Winter 12-19-2001

Using Simulation To Evaluate Web-Based Bidding in Construction

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ABSTRACT

The Internet is changing the whole business model by allowing companies to communicate instantly with suppliers, partners, and customers on a worldwide scale. To enjoy real-time data exchange and higher transaction efficiencies, companies need to use information technology (IT) solutions and change how they distribute goods and how they collaborate within the company with contractors and suppliers. While the Internet is the channel that allows instant interaction between all components of a company, IT provides the ability to streamline the structure and to influence and control the flow of information. In this paper, we evaluate the impact that using the Internet can have on the procurement aspect of the construction industry. Specifically, we describe how the traditional service procurement process in construction is affected by the use of a web-based bidding tool (WBBT). We use a simulation model on a case study to evaluate how the WBBT affected service procurement in a large pharmaceutical company. The paper describes the potential impact of IT solutions in the Construction Industry and on the procurement aspect in particular, before discussing the case study in detail.

INTRODUCTION

The Internet is changing the whole business model by allowing companies to communicate instantly with suppliers, partners, and customers on a worldwide scale. To enjoy real-time data exchange and higher transaction efficiencies, companies need to use information technology (IT) solutions and change how they distribute goods and how they collaborate within the company with contractors and suppliers. While the Internet is the channel that allows instant interaction between all components of a company, IT provides the ability to streamline the structure and to influence and control the flow of information.

In this paper, we evaluate the impact that using the Internet can have on the procurement aspect of the construction industry. Specifically, we describe how the traditional service procurement process in construction is affected by the use of a web-based bidding tool (WBBT). We use a simulation model on a case study to evaluate how the WBBT affected service procurement in a large pharmaceutical company. The paper describes the potential impact of IT solutions in the Construction Industry and on the procurement aspect in particular before discussing the case study in detail.

NEED FOR IT SOLUTIONS IN THE CONSTRUCTION INDUSTRY

Construction projects have generally been fragmented and highly dependent on information exchange in paper-based formats. Workman [16] found that people in various functional groups possess different information, tend to focus on their own part of a project, and define the entire process from their own perspective. To improve project performance and productivity, many companies have implemented various technologies. Many times, technology has been involved enough to take care of specific tasks but there has not been a complete integration that enables them to work together. Many information technologies have been implemented without verifying the means for sharing information with other technologies. The result is that information cannot be transferred from one system to another directly, and, therefore data re-entry is necessary [10].

The lack of an efficient means of disseminating information between different functional groups contributes to poor communication among these groups in the construction industry. Plotted drawings are often used to transfer designs and reports of one project phase to another and to check the compatibility of the many design efforts. Often, only a fraction of the information conveyed is required or relevant. This type of paper-based process is difficult to coordinate and may fail under time constraints due to: processing or retrieval delays, lost documents, misrouted forms, and storage problems. Elaborate procedures for checking drawings to ensure that the changes of one designer are completely and accurately added to other drawings and reports cause time and cost delays [15].

IT PROCUREMENT SOLUTIONS

Kalakota and Robinson [8] point out that billions of dollars are wasted every year because of inefficient procurement practices. Estimates of cost of goods and services range from 50-60% of sales. IT procurement solutions have the potential to be more cost efficient primarily by decreasing the number of procurement specialists necessary to perform primary tasks. In construction, the major procurement tasks include creating and delivering invitations to bid (ITBs) and requests for quotations (RFQs), processing purchase orders (Pos), attaching drawings, plans and specifications, tracking changes to bid packages, and facilitating bid analyses. Such IT solutions are also more effective because their impact include increased control over the supply chain, proactive management of key procurement data, and higher quality purchasing decisions within organizations. Further, cost savings in procurement may also be gained by using Web-

based procurement tools as an outsourced service. Outsourcing offers innovative ways to save money and participate in new markets without a significant up-front payment.

Web-based Bidding Tools (WBBTs) are found in most IT procurement solutions. WBBTs automate most of the activities that take place in the bidding process. Regardless of the claims and warranties offered by the computer service firms, many project managers are still reluctant about the impact a WBBT could have on their current bidding practices.

Web Based Bidding Tools (WBBTs)

WBBTs allow its users to issue invitation to bids (ITBs) and requests for quotations (RFQs). They allow contractor(s) to respond with their bid(s) and owners to issue purchase orders, all in a secure, online environment. Typical applications for WBBTs include traditional auctions, reverse auctions, which address markets with one buyer and many sellers, as well as, bid/ask-style exchange mechanisms, which support bidding processes in markets with many sellers and buyers for the same services or goods.

Some of the benefits commonly attributed to the use of WBBTs include:

- Creates new value for buyers, sellers, and marketplaces by facilitating negotiation, as well as auction and market mechanisms. A complete transaction history can be easily maintained.
- Reduces costs of buying and selling by automating transactions where possible, by reducing cycle time and service costs. A larger number of transactions can be supported compared to manual operations, reducing the marginal cost per transaction.
- Reduction of execution times can be accomplished through automated processing or structured data inputs. ITBs and RFQs can also be easily sent to multiple vendors and contractors reducing the workload involved at this stage of the procurement process.
- Security and reliability can be ensured through data encryption, user authentication and routine backups
- There is also a choice of deployment options offered by most vendors - either as purchased software to create a trading marketplace, by joining as an integrated part of a specific marketplace or as a hosted service, with access to over thousands of suppliers and hundreds of buyers on a specific network.

WBBTs are not without its drawbacks. Security of the information is usually the first risk that is associated with internet-based systems. Such systems are subject to various security risks including, hacking, corruption of data, theft of data (both transaction and customer data). A better understanding of security risks, especially those associated with electronic transactions, has helped companies design and architect a secure network infrastructure [9]. However, "some contractors are still nervous about submitting proposals electronically, with all the vendors having access to the information" [13].

Other risks associated with WBBT are the following:

- High fees and overall cost including the cost of software license and services and the higher cost of labor to create and maintain complex internet-based systems [4].
- Entrusting the quality and reliability of service as well as the confidential data of your company to the firm that provides the WBBT services [11, 12].
- Outsourcing adds complications of operations, training, and legalities. Further, the electronic partnerships created by outsourcing have the risk of failing [4].
- Small online markets could be negatively affected when any member joins or leaves the group [4].

TOOLS TRADITIONALLY USED IN THE EVALUATION OF INFORMATION TECHNOLOGIES

Several alternative methodologies for quantifying information management investments have been proposed in the literature. Some of the alternatives available for information research include data forms, process flow charts, process-simulation modeling, financial analyses, case studies, prototyping, decision tree analysis, net present value (NPV) at risk, and EPC Macro/Micro methodology.

Data Collection Forms

The data collection process involves the creation of the forms, collecting the data, normalizing the data, and documenting any assumptions. The data collection form compiles specific information about activities that take place in a particular process. Back et al [1] describe a data collection strategy in which a baseline condition (regarding cost and time) is measured in terms of percentages, so that changes caused by future and different information management strategies could also be measured.

The level of detail of each activity could influence the results of further analyses based on the data from the data form. It is important to segregate activities that require large amounts of resources, such as time and/or money. A major limitation in the utilization of data forms has to do with the idleness of an activity. Idleness is described as the time in which an activity is neither operational, nor generating an output.

Process Flow Charts

A process analysis is the systematic examination of all aspects of a process to evaluate and improve its operation – make it faster, more efficient, less costly, or more responsive. A basic tool for process analysis is the process flow chart that is used to analyze how the steps of a job or a set of jobs fit together into the overall flow of the process [14]. A limitation of the process flow chart is that it needs to be used in combination with other types of analyses and job-description forms in order to create a comprehensive and detailed picture of a job.

Simulation Modeling

Simulation Modeling is a modeling approach primarily used to analyze probabilistic problems. Gibson [6] suggested that a useful construction process model would need to be hierarchical, modular, standardized in structure, and capable

of representing the complex processes that take place in the construction procurement processes. Information technologies intended to improve an organization's information infrastructure could be evaluated with the use of simulation modeling to determine if they add value to the construction process. The main limitation of simulation modeling is that it does not normally provide a solution; instead it provides information that is used to make a decision [14]. Another limitation of simulation modeling is that assumptions utilized in the model might go unchallenged.

The Extend Simulation Package is a decision support modeling software package that allows the simulation of discrete and continuous events. The Extend Performance Modeling software is primarily used to simulate processes from the manufacturing and service industries. It supports the simulation of continuous and discrete events. Extend models are built by connecting blocks together in a logical sequence. The simulation itself is a series of calculations and actions, which proceed along the path of the connections [5].

Blocks are the basic building component of Extend models. Extend blocks are like blocks in a block diagram. Each block in the diagram is used to represent a specific function or process within a system. However, unlike a block in a typical block diagram, information enters the Extend block and is processed by the program defined by the block. Information is then transmitted to the next block in the simulation. Any block may create, modify, or present information, and many perform more than one of these functions.

Financial Analyses

Financial tools are favored for management decision-making, and are used to determine the financial impact of an information management strategy for which both costs and benefits are available [2]. The major drawback of using financial analyses to evaluate an IT solution is that such analyses do not incorporate information regarding the dynamics involved in today's markets, technology implementation or corporate business commitments. The measures include return on assets (ROA), break-even (BE) analysis, and payback period.

Matrix Analysis

Croom et al. [3] incorporate matrix analysis. to classify and critically analyze the contributions information technologies provide to different supply chain events. The first dimension of the matrix will be used to classify the level of the analysis. There could be three different levels: dyadic, which considers the single relationship between supplier or contractor and buyer, chain, which encompasses a set of dyadic relationships, and network, which concerns the whole network of operations. The second dimension of the matrix relates the nature of the exchange or transaction between actors in the different networks. The element of exchange considered could be assets, information, knowledge or relationships. The main drawback of the matrix analysis is that addressing the different aspects of elements and levels in the network is not always clear. The relationship between the element of exchange and the level of the analysis needs to be explicitly defined, or else, speculation and estimation error could alter the accuracy of the analysis.

Business-To-Business (B2b) Model Constructs

The B2B model represents the interaction between vendors, contractors and non-retail buyers. This model also includes marketplaces where the market owner facilitates transactions between vendors, contractors and non-retail buyers. In order to analyze a B2B model, De et al. [4] discussed several analytical constructs that have to be measured. These include transaction costs, switching costs, network externalities (marginal impact of the addition or action of a member to a network), being part of a network associated with a market niche, ongoing IT infrastructure investment, user experience models (processes or steps a user moves through to obtain a product or service), and revenue models (derived from sales transactions and cost savings). The main limitation of B2B model constructs is that they do not normally provide a solution; instead, it identifies elements that might trigger the success or failure of an e-business strategy, which could be used to make a decision.

Prototyping

Prototyping is becoming a popular strategy to evaluate a potential investment in an IT solution. Hardgrave and Wilson [7] claim that the prototyping approach has grown nearly 30% from the 1980's to the 1990's. The main drawback of prototyping is that it still requires the commitment of resources and requires a significant planning effort prior to implementation to maximize the effective use of those resources. In addition, the prototype itself does not provide the means to quantify the benefits from enterprise wide implementation.

Decision Tree Analysis

Decision Tree Analysis allows the decision maker to see the logic of decision-making by providing a picture of the decision process [14] together with the probabilities of success and failure. This methodology provides direction to take an IT investment decision. The limitation of such analysis is that it does not provide for the dynamics involved in the development and implementation of a technology. In addition, decision trees do not assist the decision maker in evaluating the "business value" of several IT possibilities.

Net Present Value (NPV)-At-Risk Method

NPV-at-Risk is a decision support methodology that incorporates risk analysis and financing models into the assessment of a potential investment. Recently, this methodology has been gaining popularity to evaluate complex capital investments in the construction industry [17]. It incorporates the time value of money into the mean-variance method using the NPV concept and takes financing methods into account using the WACC as the discount rate. The WACC is the cost of various financial sources weighted by their corresponding proportions in the overall pool of financing. The cost of a financial source is the return

expected by the investors. The most important limitation of the NPV-at-Risk analysis is that it is subject to estimation error resulting from sampling error, inappropriate discount rate, and/or inappropriate cash flow model.

Engineering Procurement Construction (EPC) Macro/Micro Methodology For Information Intensive Activities

The main purpose of the EPC Macro/Micro Methodology is to allow companies to make a more accurate company-specific prediction of information management improvements for projects that they encounter most frequently. This methodology has been used to evaluate information management improvements in the construction industry [1].

The data collection process requires special attention in order to preserve the accuracy of the data. The data for each project associated with each activity in the data form is then used as the data sets for the development of statistical distributions of time and cost for each activity. The EPC Macro/Micro methodology utilizes the Activity Based Costing Simulation (ABC-SIM) logic network, which is a Monte Carlo based modeling tool. There are several drawbacks associated with the EPC Macro/Micro methodology. The accuracy of the distributions derived through data fitting programs influences the simulation output. Another drawback is that the data collection process itself introduces subjectivity into the baseline data. Companies do not typically recollect or record project time and cost information according to specific activities. Rather, each company has a different method to record information and time and cost categories to track projects. Each person makes assumptions providing data regarding which activities correspond to which category.

PHARMCO BIDDING PRACTICES

Pharmco is a global pharmaceutical company that discovers, develops, manufactures and markets a broad range of human and animal health products, Pharmco is growing rapidly inside and outside of the United States, driven by sales of existing products and launches of new products. This rate of growth has created a need for efficient project management techniques for facility expansion and new facilities construction projects.

Within Pharmco, Global Engineering is responsible for ensuring manufacturing facilities are ready when a new candidate emerges from the pipeline despite the uncertainty of when the product may receive regulatory approval and of ultimate market demand. The Global Engineering team is currently considering the possibility of integrating e-procurement applications to their existing procurement system. These applications are expected to create a more efficient flow of information in the materials and services procurement areas. Service procurement is one of the areas that will be structurally affected by the implementation of e-procurement tools. Service procurement includes the bidding process, (sub)contractor selection and payment for completed services. Pharmco is considering deploying a WBBT in order to shorten the time cycle of their current bidding process.

PHARMCO'S TRADITIONAL BIDDING PRACTICES

Pharmco's (The name of the company and other identifying information have been disguised to protect its identity and those of its employees who assisted with this project) traditional bidding practices are fundamentally characterized by a sealed bid auction format. A sealed bid implies that a bidder for the product or service is not aware of the other bidders' information, such as their names and how much they are offering. Pharmco is also characterized by taking the role of both, the Project Manager (Global Engineering group) and the owner.

Advertising Phase

Once a substantial amount of the design phase of the construction project is completed, drawings, plans, specifications and requirements are put together by the Engineering and Procurement division of the Global Engineering group at Pharmco to initiate the advertising phase. When the package is complete, the final documents are reproduced and distributed.

Initially, a notice of proposed bidding is posted in public places and advertisements for bids are placed in newspapers, trade journals, and magazines. Generally, the advertisement describes the location, extent, and nature of the work. It also designates Pharmco & Co. as the authority under which the project originated. Regarding the bid, it gives the place where bidding documents are available and lists the time, manner, and place where bids will be received. It will also list bond requirements and start and completion dates of work.

Contractors that have never provided services to Pharmco will be subject to a pre-qualification process. Pharmco's pre-qualification of bidders follows three steps:

1. The contractors fill out a questionnaire. The questionnaire gathers all contractors' profile data including: expertise, years of experience, previous jobs, etc.
2. A ranking process helps measure the contractor's reliability. The pre-qualification process also requires that other companies previously serviced by the prospective contractor fill out report cards.
3. A final selection is done based on the previous pre-qualification and ranking steps.

Pre-bid Conference

At Pharmco's pre-bid conferences, bidders are walked through the premises where the construction project is going to take place. All questions are answered with the help of the design firm and the project management team.

Bids Closing

The architect/engineer prepares a checklist of all items that are confirmed before opening the bids. All contractors turn

in their bid package before or at the specified time and date, and at the right location. After all of the bids have been opened, the project manager may, by inspection, verify the completeness of each bid package including the submittal of a bid bond and determine the identity of the apparent low bidder, subject to later confirmation after a careful bid review and evaluation. Pharmco calls this process "De-Scoping".

At the end of the bid-opening session, the individual bids are tabulated and evaluated, and each bidder's profile is checked for financial credibility, licensing (where required), and integrity. Where unit prices form the basis of the bid, every individual line item is tabulated for each bidder in preparation for a detailed, item-by-item evaluation, analysis, and comparison of bids.

It is common to find irregularities and extraordinary questions that might require further adjustments of the contractors' bid price estimate. These irregularities are generally attributed to misunderstandings and/or conflicting specifications. For this reason, a revised bid pricing submittal deadline is specified. This extension allows contractors to clarify and correct any final changes in their respective bids. Pharmco gives such a grace period in order to avoid more costly delays because of irregularities found after a contractor has been selected. After the project managers have confidentially announced all readjustment requests, the deadline for the revised bid submittal becomes the final bid-closing deadline.

Announcement of Award

Once all adjusted bids have been received, compared and tabulated again, the successful bidder is announced. Upon being awarded the contract, the successful bidder is obligated to enter into a contract with Pharmco for the construction of the work. If the successful bidder fails to enter into contract with Pharmco, the bid bond is forfeited, and Pharmco will then award the contract to the next lowest bidder.

PHARMCO'S NEW BIDDING PRACTICES

Experience has shown Pharmco & Co. that their traditional bidding practices need to be optimized, and that the months spent completing the bidding process adds to the cost of the project and hinders the overall success of the project. Pharmco is considering outsourcing a Web-based Bidding Tool to improve the efficiency of their current bidding practices but, at this point, Pharmco is not fully aware of the possible effects in their process flow.

Pharmco's new process flow, using WBBT differs from its traditional bidding process in its virtual data hosting and its open bid auction. The WBBT software will be hosted on Pharmco's server. The network-hosted service allows the interaction with thousands of suppliers, vendors and contractors within the WBBT marketplace or other virtual marketplaces. The data exchange and transactions between Pharmco's project managers and the bidders will be simplified with the electronic data transmission capabilities incorporated in the WBBT software. The reproduction of documents, such as the original bidding documents, specifications and list of requirements, is all electronically handled. Pharmco is expecting to eliminate the need for hard copies of the bidding documentation.

The new dynamic bidding procedure will differ greatly from the current auction process. All bidders will virtually meet in an auction platform prepared by Pharmco project managers. The identity of each bidder is kept confidential. The new process will have an open bid format in which all bidders know all offers. Thus, bidders compete against each other, decreasing the bid price until the end time and date. Once the bidding starts, the process will not stop until a contract has been awarded. Offers will be placed in electronic forms that will make the tabulation, comparison and evaluation of all offers easier and more accurate. Based on the evaluation of all bids, the award is electronically awarded.

ANALYSIS OF PHARMCO'S CASE STUDY

The methodology used for the evaluation of the web-based bidding strategy is based upon the EPC Macro/Micro strategy for the evaluation of information intensive activities. Tools such as data collection forms, process flow charts, the Extend simulation modeling software, ROA, and payback period analysis, were also used for the evaluation of the applicability of WBBTs in the case study related to the procurement practices at Pharmco & Co.

Data Collection Stage

Interviews with professionals in the procurement field are an essential tool for acquiring the necessary research data. In the case study, time and cost data associated with each activity was provided by senior procurement managers at Pharmco & Co., and experts in the implementation and integration of the WBBT provider. All data was gathered through phone interview sessions and electronic mail exchanges. The data collected represents the average cost and duration of the last 10 construction projects managed by Pharmco project managers.

To complete the data acquisition stage, a data collection form for both, the traditional bidding process and the web-based bidding process, was created in order to collect data pertaining to the activities that take place in each particular process.

Several assumptions were also clarified through the interviews and data collection forms. These assumptions establish an average of:

- 5 bidders per bidding process.
- 12 bidding processes per project.
- 8 large (> $50 million) construction projects per year.
- 15% of bidders have had no previous relationship with Pharmco (Z%).
- 100% of bidding packages require corrections due to changes or omissions in the drawings, plans and/or specifications (X%).

- 60% of all bidders get a re-adjustment grace period (Y%).
- 8.25 weeks is the average duration of the traditional bidding process.
- 6 weeks is the expected duration of the new web-based bidding process.
- 15% cost savings are expected with the use of the WBBT.
- 30% timesavings are expected with the use of the WBBT.

It is important to mention that the procurement experts from Pharmco determined that the WBBT provider's forecast of 20% reduction in service costs and cycle time reductions of 50% to 80% were too optimistic. For this reason, a very conservative assumption of 15% for cost savings and 30% for timesavings was used.

Development of the Process Flow Charts

The use of process flow charts was combined with the Data Collection Forms to provide a more complete perspective of each activity in the traditional and the new bidding processes. The information gathered in the interviews and data collection forms was imperative for the creation of the process flow charts. The process flow charts were used to visualize how the different activities fit together into the overall flow of the bidding process. The process flow charts will also become the backbone of the Simulation Modeling tool.

Simulation Stage

The Extend simulation-modeling tool was used to evaluate the performance of the activities in each respective bidding process. This tool gathered statistics on the average queue length, average wait time, and utilization of all the activities in the traditional and new web-based bidding processes. Two Extend models were developed to simulate the traditional bidding process and the new web-based bidding process. The model shows bidders arriving in a random fashion. These bidders will form a line waiting for activities that handle one bidder at a time and will be combined as a "group of bidders" for activities capable of handling all bidders at once.

The simulation was setup for a 9-week duration based on a 5-day a week and 11-hours a day schedule. The Generator, Queue FIFO, Activity Delay, Select DE Output, Batch, Un-batch, Combine, Input Random Number and Exit blocks were found in the Discrete Event (DE) library. The Generator block models the arrival of the bidders. In these models, a Generator with a Poisson distribution averaging one bidder every 0.2 weeks was used. The Queue FIFO block is used to represent the waiting line for different activities, since the first bidder in the line will be the first out of the queue. Activity Delay blocks represent the delays found in the bidding process.

The Select DE Output, Combine, and Input Random Number blocks were used to create a routing yield for several activities in the process flow. In these blocks the following assumptions were integrated into the model: 15% of bidders have had no previous relationship with Pharmco (Z%), 100% of bidding packages require corrections due to changes or omissions in the drawings, plans and/or specifications (X%) and, 60% of all bidders get a re-adjustment grace period (Y%). The Batch and Un-batch blocks were used accordingly to delay the activities based on individual bidders or a "group of bidders". Bids that have been completely evaluated end in the Exit block. The Exit block allows items to be counted as they pass out of the simulation. A Plotter Discrete Event block from the Plotter library is used to plot both the queue length and the number of bidders that exit the system.

Simulation Results and Discussion

The simulation analysis has been very useful to identify the major bottlenecks in the traditional and new web-based bidding processes. In this case, the bottleneck activities are all of those with an "average queue length" greater than zero. These activities are the major cause of time delays and large idle times.

It is important to notice that the queue length for some of the bottleneck activities reached a maximum of 4 or 5 bids in the waiting line (see the "Max. Queue Length" column in Table 1). These values are extremely high queue lengths, especially when considering that a total of 5 bids were processed during the whole duration of the simulation. A percentage of improvement calculation was used to determine the change in efficiency of the major bottleneck activities after implementing the WBBT. The Improvement (%) can be represented as shown in Eq. 1:

$$\text{Improvement (\%)} = [\text{Performance (0)} - \text{Performance (1)}] / \text{Performance (0)} \quad (1)$$

where, "Performance (0)" is the average queue length of an activity of the traditional process and "Performance (1)" is the average queue length of an activity of the new web-based process. Overall, the percentage of improvement for the efficiency of the bottleneck activities represents a 58.2%.

Financial Analysis

Financial analysis tools were used to determine the cash flow impact to Pharmco's business after a possible implementation of the WBBT. Since the WBBT is being used to generate savings and not revenues, the profitability for the financial analyses described in this section will be derived from expected savings associated with use of the WBBT.

Cost Analysis

The cost analysis classifies the costs associated with the bidding process in expenses incurred by leading procurement personnel's salary, overhead, administrative and secretarial support, and miscellaneous expenses. From these expenses, Pharmco representatives calculated a rate per an hour for each of the leading procurement employees. This information combined with the expected working hours per week and duration of the process was utilized to calculate the expenses associated with the traditional and web-based

bidding processes (see Tables 2 and 3). The total calculated expenses for the traditional bidding process are $38,370.00 and for the new web-based bidding process are $23,802.00, which represents a difference of $14,568.00.

ROA Analysis

The ROA per bidding process was calculated with the estimated cost of the traditional and new web-based bidding processes and the cost of implementing and the WBBT. The total ROA per bidding process was calculated to be 1.2%. It is important to realize that Pharmco, on average, performs 12 bidding processes per project, which represents an ROA of 14% per project.

Payback Period

The WBBT requires an initial investment of $1,250,000.00. Cash inflows, based on savings per year, are expected to be of $515,145.00. In this case, three years is the payback period of the investment.

SUMMARY AND DISCUSSION

New information technology (IT) investments are helping many companies to generate higher productivity rates and to create more efficient processes. Businesses must earn enough rates of return on IT investments to compensate for the rapid obsolescence, depreciation and falling market value of these IT assets. IT investments must be extraordinarily productive during their short lives.

Several computer service firms that provide IT solutions have developed multi-tasking e-procurement tools. The procurement activities most commonly automated by e-procurement tools have been: creating and delivering ITBs and requests for RFQs, processing POs, attaching drawings, plans and specifications, tracking changes to bid packages, and facilitating bid analyses. Web-based Bidding Tools (WBBTs) are found in most IT procurement solutions. Application service providers claim the WBBTs maximize revenues and savings when executing trading transactions. On average there is a 5% to 20% reduction in service costs and cycle time reductions of 50% to 80%. Regardless of the promises and warranties offered by the computer service firms, many project managers in construction are still reluctant about the impact a WBBT could have on their current bidding practices. This study investigates how the traditional service procurement process is affected by the implementation of a WBBT.

A case study was developed based on Pharmco & Co.'s recent initiative to invest in a WBBT. A pilot scenario was created based on a typical process plant construction project. After comparing the process flow charts of Pharmco's traditional bidding process and the new web-based bidding process, several differences and benefits related to the use of a WBBTs were recognized:

- Less time will be spent while reproducing documents and drawings in the new web-based bidding process.
- Most activities will be done and managed electronically in the new web-based bidding process.
- The bidding format is different in both processes
    - The traditional bidding process has a paper based closed bid format.
    - The new web-based bidding process utilizes an open bid format in an electronic-channel auction.
- No more time extensions will be granted for bid readjustments in the new web-based bidding process.
- Bid analyses, comparisons and tabulations will take less time in the new web-based bidding process.

In Pharmco's case study it was found that a WBBT could achieve immediate rates of return. A decrease in the number of bottleneck activities, a 58.2% improvement in the efficiency of the bottleneck activities, a 65.8% shorter duration of the bottleneck activities, a 14% rate of return per project, $515,145.00 dollars saved per year and a 3-year payback period, support the previous statement. In Pharmco's case study, there is a good probability that the productivity claims stated by various WBBT application service providers is accurate.

However, the large amount of risks associated with the implementation of a WBBT is still a major concern and cannot be ignored. These risks require further investigation. Project managers need to be aware of all of these risks prior to committing approximately $1.25 million dollar to invest on a WBBT. There are several questions that still need to be considered:

- Are the returns worth the risks associated with entrusting confidential data about the company to the firm that provides the WBBT services, entrusting a partnership agreement with contractors with whom there has been no previous relationship, and entrusting the quality of the services being contracted?
- Who guarantees that the lower margin of profit that contractors get when using a WBBT is not in one way or another translated into lower quality products and services?
- The declining economy has generated a large instability for start-ups and small technological companies. Are WBBT application providers going to survive the declining economy and be in existence long enough after investing in their solutions?

The major drawbacks of the strategy used to evaluate Pharmco's case study for the evaluation of the implementation of a WBBT solution are:

- It does not provide a solution; instead, it provides information that is used to make a decision.
- Assumptions used in the different analyses might represent sources of errors are not applicable to every case scenario.
- This strategy is not useful when trying to develop a generic methodology.
- The data collection process itself introduces subjectivity into the baseline data.

For example, barriers of implementation, specific to the construction industry, could be researched by developing case studies of several construction companies. Alternatives that could prevent the consequences associated with the risks

of implementing a WBBT could be investigated. These alternatives should be complementary to the WBBT solution and may ease its implementation and utilization.

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TABLE 1: Data from Extend Simulation Model

Activity	Duration (wks)	Duration / Bidder (wks)	Evaluation			
			Avg. Queue Length	Max. Queue Length	Avg. Wait (wks)	Activity Utilization (%)
Traditional Bidding Process						
Documents and Drawings are reproduced and delivered.	0.400	0.080	0.089	5.0	0.160	4.4%
Verification of completeness of bidding packages	0.160	0.032	0.035	5.0	0.064	1.8%
Bids review and evaluation	1.600	0.320	0.320	4.0	0.576	17.8%
Verify bidders licensing and integrity	0.160	0.032	0.277	3.0	0.499	17.4%
Bids re-adjustment grace period	1.750	0.350	0.003	1.0	0.015	7.8%
New Web-based Bidding Process						
Verification of completeness of bidding packages	0.110	0.022	0.024	5.0	0.044	1.2%
Bids review and evaluation	1.120	0.224	0.224	4.0	0.404	12.4%
Verify bidders licensing and integrity	0.160	0.032	0.195	3.0	0.351	12.2%

TABLE 2: Current Costs of the Traditional Bidding Process

Current Costs of the Traditional Bidding Process	Hrs/Wk	No. Trips	No. Wks	Rate/Hr	Rate/Trip	Expenses	Percent of ATPC
Direct Costs							
Procurement Leader	7.00		8.25	$ 90.00		$ 5,197.50	0.00035
Site Contract Administrator	11		8.25	$ 60.00		$ 5,445.00	0.00036
Equipment Group - Pharmaceutical Equipment	3		8.25	$ 90.00		$ 2,227.50	0.00015
Expeditor	1		8.25	$ 90.00		$ 742.50	0.00005
Sub Total						$ 13,612.50	0.00091
Indirect Costs							
Management	1		8.25	$ 90.00		$ 742.50	0.00005
Construction Auditor	4		8.25	$ 80.00		$ 2,640.00	0.00018
Clerical	4		8.25	$ 30.00		$ 990.00	0.00007
Sub Total						$ 4,372.50	0.00029
Travel Expenses		2			$ 1,200.00	$ 2,400.00	0.00016
Total Direct and Indirect Cost						$ 38,370.00	0.00256
Pharmco Assump tions for Traditional Bidding Process:							
Current Duration of Bidding Process (wks)	8.25						
Average Total Procurement Cost (ATPC)	$ 15,000,000.00						
(Equivalent to 1.5 - 2.5% of the total project cost)							
Average Total Duration of Procurement (wks)	100						
Cost of Buying and Installing Dynamic Trade	$ 1,250,000.00						

TABLE 3:
Expected Costs of the New Bidding Process

Expected Costs of the New Bidding Process	Hrs/Wk	No. Trips	No. Wks	Rate/Hr	Rate/Trip	Expenses
Direct Costs						
Procurement Leader	7.00		6	$ 76.50		$ 3,092.51
Site Contract Administrator	11		6	$ 51.00		$ 3,239.78
Equipment Group - Pharmaceutical Equipment	3		6	$ 76.50		$ 1,325.36
Expeditor	1		6	$ 76.50		$ 441.79
Sub Total						$ 8,099.44
Indirect Costs						
Management	1		6	$ 76.50		$ 441.79
Construction Auditor	4		6	$ 68.00		$ 1,570.80
Clerical	4		6	$ 25.50		$ 589.05
Sub Total						$ 2,601.64
Travel Expenses		2			$ 1,200.00	$ 2,400.00
Total Direct and Indirect Cost						$ 23,802.15
Pharmco Assumptions for New Bidding Process:						
Current Duration of Bidding Process (wks)	6					
Average Total Procurement Cost (ATPC)	$ 15,000,000.00					
Cost Savings	15%					
Time Savings	30%					
Expected Duration of New Bidding Process (wks)	6					