A Study on the Value and Impact of B2B E-commerce: The Case of Web-based Procurement

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Abstract

Web-enabled business-to-business (B2B) e-commerce enhances inter-organizational coordination and results in transaction cost savings and competitive sourcing opportunities for the buyer organization. However, organizations are unsure if this is an improvement over existing information technology such as EDI. In particular, what is the value of B2B e-commerce to a buyer organization and how to measure this value? What factors most affect the realization of the value of B2B e-commerce? Using the case of Web-based B2B procurement system, we propose a framework to quantify and measure the value of B2B e-commerce system and identify the factors that determine this value. We apply our methodology to help a major mid-western heavy equipment manufacturer evaluate the potential of its Web-based procurement system. Our preliminary results indicate that, even though all stages of B2B procurement is affected by the Web, the value of Web-based procurement is most determined by the process characteristics, organization of business units and the "extended enterprise".

(Keywords: Inter-organizational information systems, Value of B2B e-commerce, Web-based procurement, Measurement of value, Extended enterprise)

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1. Introduction

Web-enabled applications for business-to-business (B2B) electronic commerce are expected to enhance inter-organizational coordination and improve relationships among business partners. In B2B procurement, proposed potential benefits are in transaction cost savings and competitive sourcing opportunities. However, organizations still are unsure whether a Web-based B2B e-commerce system can deliver the promised benefits. For example, is the use of the Web an improvement over existing, and mature, information technology (IT) systems, such as electronic data interchange (EDI)? In this context, two of the important research questions that we address in this paper are:

1. What is the value of Web-based procurement to an enterprise? How is it created? How do we measure this value?
2. What factors most affect the realization of the potential value of a Web-based procurement system?

Central to this inquiry is the need for organizations to measure and determine the impact of Web-based system on B2B processes and the value to the enterprise. Knowing the value of Web-based systems is a necessary first step to motivate users to adopt the system. In the current economic environment, when organizations are critically evaluating each of their investment, Web-based B2B systems are no exception. But, as IT evolves from a mere productivity tool to a more pervasive and strategic business tool, the measurement of its value to an organization has become more challenging. Most evidence of Web benefits at organizational level are anecdotal and there are very few systematic studies that look at the value from organization's perspective. Moreover, the nature of the Web creates impacts beyond the traditional organizational boundaries, requiring the cooperation of business partners and, in some cases, even competitors within the industry. Thus, there is a need for a better framework to determine the value of the Web for an organization.

Using Web-based B2B procurement as a case, we present a value framework that draws on prior work on IT impact, but considers the capability of Web to create new value. We apply our methodology to help a major mid-western heavy equipment manufacturer evaluate the potential of its Web based procurement system. Our preliminary results indicate that even though all the stages of B2B procurement can be affected by Web, the realized value is dependent on the characteristics of B2B process, the organization of business units and the supply chain. Our B2B impact framework, in addition to clearly identifying the areas of Web value, help organizations understand and manage the critical factors that influence this value.

Our paper is organized as follows. We discuss Web-based procurement systems to know how they create benefits for an organization and formulate the research questions being addressed in this paper. We then review the existing literature on IT value and present the need for a different framework to understand value of the Web. Our valuation framework is presented followed by an analysis of the effect of critical factors on the

value of Web-based system. We use our framework for evaluating the Web-based procurement efforts of a large organization, drawing important implications for B2B strategies based on the results of our analysis.

2. Web-based B2B procurement systems

A significant proportion of organizational resources are devoted to managing inter-organizational processes, such as procurement of goods and services from other companies, collaboration for product development, and financial transactions between companies. Among these, the procurement of goods and services, called business-to-business (B2B) procurement, involves the largest cost for an enterprise, with many organizations spending 50% to 60% of their revenues on goods and services [12]. Yet, information technology applications have focused mostly on more structured processes, such as manufacturing, leaving most procurement processes inefficient and ineffective. Procurement usually covers two types of purchases – direct and indirect. Direct purchases involve materials, such as raw materials and components, which go into the finished products sold to the customer. Indirect purchases, on the other hand, involve goods and services that are not part of the finished product, but support the internal business activities. Examples of such items are computers, office equipment, operating supplies and office supplies. Indirect procurement involves a wide variety of items of different complexities, and caters to a range of internal needs and preferences. In addition, unlike direct items which are managed through company-wide standards and controls, indirect purchases are highly decentralized and have multiple and, in many cases, incompatible applications within the same organization. Thus, managing indirect procurement through traditional IT systems has been a major challenge to IS professionals.

The use of the Internet for procurement[2] has generated great excitement among organizations because of its potential to reduce procurement costs and improve strategic sourcing [6,16]. The availability of electronic markets and industry specific B2B exchanges has added to the choices available for organizations to manage their procurement [1]. However, from the point of view of B2B procurement, we have identified four models of Web-based procurement systems (figure 1). These models reflect the different ways that a buyer or supplier can choose to execute a B2B transaction [13,17,22]. Each model creates value for the buyer and seller in unique ways and organizations typically use more than one, if not all, models. We discuss briefly the four procurement models.

Buy-side procurement system: This form of procurement system is developed and implemented by large buyer organizations to Web-enable their purchases with selected suppliers. The entire procurement cycle, covering product development, transactions and procurement management are Web-enabled and integrated. This actually creates a virtually integrated IOS between the buyer and the seller, like the EDI system, but with greater scope and capabilities. The two major areas of emphasis of this system are transaction efficiency and process control.

[2] In this paper, we use the term "procurement" to refer to the procurement of indirect materials

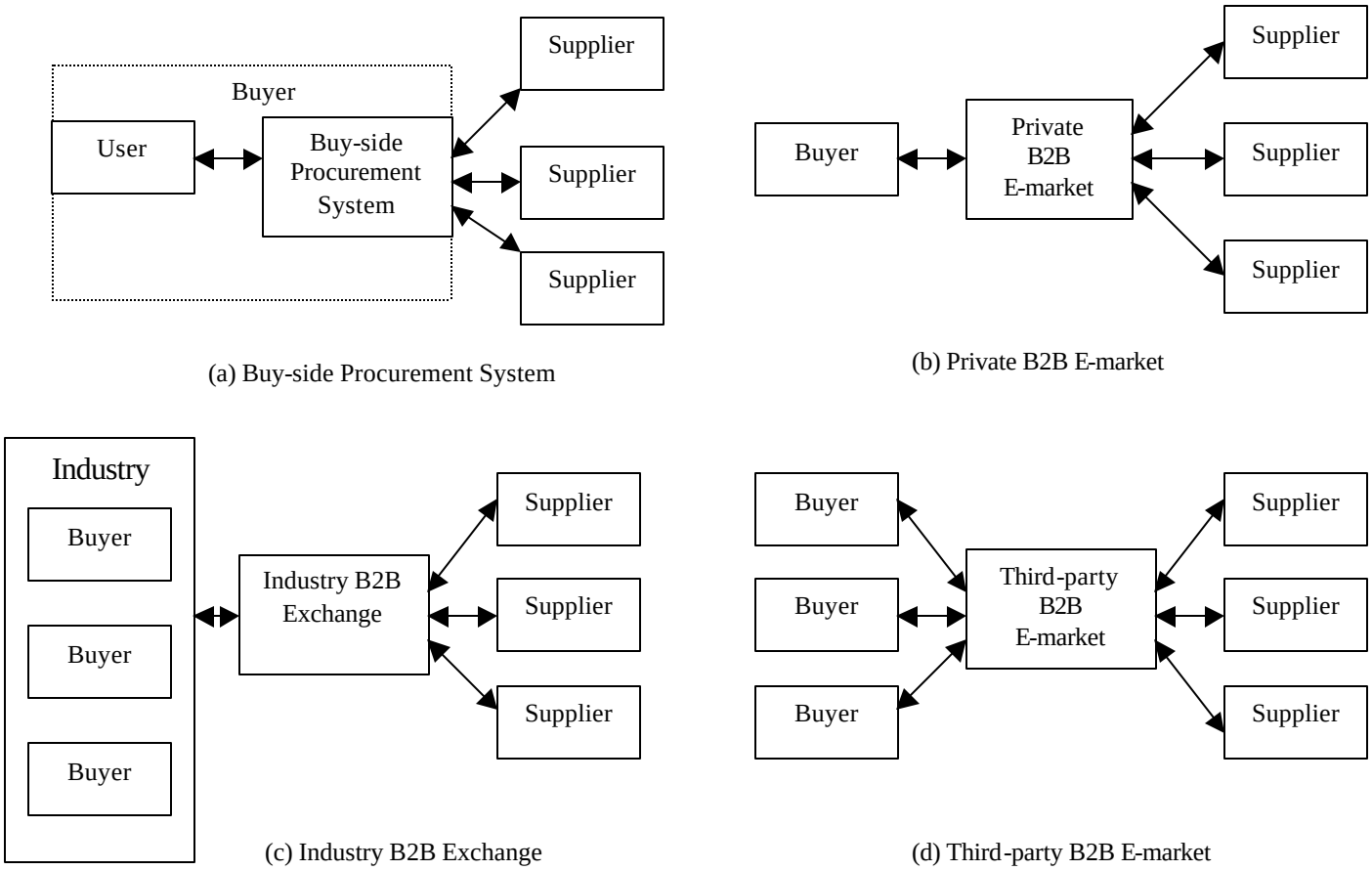


Figure 1. Web-based procurement models

Private marketplace: Some organizations form their own electronic markets to aggregate their suppliers to get competitive price for products. The suppliers are limited to those who wish to trade with the buyer-owned private e-market, which limits the extent of liquidity and competition possible. The emphasis of private electronic markets is on reducing the procurement price of the items, but the organization forming the market place has control over how the market operates. Private e-markets also reduce search costs for locating sellers and serve as exchange mechanisms for proprietary knowledge of the enterprise. Examples of such marketplaces are Walmart's RetailLink and GE's Global Exchange.

Industry B2B exchange: Each organization building a private e-market limits the liquidity of each market and forces suppliers to work with multiple markets. Hence, organizations in some industries form consortiums and build industry-specific B2B exchanges. This model aggregates buyers and sellers in the specific industry. As this is an industry-wide effort, it is easy to build liquidity with suppliers wanting to participate where most of the industry purchases are going to be. The emphasis of industry-wide exchanges is to increase transparency of the process and force competition among suppliers, which results in lower prices for buyers. This model also reduces the search

costs for both buyers and sellers. Examples are Covisint in the auto industry and Transora in the consumer goods industry.

Third-party marketplace: These marketplaces are created by companies called market-makers, (or infomediaries), who have both technological and domain expertise. Third-party marketplaces can be horizontal or vertical. Horizontal marketplaces aggregate buyers and sellers across a particular function across multiple industries. Fob.com is an example of such horizontal marketplace. Vertical marketplaces aggregate buyers and sellers across a particular industry across multiple functions. VerticalNet is an example of a vertical marketplace. Third-party marketplace is suitable in fragmented markets (buy side or sell side), where locating the buyer or seller is very expensive and in standard and commodity products, where price and availability are the major purchase criteria. Third-party markets provide value by lowering the product price for the buyers, and lowering the search costs for both buyers and sellers [1].

Table 1. Value created by different forms of Web-based procurement

Form of Web-based procurement	Factors that create the value	Factors that affect realized value
Buy-side procurement system	Reduced transaction costs Higher process quality Increased system responsiveness Lower development costs Increased control	Process characteristics Degree of centralization Degree of integration with the enterprise systems Bargaining power of the buyer
Private B2B e-market	Reduced product price Knowledge creation and dissemination Lower search costs to locate sellers	Product characteristics Rate of innovation in the industry Supplier fragmentation Bargaining power of the buyer
Industry B2B exchange	Reduced product price Increased utilization of surplus assets Lower search costs to locate sellers or buyers	Product characteristics Size of industry Industry fragmentation Power of buyers and sellers Coordination among the buyers
Third-party B2B e-market	Lower product price for buyers Lower search costs for both buyers and sellers Service quality	Industry fragmentation Liquidity Industry participation

Table 1 summarizes the factors that create value and factors that affect the value in each form of B2B procurement system. Even though researchers have predicted a significant shift towards more electronic market based transactions [1,18], each Web-based model creates value in a different way and B2B managers have to evaluate the role of each model in their enterprise. But, it is clear that organizations, buyers or sellers, can derive competitive advantage from any of these systems in the form of economic benefits and increased business opportunities [9,11,29]. However, our interactions with B2B managers of a large manufacturing organization showed that there are still doubts about

the real benefits of the Web. For those organization that already have some form of IOS, such as electronic data interchange (EDI), there is uncertainty if the Web is an improvement over the existing system. Also, the different players in the B2B procurement process, such as user, business units, central procurement managers and the suppliers, each have their own expectations from the system, which are often at conflict with the expectations of other players. Hence, all the players may not perceive the same value from implementing a B2B system and their perception is critical for successful adoption of the system [8].

It is important for researchers and practitioners to know more precisely how the Web impacts B2B processes in an organization and all the players involved. In studying Web-based procurement, our research questions become more specific and are summarized as follows:

1. What are the impacts of using Web-based procurement system? Where and how do these impacts occur in organizations?
2. What is the value of Web-based procurement system to an organization? How do we measure this value?
3. What factors affect the realization of the benefits of Web-based procurement? How do they affect the level of benefits and what is their relative importance?
4. What strategies can be used by organizations to motivate increased participation in Web-based procurement by internal users and external partners? What are the implications of these strategies?

To answer these questions, we take the case of a Web-based procurement model, the buy-side procurement system[3], and analyze the creation and realization of value by the buyer organization. Many large organizations, particularly manufacturing firms, find that third-party procurement systems are not adequate or have to make extensive design changes to meet their customized needs of procurement. Several of them have initiated efforts to create a buy-side Web-based procurement system that is capable of integrating with their internal operations, yet allow them to use the Web to improve their sourcing opportunities. As they explore the potential of private e-markets or industry B2B exchanges, they do not want to abandon their Web-based initiative and there is a need to identify where the value of their Web-based system lies and what factors help realize the maximum value. In the following section we review the existing research literature on the impact of IT systems and then derive our framework to study Web impact.

3. A review of literature on information technology impact and value

The impact of IT on firm performance has long been a subject of intense research, with issues studied ranging from measurement of the impact, to the conditions that are necessary to realize these impacts. The realized impact in the form of actual improvement in firm performance represents the value of the IT system to the organization. However, researchers have pointed out the conflicting results yielded by these studies [7,10,21,25]. Some of these issues relate to measurement, while others relate to the complexity of isolating the effect of IT on firm performance [21]. Part of the

[3] From this point, we use the term "Web-based procurement system" to refer to the "Web-based buy-side procurement system" model

problems of relating IT investments to firm performance is the effect of confounding factors, such as other internal performance improvement measures and external economic influences. Another issue is that some IT investments may provide benefits after a certain period of time, but may actually increase operating costs in the short run [15]. Researchers suggest a process-oriented approach to overcome these confounding problems. Some scholars suggest that the locus of impact, i.e. the business process, be the primary level of value analysis for the benefits to become discernible for the investing firm [14]. Others suggest a multi-stage, process-oriented study to measure the first-order and higher-order impact of IT [5]. Some researchers have used such an approach to understand how EDI benefits an organization [19].

Research on IOS impact and value, particularly use of EDI, has shown that it is largely positive in improving the efficiency of business processes and overall performance of organizations [19,26]. The electronic processing and communication of inter organizational data improves the timeliness and accuracy of the information, allowing the trading organizations to better plan and manage their assets, such as inventory [4]. The use of IT improves the process quality, which in turn improves the level of output [20]. This type of impact is mainly on the operational level and results in cost reduction, higher productivity and improved quality [19]. IOS also increases the bargaining power of the buying organization, which now has a better information visibility of its business processes [23,24]. At the same time, however, by having access to more information about the buyer, a supplier can better match the preferences of the buyer and extract a premium price. The close relationship built between the buyer and the supplier may also enable the supplier to gradually increase the level of business with the buyers.

These impacts, however, are neither guaranteed upon implementation of the system nor are they uniform across the organization [5,7,19,27]. Realization of the value of the system is conditional upon internal and external factors, some of which are controllable by the organization [27]. These are called conversion contingencies, i..e "a spectrum of things that are likely to influence realized value from a system" [7]. For example, the contribution of IT system depends on other resources, such as people and investments in associated processes [15]. In a study of EDI impact [19], it was found that the level of operational benefits of EDI increased with increased integration of IOS with internal systems, but decreased with more parts variety and number of trading partners. Suppliers handling a higher proportion of their business electronically saw higher performance than other suppliers. With respect to strategic impact, the size of the supplier determined what incentives are needed to join the system. The strategic benefits were found to be higher if the buyer initiated the system or if the system had been used for a longer period of time.

Even while some of the issues and critical variables of previous research are relevant for Web-based systems, some issues and variables assume increased importance. The capability of EDI to reduce the communication and processing costs and errors are also found in Web-based systems. But, in Web-based systems, the potential to reduce search costs is great and affects each B2B transaction. Thus, in our research, for example, savings in search cost emerges as an important economic benefit. Coordination costs are

reduced significantly by using the Web and our research quantifies the extent of economic impact of this reduction. The Web allows organizations to choose from different procurement models, an issue that did not arise with EDI systems.

Many studies have looked at different pieces of the B2B puzzle, such as supplier selection [3] and impact of electronic markets [1,9]. B2B e-commerce is rapidly transforming how organizations structure and coordinate their business relationships, but there are very few systematic studies in this area that tries to understand the impacts comprehensively from an organizational perspective. In the following sections, we develop our B2B value framework and evaluate the role of business factors in determining the level of the impact. We follow this by presenting an empirical case study of the Web impact in a particular organization.

4. Value and impact of Web-based procurement

Our framework is based on a multi-stage impact model of information technology on enterprise processes [5,10,15,19]. The principle is that certain features or capabilities of the Web are used to enable B2B operations, which have impact on a set of intermediate variables. These intermediate variables lead to improvement in the performance variables. Any improvement in each of the performance variables contributes to the improvement of the effectiveness of the procurement process, which is the B2B goal of the enterprise. The framework is shown in figure 2.

4.1 Impact on B2B tasks

A Web-based procurement system provides enhanced search capabilities, faster and accurate processing, real-time and rich-media information support, and low communication and coordination costs [6,16]. From the buying enterprise point of view, use of a Web-based system affects four major categories of B2B operations - search, order processing, monitoring and control, and coordination.

Search: Search costs are costs incurred by the buyer to locate an appropriate seller and purchase a product [2]. Search costs in procurement are incurred at two places – when the professional buyer looks for a supplier for contracting purchases and when the individual user in the organization looks for the appropriate product to order. In both cases, the Web and associated search engines considerably lower the search costs, which can be quite significant in large organizations. Web-enabled search engines help users to easily search using multiple methods to ensure that she can find the right product even with limited available information. This "user-friendliness" of the system reduces the "premium buys", where the user goes around the procurement system and incurs higher processing and product costs [12].

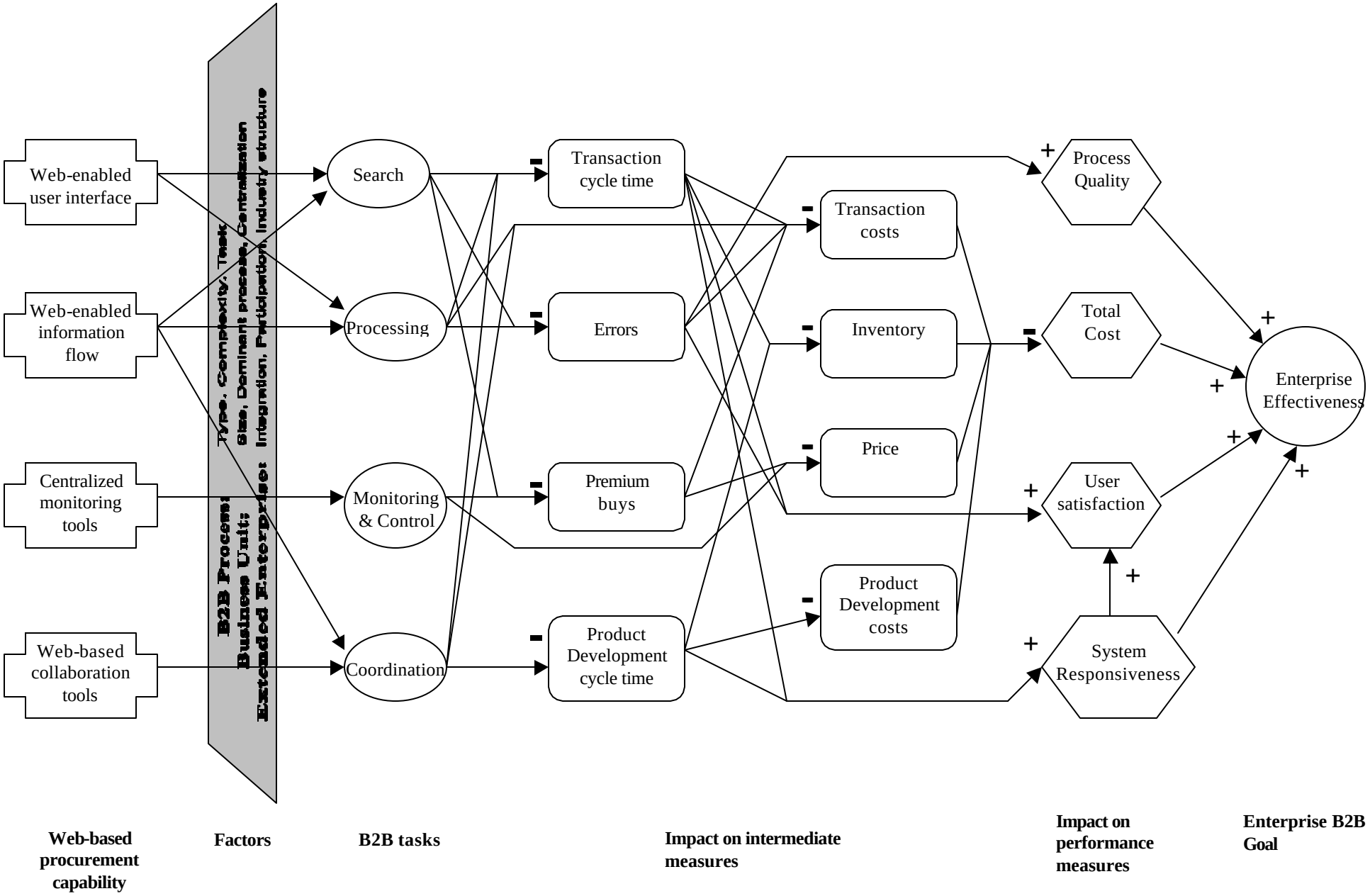


Figure 2. Framework for evaluating the impact of Web-based procurement

Processing: Web-based procurement system involves electronic document routing and information flow, thus reducing labor costs involved with manual processing. Web-based system can automatically route the product request for the necessary approvals and order placement with suppliers. This reduces the transaction cycle time and gets the materials to the user faster. As the system requires minimum data inputs during the information processing cycle, much of the sources of errors are eliminated. Thus, we find that Web-based procurement processing lowers the cycle time, errors and the processing costs.

Monitoring and control: Using a Web-based procurement system, organizations can achieve their twin objectives of responding effectively to the user needs as well as leveraging their combined buying power. Users can search the catalog to identify the most cost-effective supplier and place their orders. Corporate B2B managers can aggregate the demand for the whole enterprise and use this to negotiate competitive prices for the products, which they can then make available to any business unit, irrespective of the size or location of the unit. Centralized control, combined with the availability of an increased range of items on the electronic catalog, motivates more users to order through the e-procurement system, reducing the extent of "premium buys". Thus, the major benefits of Web-based monitoring and control are reduction in average product price and reduction in "premium buys".

Coordination: One of the major advances of Web-based IOS over other traditional IOS, is its ability to support increased and more complex coordination. Several times, during the fulfillment of an order, procurement personnel need to communicate and exchange information with the suppliers and users. Using a Web-based procurement system provides real-time information flow and is less costly to coordinate with suppliers and users. This leads to faster resolution of any problems and results in lower order cycle time. The low communication costs of the Web and the lesser time spent by the procurement staff in coordination results in lower transaction costs. Improved coordination capability also helps to speed up product development cycle time and avoid design of duplicate components.

4.2 Impact on performance measures

The impact of the use of Web for B2B on performance measures can be discussed based on the concept of first order and higher order impacts suggested in IT literature [5,15]. The first order impact is on intermediate measures that are closer to the process, which in turn affects the performance measures. One of the most visible performance impacts of Web-based procurement is the lower ***total procurement cost***. The reduction in transaction cycle time, caused by the use of Web-based procurement, reduces the labor time used in the process and the labor cost component of the transaction costs. Costs incurred due to electronic processing and coordination is several magnitudes lower than those involved in manual processing and coordination. Lower incidence of errors in a Web-based procurement system reduces the need for labor for error resolution, reducing transaction costs. With less lead times for acquiring products, organizations can store less in inventory and increase inventory turns, leading to lower inventory costs. Lower

average price negotiated for contracted items and the lower product development costs contribute to the reduction in the total procurement costs.

Quality of the procurement process is an indicator of how well the system meets the procurement needs of the enterprise. Any error in the processing cycle decreases the chance that the product delivered to the user will fully meet her expectations. A measure of process quality is the proportion of B2B orders rejected or returned by the user. Another measure is the number of user complaints about the product. By reducing the probability of errors, a Web-based system can reduce the potential mismatch between user needs and the delivered product, thus reducing user complaints.

User satisfaction refers to the perception of the user in the system's effectiveness to meet her business demands. This is more than the receipt of a matching product. User satisfaction is affected by how well the system is perceived to meet user expectations. Higher cycle time and more errors in the process leads to lower user satisfaction. Access to required information with minimum effort, faster resolution of complaints, and ease of use of the system interface are some ways in which user satisfaction can be improved by a Web-based system.

System responsiveness is the ability of the B2B procurement system to respond to the needs of the user and the enterprise. It reflects not only the time taken to get the user what she needs, but also the ability to locate alternative sources, within a reasonable time, if necessary. For example, a user or a business unit may require a critical item to prevent the idling of expensive production machinery. Delay in locating or procuring the item may cost more, though indirectly, than even the cost of the item. In such situations, a responsive system will help search internal and external locations to find the item in the shortest time possible and the best way to get it to the business unit.

In summary, by implementing a Web-based procurement system, a firm can anticipate the following potential impact on its intermediate and performance measures.

<u>Impact on intermediate measures</u>

1. *Lower transaction costs*
2. *Lower inventory holding costs*
3. *Lower price*
4. *Lower product development costs*

<u>Impact on performance measures</u>

1. *Higher process quality*
2. *Lower total procurement costs*
3. *Increased user satisfaction*
4. *Increased responsiveness of the system*

The potential value of a Web-based procurement system to an organization is the extent to which it can derive benefits from the systems, net of its investments and other implementation costs. One way to estimate the value of a system is to quantify the

improvements in the performance measures in economic terms at the process level and aggregate them at the business unit or the firm level. However, measuring and quantifying the impact on the intermediate measures will provide more precise estimate of the value of the system [15,19], but require more detailed data at process level.

5. Factors that affect the value of Web-based procurement

An important research question in our study is the effect of business conditions on the potential value of a Web-based system. Research on IT impact shows that implementing a system does not, automatically, guarantee realization of the potential value [5,7,19,27]. The realized value depends on several conversion contingencies [7]. These conditions could be firm level controllable conditions, such as training of users, or can be external influences, such as actions of competitors and technology [27].

In the case of Web-based procurement, the tasks, such as search, processing, monitoring and control, and coordination, are facilitated resulting in improvements in procurement measures, such as transaction costs, price, and quality. These benefits are realized as first-order effects at the level of individual transactions and it is reasonable to expect differences among transactions to account for the differences in the level of benefits. Assessing the impact of technology needs to consider the transaction as the basic unit of analysis and identify the principal dimensions on which the transactions differ [28]. Hence, in this study we start with B2B transactions as the first level of analysis. We use the results of transaction level analysis to study the aggregated impact at higher levels of analysis, such as business units or suppliers.

All B2B transactions occur in the context of individual business units, which use procurement systems to serve the needs of their internal customers. At the level of business unit, the benefits of each transaction are aggregated to determine the total benefits. Thus the organization of the B2B transactions within the business unit plays an important role in determining the benefits of Web-based procurement at the business unit level. The volume distribution of the different types of transactions, the size of the business unit, the nature of its core business and the procurement relationship with corporate purchasing, all have implications for transaction costs and potential Web-based savings. Hence, the next level of analysis is the business unit within a firm.

The scope of B2B operations includes inter-organizational processes and information exchange between the firm and its business partners, such as suppliers and distributors. A Web-based system breaks down the barriers between firms and helps virtually integrate all the steps in the procurement process into a request-to-fulfillment-to-payment process. Web technology allows integration of several levels of suppliers and distributors with the enterprise systems in order to form an "extended enterprise" [4]. The success of the Web-

[4] The term "extended enterprise" refers to an expanded scope of studying the impact of Web-based information systems beyond the traditional organizational boundaries. In our study, we use it to refer to the B2B processes and issues from the perspective of a buying organization and covers the internal user, the procurement department, business units, immediate suppliers and suppliers of these suppliers, up to the last tier of supplier whose inputs are used by the buying organization

based procurement system depends on the effective participation of this "extended enterprise". Thus, the third level of analysis is the "extended enterprise".

In selecting the factors for our study, we look at how Web-based procurement creates value for an organization. Our premise is that the ex-post transaction costs of using the Web are very low for all transactions and, hence, the value of the system is primarily dependent on the level of inefficiencies and transaction costs that exist prior to using a Web-based system. For example, a procurement transaction that is automatically triggered based on re-order level incurs very little by way of transaction costs in a non-Web environment. On the other hand, a transaction for buying computer involves several approvals and processing, thus incurring more transaction costs. When an e-procurement system is used for these transactions, the costs are not very different for processing each transaction, making the marginal benefits more for the latter transaction than the former. Thus, in our analysis, we are interested in identifying those factors that create differences in transaction costs prior to the use of Web-based system.

We now develop our propositions on how the factors at these three levels of analysis affect the realizations of the benefits from a Web-based procurement system.

5.1 B2B process characteristics

Transaction cost economics identifies transaction frequency, uncertainty and asset specificity as the principal dimensions on which transactions differ and thus have different transaction costs [28]. In B2B procurement, more transaction frequency, higher uncertainty, and need for asset specific investments all lead to higher transaction costs. While looking at the use of information technology on inter-organizational systems and transaction costs, [18] focus on asset specificity and complexity of description of the product as the important factors that create differences in the impact. Thus, the transaction level factors that emerge for consideration in this study are the frequency, uncertainty, specificity and complexity of description.

The frequency of a particular type of transaction is more appropriate for study when aggregated at the business unit level. Uncertainty arises more due to inter-organizational aspects, such as supply availability, lack of proper communication and opportunistic bargaining, and relate to the extended enterprise than to a specific transaction. Specificity and complexity emerge as the transaction level dimensions that can be used to categorize transactions and study the differential effect on the value of Web. In the case of B2B procurement, for reasons discussed below, the specificity can be combined with other process characteristics to group transactions into different types of process. Thus, we look at process type and complexity as the two dimensions with which to study the effect on the value of Web-based procurement.

Type of process: While designing a procurement procedure for a product, organizations take into account aggregation economies [28], which help them route similar transactions through the same type of process. An important criterion to categorize the processes is the level of transaction costs involved. These costs are higher for asset specific purchases, which require investments that cannot be put to alternative

uses without loss of value. In addition, if the item is customized, it requires higher search time to match the need with product specifications. It also requires more coordination and monitoring to ensure that the user gets the right product. In a non-Web environment, when the demand for such items are regular and such procurements are made more frequently, organizations reduce the very high transaction costs by making the process very structured and the re-orders automatic. Examples of such structured processes include procurement of tooling items, welding wires and maintenance parts.

On the other end, there are items that have sporadic demand and every user request involves more time in search, input and processing for each transaction, mostly in the form of labor. There is need for human involvement in the processing, which increases the incidence of errors, and more staff time is spent in error resolution. The greater variety of these requests precludes setting up of any structured procedures. Even though the individual value of these items may be small, the transaction costs involved in processing these purchases are very high. Examples of such unstructured procurement are office furniture and office supplies. Between fully structured and fully unstructured types, we encounter different degrees of structuredness of the procurement process.

The structured ordering procedures result in the need for less time by the user and procurement staff for search, input and processing activities at the level of each transaction. The streamlined and repetitive nature of the orders reduces the scope for errors in input and processing. The use of Web is mainly to replace the paper based manual communication with electronic communication. When we Web-enable such unstructured procurement, we save on the staff resources used for search, input, processing and error resolution. Thus, we expect the use of Web for unstructured processes to result in higher transaction cost savings than its use for more structured processes.

> **Proposition 1:** Use of Web-based procurement for unstructured procurement results in greater value than its use for structured procurement.

Complexity of process: The complexity of a transaction refers to the need for additional efforts to process the transaction successfully. For example, a critical component may have to undergo special inspection prior to any use, requiring investments in testing equipments or inspection personnel. As the complexity of a required item or ordering process increases, it involves more transaction costs due to more search time, increased coordination requirements, need for more data processing, and the higher probability of errors. But, even if the complexity is high, if the transaction volume is insignificant, the organization cannot expect significant value from the use of Web. Hence, the realized value depends not just on the complexity of the procurement process, but also on the transaction volume of this procurement category.

> **Proposition 2:** The value of Web-based procurement increases with the complexity and transaction volume of the process.

5.2 Organization of business units

The effect of the process level factors tells us the impact at the level of transactions. However, the procurement systems, which handle these transactions, serve different business units and user constituencies, and each unit perceives and realizes different values even from the same Web-based procurement system. Since the total benefit of Web-based procurement for a business unit is the aggregation of the benefits from individual procurement transactions, the total volume of B2B transactions at the business unit determines the value of the Web to this unit. Also, the first proposition implies that the type of process that is predominant in a business unit determines the potential value from the Web for this unit. One of the major costs of central purchasing department in a non-Web environment is the cost of internal coordination, which includes the agency costs and decision information costs [9]. Organizations responded to this by decentralization of purchases to individual business units, but incurred opportunity costs due to loss of volume buying and control over procurement process. The extent of centralization had been a trade-off between these costs, but the use of Web-based procurement allows organizations to centralize their procurement and still lower both the costs. Since different business units can be expected to have different levels of centralization, we expect the benefits also to be different. Thus, we look at the size of business unit, the dominant type of process in the unit and the degree of centralization as factors that affect the value of Web-based procurement.

Size of business unit: The use of Web results in positive operational benefits (in terms of cost savings) on each transaction, irrespective of its type, even though the level of benefits may vary. The benefits accumulate more as the volume of transactions of the business unit increases. Hence, between two business units with similar distributions of the different types of transactions, a larger business unit can be expected to derive higher transaction cost benefits than a smaller business unit. In addition, the benefits due to price reduction through centralization are higher for a business unit with larger volume of B2B purchases.

> **Proposition 3:** Among business units with similar distributions of different types of B2B processes, larger business units realize higher values from the implementation of Web-based procurement.

Dominant type of B2B process: While we earlier proposed the effect of the types of processes in isolation, a business unit deals with a mix of structured and unstructured processes. Some units, such as manufacturing facilities, can be expected to have a dominance (higher proportion) of structured procurement processes, while other units, such as sales or administrative facilities, can be expected to have a dominance of unstructured processes. The potential value of Web-based procurement cannot be realized unless the dominant type of process is Web-enabled.

> **Proposition 4:** Business units can derive higher value from Web-based procurement only by Web-enabling the dominant type of procurement process.

Degree of centralization: Web-based procurement systems enable organizations to centralize their purchase processes while at the same time given enough flexibility to the local units to serve their local sourcing needs. Centralized procurement benefits a business unit in three ways. First, the administrative costs (part of the transaction costs) are spread over a larger volume of purchases, thus reducing the operational costs for each business unit. Second, the visibility of enterprise-wide procurement demand and preferences helps buyers to negotiate lower prices for goods and services. Third, centralized control and monitoring, combined with the user-friendly Web interface motivates more users to order through the e-procurement system and reduces the volume of "off-contract" purchases. Most of these purchases cost more and are charged to the business unit, reduction in "off-contract" purchases directly benefits the business unit. But, it is important to note that a business unit which had most of its procurement centralized even before implementing a Web-based system will derive less benefits than a business unit which had most of its procurement decentralized. Hence, the benefits depend on the increase in centralization, rather than the level of centralization achieved by using the Web.

> **Proposition 5:** The value of Web-based procurement system will be higher for a business unit that achieves a greater *increase* in centralization due to the use of Web.

5.3 Extended enterprise

The major benefits of inter-organizational technologies, such as Web-based procurement, are realized only when there is an efficient flow of information across organizational boundaries and a critical mass of business transactions go through the system [4,21]. A supplier, who is able to manage its production operations efficiently based on timely and accurate information received from the buyer, as well as its down-stream suppliers, benefits the entire supply chain. This efficient flow is facilitated by better integration of the new and old systems across all business partners. The participation of external partners, such as suppliers, is also critical to realize the value across the supply chain. In addition, the uncertainty in a fragmented supply chain drives up the transaction costs in a non-Web environment and is an important factor to consider in determining the value of the Web. Hence, the extended enterprise factors that are important to realize the value of a Web-based system are the integration of Web-technology with existing systems, the participation of the business partners and current level of fragmentation in the supply chain.

Integration of e-procurement with enterprise systems: E-procurement systems interact with other information systems in the enterprise and the supply chain to enable the procurement process. For example, inventory, personnel data and supplier data are accessed from the ERP system of the buyer. Design systems provide data for product development process. Supplier's manufacturing information system is accessed for fulfillment information and order tracking. The full potential of an e-procurement system can be realized only when all the information exchange and sharing is done electronically, with minimum need for turnover of paper documents. For example, even if the buyer side of procurement process is fully automated and the purchase order is sent

electronically to the supplier, if the supplier prints the purchase order and re-keys the data into his own system, the chances for errors and delays are increased, reducing the benefits of e-procurement.

> **Proposition 6a:** Web-based procurement systems that have greater integration with existing enterprise systems yield higher value than procurement systems with lower integration.

Among the various information system applications present in organizations, some are closely related while others are disparate. For example, the functions of production planning and materials management may be closely connected, while production planning and human resource management may not have such close connection. As we integrate the existing information system applications into e-procurement, connecting to closely related systems helps leverage the synergy among those systems. An e-procurement system connected to production planning benefits more if it also connected to materials management, but benefits may be less if connected to human resource management.

> **Proposition 6b:** Web-based procurement systems that are integrated with closely related systems result in higher value.

Participation of business partners: From the enterprise point of view, business units and suppliers are the two most important participants in e-procurement system. Business unit procurement managers are reluctant to reduce their control over procurement decisions and hence need strong incentives to motivate their users to purchase through the Web-based procurement systems. Suppliers are resistant to Web-based procurement as they anticipate fierce competition online and they need strong incentives to Web-enable their catalog and ordering process. The potential value of the system cannot be realized unless both users and suppliers participate in the system. There is also a behavioral aspect involved here. Higher participation by business units or supplier convinces the benefits of Web-based procurement and motivates them to participate. However, increased participation by business units or suppliers alone is not sufficient to realize significant benefits of e-procurement. In fact, we expect that the benefits are modest at low participation of business units, irrespective of the level of participation of the suppliers. Similarly, the benefits are expected to be modest at low participation of suppliers, irrespective of the level of participation of business units.

> **Proposition 7a:** The value realized from Web-based procurement system is low when a small number of business units participate in the system, irrespective of the number of suppliers participating.

> **Proposition 7b:** The value realized from a Web-based procurement system is low when a small number of suppliers participate in the system, irrespective of the number of business units participating.

We expect a synergy effect depending on who participates in e-procurement, similar to that proposed in e-procurement integration. In the "extended enterprise" supply chain, partners who have a close business relationships may add more value if they participate together in the system, rather than the participation by two unrelated partners. Suppose an MRO supplier and its suppliers participate in e-procurement, inefficiencies are reduced to a greater extent as information flow is optimized at a greater extent in the purchase process. But, if an MRO supplier and an office products supplier participate in e-procurement, each purchase process needs to be optimized, which cannot be done without participation of the lower tiers of suppliers.

> **Proposition 7c:** In Web-based procurement, participation by business partners, who themselves have closer business relationships in the same product supply chain, results in higher value than participation by suppliers not related in the supply chain.

Industry fragmentation: The characteristics of the industry play an important role in realizing the benefits of Web-based procurement. Industry fragmentation of the demand or supply is an important factor that can be managed by using the Web. In an industry fragmented on the demand, supply or both sides, we expect high levels of search costs and inefficiencies in the traditional procurement. Fragmentation also leads to transaction uncertainties [28], increasing the transaction costs in the procurement process. Intermediaries play an important role in reducing the transaction costs, but even they are limited by technology. Such fragmented industries are greatly benefited by the Web, which allows the integration of demand and supply on a global scale. We expect that enterprises that procure from a fragmented product supply chain derive higher benefits from Web-based procurement.

> **Proposition 8:** The value of Web-based procurement is greater if the existing product supply chain is more fragmented on the demand, supply or both sides.

The three levels of analysis, in the increasing order of scope of application, gives us insights into the effect of the critical factors on the value of Web-based procurement systems. We now present an empirical case study, in which we used our framework to evaluate the Web-based procurement plans of an organization.

6. Empirical case study

Our research site is a large manufacturer of heavy equipment located in the mid-west. This organization pioneered electronic commerce initiatives in its industry and is in the process of developing and implementing strategies. Indirect purchases account for nearly $2-3 billion annually and hence the organization saw potential for significant cost reduction. The implementation of the Web-based procurement system has to move from the experimental stage to enterprise-wide adoption and the management wanted to validate the real benefits to motivate its internal users and suppliers. In addition, the management also wanted to know the factors that affect the realization of these benefits so that the implementation strategies can be tailored accordingly.

The research team used several data sources for this study. The first was a set of process related data from internal procurement records that told us of the distribution of process types and complexities. The second set of data was interviews conducted with the users, purchasing analysts, and procurement managers at individual business units. These interviews helped us gather data on the benefits perceived by different types of users. The third set of data was a limited internal study conducted by the organization on measuring the time saved for different types of procurement activities by using the Web-based system. Due to the limited data availability at the time of this paper, we use the operational cost savings as the value of using a Web-based system and evaluate the effect of process type and complexity on these benefits. But, even this limited data provided very interesting insights into the need for considering the variations in processes and business units within the same organization instead of looking at the total impact on the organization of Web-based system.

6.1 Operationalizing the value and factors

In order to measure the value, we looked at the time and error reduction achieved by the use of Web for procurement. Any reduction in search and input time, or processing time can be realized as reduced staff time and, hence, staff costs. Automation of B2B transactions further reduces the need for manual labor and hence staff costs. Also, traditional B2B transactions have a high probability of errors because of human data input. Error resolution requires manual intervention by procurement personnel to enable completion of the transaction. Any reduction in the percentage of errors directly leads to savings in staff time and, hence, staff costs. Due to better information access and the reduction in cycle time, we can also expect reduction in inventory holding costs. Thus, we operationalize the benefits as savings in search, processing and error resolution, and savings in inventory holding costs. We present the computation relationships for these benefits for each transaction.

Search savings = Reduction in search and input time * Labor cost (1)

Process savings = Processing time reduction per transaction * Labor cost (2)

Error savings = Error reduction * Average error resolution time per transaction * Labor cost (3)

Inventory savings = Percentage reduction in inventory holding * (Storage rate + Internal funding rate) (4)

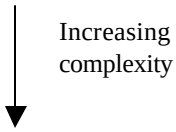
In all the above computations, Labor cost = Average staff salary per unit time.

Type of process: In this study, we categorize the B2B procurement processes into two types based on the extent of automation and structuredness of a majority of transactions in each group. One group of items is mostly consumed by the manufacturing facilities, inventoried and purchased through an automated replenishment system. The user is involved mostly in requesting the items from the internal inventory. Examples of these items include tooling items and welding wires. These structured processes are called planned procurement. A common practice in the industry to manage planned

procurement is to have on-site inventory management systems called shop-floor "cribs". Another group of items is consumed throughout the enterprise and is usually ordered based on individual user request. Examples of these items include office stationery and office furniture. These unstructured processes are called unplanned procurement.

Complexity of process: As far as planned items are considered, though some of the items may be classified as complex, these complexities are subsumed in setting up the items in an e-procurement system and do not affect day-to-day transactions. Hence, we look at complexity only of unplanned transactions, and group them into five categories, of increasing complexity, according to the need for transaction specific processing and the number of data inputs required for completing a transaction.

1. Office supplies
2. MRO (maintenance, repair and operational items)
3. Office equipment (including computer equipment)
4. Software and services
5. Special materials (hazardous materials)



Office supplies qualify as the simplest items, in terms of the specification and any additional efforts to receive and consume them. MRO items require precise identification of the part number and specifications, but the presence of industry standards for parts reduce this problem to a great extent. Office equipment is more complex than MRO because of the presence of multiple options and the absence of standards, requiring the user to provide more descriptions to identify the item. Software and services have several possible combinations and customizations that make it complex to specify the need. Also, it is important to consider compatibility and other technical issues before placing the order. Hence, we consider this category more complex than office equipments. MRO items, office equipment, and software and services can be classified as moderately complex categories. A category of special items called "hazardous" items have to satisfy several safety and government regulations, and also may need specific investments in order to receive, store, use and dispose of the item. Hence, we classify this group as the most complex transaction.

6.2 Findings and discussion

Type of process: In this organization, we found that the planned (structured) transactions accounted for 55% of total volume of procurement and unplanned (unstructured) accounted for 45%. The savings in processing, errors, and inventory are plotted for each of the two types of procurement. The results of the operational impact are shown in figure 3. *The total cost savings from using Web for unplanned procurement is significantly higher than for planned procurement*, which is what we had expected. Thus, an organization will benefit more by first bringing in the unplanned items into the system than by bringing in planned item.

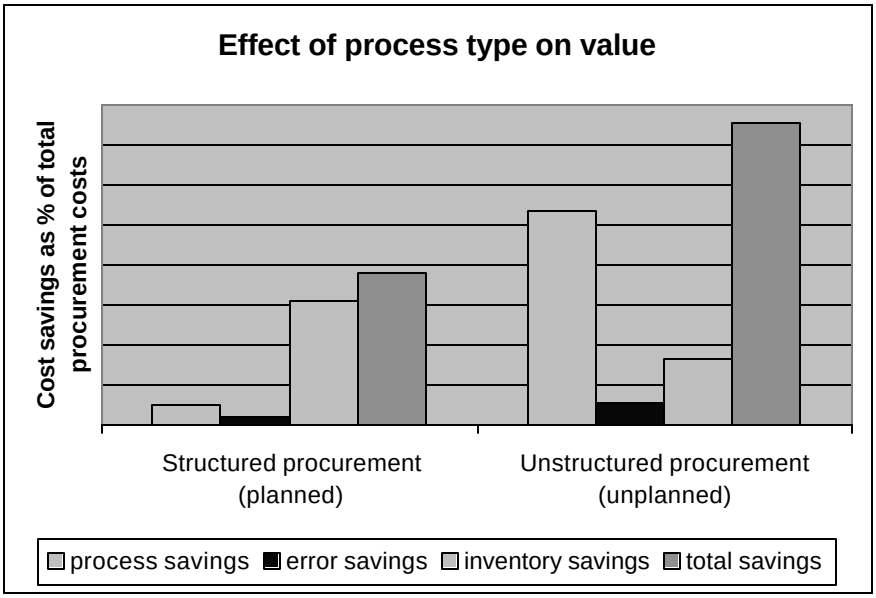


Figure 3. Impact of Web-based procurement for different process types

However, an interesting point to note is the differences among the components of cost savings. *While unplanned transactions result in higher process savings and higher error savings, the savings in inventory are significantly lower than that for planned transactions*. A possible explanation for this is the presence of higher level of inventory for planned transactions in order to maintain a high level of service and avoid shortages. In contrast, users ordering unplanned items usually assume a certain lead time and take that into account when placing orders, reducing the need for high inventories. *When using the Web, thus, the firm is able to achieve a much higher inventory reduction in the case of planned than in unplanned transactions*.

An important implication of the effect of transaction types on operational benefits, is what type to focus when rolling out the procurement system. Even though Web-enabling unplanned transactions gives greater returns than planned transactions, if a business unit has a dominance of planned procurement and high inventory levels, bringing in the planned items into the system will result in higher savings, primarily due to inventory reduction, than bringing in unplanned items. On the other hand, if the two types of transactions are evenly distributed or unplanned transactions dominate, there is a higher incentive to start the implementation with unplanned transactions.

Complexity of process: We plotted operational cost savings for the five types of unplanned transactions, organized in the increasing order of procurement complexity, taking into account their volumes in this organization. As shown in figure 4, *moderately complex items, i.e. MRO, office equipment and software and services, have the potential to return higher benefits than simple or more complex items.* As the "software & services" category does not involve any physical inventory to maintain, there are no

inventory savings for this category of items. However, the total savings are significant because of the reduction in processing and error resolution costs.

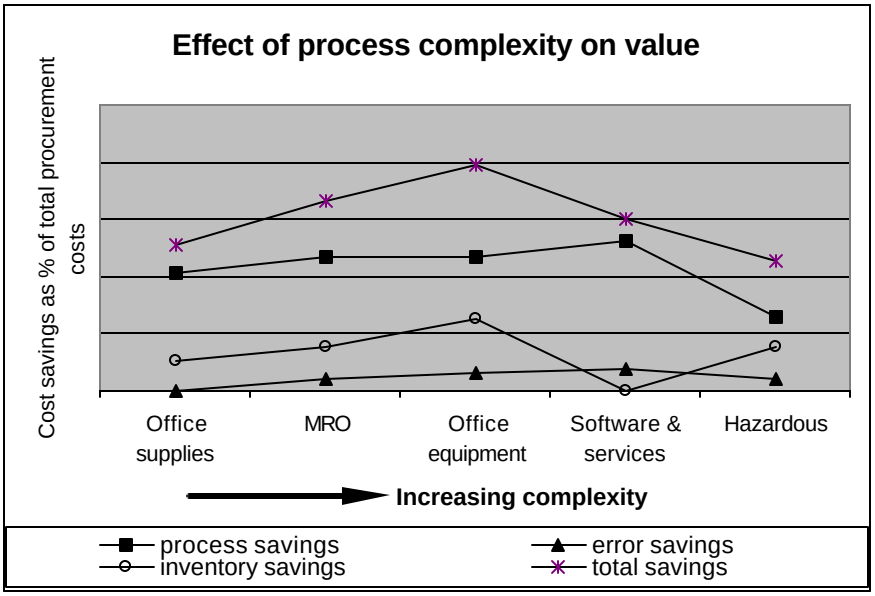


Figure 4. Impact of Web-based procurement for different process complexities

Figures 4 shows that the volume of transactions in each category is an important factor to consider while implementing e-procurement. While motivating the internal users and business units in adopting Web-based system, both the unit transaction benefit and the volume of purchases in each category of complexity should be taken into account. For example, a business unit with a dominance of complex purchases will not realize significant benefits, unless it Web-enables its complex purchases. More complex purchases require more time and efforts to be set up in an e-procurement system and the decision on which item to Web-enable at earlier stages depends on the distribution of the transactions of different complexity.

Impact on internal requests: When Web-based procurement system is discussed, usually the focus of the impact is on ordering and fulfillment process. However, we realized during our study that, once an e-procurement system is implemented, the centralized catalog and information flow capability is readily available to support several tasks relating to internal requisition of materials. For example, a shop floor user can log on to the e-procurement system and search for tool availability in the inventory of other units. In traditional B2B systems this process could have taken longer because of having to perform the search and request manually. Use of e-procurement system also reduces the errors thus saving the time of procurement staff in error resolution. The impact on the time saved and internal productivity gain are significant when we consider the volume of such requests. In our study, we estimated that on average a business unit in this firm handles 150 internal requests per day among its 30 or so units. For each internal request, the e-procurement system could save $3.61 in search and input and $1.20 in errors.

Assuming 300 working days a year, the annual total cost savings by using e-procurement for internal requests alone are an impressive $6.5 million.

6.3 Implications of the analysis for the development of adoption strategies

Buyer organizations implementing a buy-side Web-based procurement system cannot do it in one-step. There are two major strategies to choose from.

1. All the purchases can be Web-enabled, but the system is implemented one business unit at a time.
2. A specific type of purchase is Web-enabled across the enterprise, and after successful implementation, the next type of purchase is Web-enabled.

In addition, the buyer organization should also consider the participation of suppliers in order to realize the benefits from the Web.

If the organization chooses to implement by business units, then it will compare the characteristics of business units to decide where to implement first. The units with the highest decentralization of existing purchases should be chosen because of the potential for greatest change in centralization (proposition 5) and resulting higher benefits. However, if the choice is between business units with similar distributions of purchase types, the larger the unit, the greater the benefits from Web-based procurement (proposition 3). After a business unit has been chosen for implementation, the type of purchase to implement first is decided by its proportion of planned and unplanned procurement, and its inventory levels. If the business unit has a higher proportion of planned procurement combined with high inventory levels, Web-enabling planned procurement yields greatest benefits. Otherwise, Web-enabling unplanned procurement yields greatest benefits.

If the implementation strategy involves enterprise-wide adoption of the system, the process type and complexity play a critical role in selecting which purchases to Web-enable first. Unplanned and complex purchases involve a high level of search and coordination. They also require stricter control in view of potential non-compliance hazards. This type of purchases requires higher levels of human interaction. Thus, the firm should Web-enable the search process of unplanned and complex purchases in order to derive maximum benefits (proposition 1 and 2). However, if the proportion of unplanned and complex purchases is very low compared to other types of purchases, the greatest benefit comes from Web-enabling moderately complex purchases.

Once an implementation strategy is chosen, there are two critical factors that influence the realization of maximum benefits – integration of Web-based procurement with current systems and the participation of suppliers. The procurement system should be designed to automatically retrieve and use data that is already available in the system, instead of duplicating the input. Also, it should provide the necessary data required by other applications. The greater the level of the integration with the organization and supplier systems, the greater will be the benefits (proposition 6a). In a manufacturing organization, purchasing is closely linked with engineering design and materials management, because of the higher need for customized components. The focus in implementation should be to integrate the Web-based procurement system with the

design and materials management applications, rather than with accounting or human resource applications (proposition 6b). Thus, buyer organizations should not only integrate with other applications, but integrate with applications whose functions are closely related to the procurement process.

The other critical factor is participation. In order to encourage more use of the Web-based system, more suppliers have to be included in the procurement systems by adding their products to the electronic catalog (proposition 7, 7b). However, if the suppliers who are connected to the buyer-side system are themselves connected to their suppliers, there is further reduction in the cycle time and errors and improved coordination is possible. This leads to higher benefits than if two suppliers not related in the supply chain are added to the catalog (proposition 7c). Hence, buyer organizations should not only look to add more of their suppliers to the system, they should also motivate the suppliers' suppliers to join the Web-based system. We summarize our study findings and their potential implications in table 2.

Table 2. Summary of the effect of process factors on value of Web-based procurement

Factor	Effect on value of Web-based procurement system	Implications for practice
Process type	Unplanned transactions yield higher operational savings Planned transactions yield higher inventory cost savings	Implementing planned or unplanned procurement will depend on the dominant type of transactions. The organization should identify type of transaction that provides the greatest source of operational improvement and value.
Process complexity	Web-enabling moderately complex transactions yield higher operational savings than simple and complex transactions	The complexity of transactions and the volume of each category of complexity both should be considered when Web-enabling transactions. Moderately complex items should be first brought into the system. But, if a business unit has a dominance of complex transactions, unless the complex items are brought into the system, expected value from the Web may not be realized.

7. Future research and conclusion

This study is part of an ongoing research represented by our overall framework in figure 2. In this phase, the data related to the B2B transactions and limited cost implications in one organization. Further survey will complete the collection of data to cover the business unit and the "extended enterprise" factors, and the other effectiveness measures, i.e. quality, user satisfaction and system responsiveness. The expanded research will help us understand the impact beyond the transactions. In particular, coordination benefits of a Web-enabled B2B supply chain is expected to be significant and cannot be ignored by organizations.

Global scope and enhanced supply chain coordination capability beyond immediate business partners illustrate the big leap that Web-based IOS makes over traditional IOS. Using the Web, organizations and its several levels of suppliers can integrate their supply chain across the "extended enterprise" in order to remove the inefficiencies and to be able to respond effectively to demand changes. While previous generations of IOS were linear links between organizations, Web-based IOS are truly networked business systems. The economic contribution of each participant in this network, benefits realized by each participant, optimal incentives for increased participation and the type of "network externalities" created are very interesting issues for research and practice. Also, the strategic impact of this network and its critical drivers are areas of research that will have tremendous value for organizations in the new economy.

Even as organizations are moving to Web-enable their B2B processes in the hope of improving their B2B supply chain and reaping economic benefits, there is a need to fully understand how this value is created and realized. Once we know how the value is created, it is critical to identify the factors that explain the differences in the realization of Web potential across the entire B2B supply chain. This will help B2B managers to plan their B2B adoption strategies to ensure that the migration to e-procurement results in maximum benefits to the "extended enterprise". We have provided a start to this effort by developing a framework for understanding the value of Web-based procurement and the factors that affect the value. We were able to establish the effects of process related factors, such as type and complexity, in determining the value of Web-based procurement to an enterprise, and the implications for implementation strategies. Future work on this research will combine this economic perspective with behavioral perspectives of user adoption and validate our framework both theoretically and empirically.

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