S. Winning the last mile of e-commerce. *MIT Sloan Management Review, 42,* 4 (2001), 54–62.

41. Mak, K.-T., and Ramaprasad, A. Knowledge supply network. *Journal of the Operational Research Society, 54,* 2 (2003), 175–183.

42. Malone, T.W.; Yates, J.; and Benjamin, R.I. Electronic markets and electronic hierarchies. *Communications of the ACM, 30,* 6 (1987), 484–497.

43. Martin, T.N., and Hafer, J.C. Internet procurement by corporate purchasing agents: Is it all hype? *SAM Advanced Management Journal, 67,* 1 (2002), 41–47.

44. McKnight, D.H.; Choudhury, V.; and Kacmar, C. Developing and validating trust measures for e-commerce: An integrative typology. *Information Systems Research, 13,* 3 (2002), 334–359.

45. Mithas, S., and Jones, J.L. Do auction parameters affect buyer surplus in e-auctions for procurement? *Production and Operations Management, 16,* 4 (2007), 455–470.

46. Monczka, R.M.; Handfield, R.B.; and Trent, R.J. *Purchasing and Supply Chain Management.* Boston: South-Western College Publishers, 2001.

47. Orlikowski, W.J. The duality of technology: Rethinking the concept of technology in organizations. *Organization Science, 3,* 3 (1992), 398–427.

48. Orlikowski, W., and Robey, D. Information technology and the structuring of organizations. *Information Systems Research, 2,* 2 (1991), 143–169.

49. Pare, G., and Raymond, L. Measurement of information technology sophistication in SMEs. In G.C. Moore (ed.), *Administrative Sciences Association of Canada Nineteenth Annual Conference.* Nova Scotia: Acadia University, 1991, pp. 90–101.

50. Parker, R. Public-sector trial aims to allay online security fears. *Supply Management, 7,* 2 (2002), 8.

51. Pearson, J.N.; Ellram, L.M.; and Carter, C.R. Status and recognition of the purchasing function in the electronic industry. *International Journal of Purchasing and Materials Management, 32,* 2 (1996), 30–36.

52. Podsakoff, P.M., and Organ, D.W. Self-reports in organizational research: Problems and perspectives. *Journal of Management, 12,* 4 (1986), 531–544.

53. Podsakoff, P.M.; MacKenzie, S.B.; Lee, J.-Y.; and Podsakoff, N.P. Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88,* 5 (2003), 879–903.

54. Purvis, R.L.; Sambamurthy, V.; and Zmud, R.W. The assimilation of knowledge platforms in organizations: An empirical investigation. *Organization Science, 12,* 2 (2001), 117–135.

55. Rai, A.; Patnayakuni, R.; and Patnayakuni, N. Technology investment and business performance. *Communications of the ACM, 40,* 7 (1997), 89–97.

56. Rai, A.; Patnayakuni, R.; and Seth, N. Firm performance impacts of digitally-enabled supply chain integration capabilities. *MIS Quarterly, 30,* 2 (2006), 225–246.

57. Rai, A.; Tang, X.; Brown, P.; and Keil, M. Assimilation patterns in the use of electronic procurement innovations: A cluster analysis. *Information & Management, 43,* 3 (2006), 336–349.

58. Reichheld, F.F., and Schefter, P. E-loyalty: Your secret weapon on the Web. *Harvard Business Review, 78,* 4 (2000), 105–113.

59. Rozeboom, W.W. Sensitivity of a linear composite predictor items to differential item weighting. *Psychometrica, 44,* 3 (1979), 289–296.

60. Saunders, C.S., and Clark, S. EDI adoption and implementation: A focus on interorganizational linkages. *Information Resource Management Journal, 5,* 1 (1992), 9–19.

61. Scott, W.R. *Institutions and Organizations.* Thousand Oaks, CA: Sage, 1995.

62. Segev, A., and Gebauer, J. B2B procurement and marketplace transformation. *Information Technology and Management, 2,* 3 (2001), 241–260.

63. Simchi-Levi, D.; Kaminsky, P.; and Simchi-Levi, E. *Designing and Managing the Supply Chain.* New York: McGraw-Hill, 2000.

64. Smith, H.; Keil, M.; and Depledge, G. Keeping mum as the project goes under: Toward an explanatory model. *Journal of Management Information Systems, 18,* 2 (Fall 2001), 189–227.

65. Sohal, A.S.; Power, D.J.; and Terziovski, M. Supply chain management in Australian manufacturing: Two case studies. *Computers & Industrial Engineering, 43,* 1–2 (2002), 97–109.

66. Subramani, M. How do suppliers benefit from information technology in supply chain relationships? *MIS Quarterly, 28,* 1 (2004), 45–73.

67. Swanson, E.B. *Information System Implementation: Bridging the Gap Between Design and Utilization.* Homewood, IL: Irwin, 1998.

68. Thong, J.Y.L. An integrated model of information systems adoption in small businesses. *Journal of Management Information Systems, 15,* 4 (Spring 1999), 187–214.

69. Thong, J.Y.L. Resource constraints and information systems implementation in Singaporean small businesses. *Omega, 29,* 2 (2001), 143–156.

70. Vanlommel, E., and De Brabander, B. Price–cost margins and market structure: A contingency approach. *Journal of Industrial Economics, 28,* 1 (1979), 1–22.

71. Venkatesh, V., and Bala, H. Adoption of interorganizational business process standards in business-to-business integration: An exploratory study. *Systemes d'Information et Management, 12,* 2 (2007), 53–80.

72. Wan, Y.; Menon, S.; and Ramaprasad, A. A classification of product comparison agents: Using the ecological food chain as an analogy for agent classification. *Communications of the ACM, 50,* 8 (2007), 65–71.

73. Weill, P., and Broadbent, M. *Leveraging the New Infrastructure: How Market Leaders Capitalize on Information Technology.* Boston: Harvard Business School Press, 1998.

74. Wernerfelt, B., and Montgomery, C.A. Tobin's *Q* and the importance of focus in firm performance. *American Economic Review, 78,* 1 (1988), 246–250.

75. Williamson, O.E. Transaction cost economics. In R. Schmalensee and R.D. Willig (eds.), *Handbook of Industrial Organization,* vol. 1. New York: North-Holland, 1989, pp. 136–184.

76. Wright, D. Comparative evaluation of electronic payment systems. *INFOR, 40,* 1 (2002), 71–86.

Appendix A: Survey Items

Survey item	Measure type	Reason
Top management support (adapted from [13, 70]) Senior management in your firm actively participates in . . . TMS1: Articulating a vision for your organizational use of e-procurement systems TMS2: Formulating a strategy for the organizational use of e-procurement systems TMS3: Establishing goals and standards to monitor e-procurement systems TMS4: Deploying information technology in your organization	Formative	The items measure four types of activity that senior management may be involved in. It is reasonable for them to only participate in some but not all four activities. These items are not necessarily interchangeable and do not have to covary. For example, senior management participation in deploying IT or formulating a strategy does not have to covary with establishing goals and standards to monitor e-procurement.
Organizational readiness IT sophistication (adapted from [49]) In my company, information technology (IT) is important for the fulfillment of the following objectives. ITS1: Operational costs reduction ITS2: Productivity improvements ITS3: Improved access to information ITS4: Improved quality of decision making ITS5: Improved competitiveness ITS6: Improved service to customers	Formative	The six measures for IT sophistication examine distinct aspects of IT usage that are not interchangeable and do not have to covary.
Financial resources (adapted from [15]) FINA1: What was the approximate total revenue of your organization last year? FINA2: How many people are employed in your organization?	Formative	These two measures examine distinct types of resources that are not necessarily interchangeable and do not have to covary. A firm with high revenues may have few employees and vice versa.

(continues)

Appendix A. Continued

Survey item	Measure type	Reason
Trusting beliefs about suppliers (adapted from [44])	Reflective	The three items are interchangeable and are expected to covary. They tap into the same underlying theme of competence.
Supplier competence		
COMT1: In general, most suppliers that use electronic procurement technology are competent at serving their customers.		
COMT2: Most suppliers that use electronic procurement technology do a good job at meeting customer needs.		
COMT3: Most suppliers that use electronic procurement technology are good at what they do.		
Supplier benevolence	Reflective	The three items are interchangeable and are expected to covary. They all tap into the same underlying theme of benevolence.
BENV1: Most suppliers that use electronic procurement systems would act in the customers' best interest.		
BENV2: If a customer required help, most suppliers that use electronic procurement systems would do their best to help.		
BENV3: Most suppliers that use electronic procurement systems are interested in customer well-being, not just their own well-being.		
Supplier integrity	Reflective	The three items are interchangeable and are expected to covary. They all tap into the same underlying theme of integrity.
INTG1: I am comfortable relying on suppliers that use electronic procurement systems to fulfill their obligations.		
INTG2: I always feel confident that I can rely on suppliers that use electronic procurement systems to do their part when I interact with them.		
INTG3: I feel comfortable doing business on the Internet with suppliers that use electronic procurement technology.		
Security safeguards (informed by [44])	Formative	SEC1 and SEC5 deal with security in general. SEC2 is focused on legal structures, while SEC3 and SEC4 are concerned with technical aspects. Thus, these items are not interchangeable and do not have to necessarily covary.
I feel comfortable . . .		
SEC1: With the safeguards that electronic procurement systems provide to conduct transactions.		
SEC2: That legal structures adequately protect me from problems regarding electronic procurement systems.		

SEC3: That technological structures adequately protect me from problems regarding electronic procurement systems.		
SEC4: That encryption and other technological advances of electronic procurement systems make it safe for me to do business on the Internet.		
In general, electronic procurement systems . . .		
SEC5: Provide a safe environment in which to transact business.		
EPI standards efficacy (informed by [36])	Formative	The first measure is focused on the use of the system by the purchaser while the second item is concerned with use in general within the organization. While these items are expected to reasonably correlate, they are not conceptually interchangeable.
Standards flexibility		
The electronic procurement standards in your organization typically . . .		
FLEX1: Restrict how purchasers use the system.		
FLEX2: Are flexible in how IT can be used.		
Standards comprehensiveness	Formative	The first item is concerned with comprehensiveness for different purchase decisions, while the second is concerned with coverage across the range of interaction with suppliers. Finally, the third item taps into the relative comprehensiveness of standards. These items do not tap into the same underlying theme, are not interchangeable, and do not necessarily have to covary.
The electronic procurement standards in your organization typically . . .		
CPRH1: Provide your procurement group with a range of options suitable for different purchase decisions.		
CPRH2: Address the full spectrum of relevant standards issues for interaction with suppliers.		
CPRH3: Your industry standards for procurement are more or less comprehensive in comparison to other industries.		
Procurement productivity	N/A	Computed as total dollar value of goods procured by the organization divided by the total number of individuals employed in procurement.
What is the number of individuals employed in procurement for direct/indirect goods (including management, purchasing agents/buyers, lawyers, and support staff)?		
What is the total dollar value of goods they procured in 2002?		

Note: The items used to measure assimilation of the four electronic procurement innovations are provided in the Instrument Development section. N/A = not applicable.

Appendix B: Assessment of Mediation Effects

In a post hoc analysis, we used two approaches to evaluate mediation by Aggregated EPI Assimilation in the theorized model.

1. We compared the full mediation model with competing models that included direct and mediated effects of the independent constructs. Five alternative partially mediated models were constructed by adding one direct path from each of the five constructs to Procurement Productivity (Table B1). Only the direct path from Organizational Readiness to Procurement Productivity increased the explanatory power of the model.
2. We applied the mediation analysis technique suggested by Hoyle and Kenny [30] and applied by researchers, such as Rai et al. [56] and Subramani [66].[2] The test results (see Table B2) show that three mediation paths were significant at $p < 0.05$, providing additional evidence of the mediation structure.

Table B1. Nested Model Analysis to Test Mediation Effects

Direct path added to the model	R^2 with direct path	R^2 without direct path	f^2 value	Pseudo $F(1,158)$[1]	Conclusion
TMS → PTY	0.233	0.232	0.001	0.206	Not significant
OR → PTY	0.257	0.232	0.034	5.316	Significant
TBS → PTY	0.234	0.232	0.003	0.413	Not significant
SEC → PTY	0.235	0.232	0.004	0.620	Not significant
STD → PTY	0.233	0.232	0.001	0.206	Not significant

Notes: TMS = top management support; PTY = procurement productivity; OR = organizational readiness; TBS = trusting beliefs about suppliers; SEC = security safeguards; STD = EPI standard efficacy. [1] f^2 is calculated as $(R^2_{\text{full}} - R^2_{\text{excluded}})/(1 - R^2\text{full})$. The pseudo-$F$ statistic is calculated as $f^2 * (n - k - 1)$, with $1,(n - k)$ degrees of freedom where n is the sample size and k is the number of constructs in the model.

Table B2. Test of Mediation–Mediated Path Analysis

Mediated path	Mediated path coefficient	Z statistic
TMS → AGG → PTY	0.110	4.123*
OR → AGG → PTY	0.235	7.289*
TBS → AGG → PTY	–0.024	–0.938
SEC → AGG → PTY	0.014	0.630
STD → AGG → PTY	0.058	3.054*

Notes: TMS = top management support; AGG = aggregated EPI assimilation; PTY = procurement productivity; OR = organizational readiness; TBS = trusting beliefs about suppliers; SEC = security safeguards; STD = EPI standard efficacy. * One-tailed test significant at $p < 0.05$.