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Analysis of Functionalities of Commercial Websites Used for Procurement: Implications on Design and Operations

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Abstract: This research analyzes the functionalities of commercial websites used for electronic procurement and links them with the benefits as perceived by users and with relevant operations. Findings from a Data Envelopment Analysis (DEA) used on data collected from 88 corporate buyers working in a wide range of industries and using the World Wide Web to support the procurement process show that adding advanced functionalities to informational websites can reduce their efficiency, which suggest that commercial websites are more often used to reduce buyers' search costs than their processing costs. Possible explanations and implications of such findings on the design of commercial websites used for business-to-business transactions and on operations for both vendors and buyers are discussed.

Keywords: Operation strategy for e-commerce – DEA.

I. Theoretical Background

The World Wide Web has emerged as a promising medium for electronic commerce and thousands of "dot.com" and "brick and mortar" organizations have set up commercial websites to do business over the Internet [6] [14] [15]. The commercial websites hence deployed have the potential to support supply chain operations in general and procurement in particular [8]. Today, business-to-business transactions account for the largest proportion of the transactions conducted over the Internet.

Generally speaking, commercial websites can have four functionalities that support the procurement process [4] [13]. The identification functionality of commercial websites allows buyers to spot potential vendors of a given input. The selection functionality gives buyers an online access to pricing and other relevant information that allow them to compare different offerings and select a supplier for the pondered input. The execution functionality allows buyers to check the availability of a given input, place orders and make payments. Finally, the post-sale functionality allows buyers to track the status of their orders and of their shipments online.

Previous work has considered these functionalities as different stages of a growth model for commercial websites [16] [17]. Although their degree of integration to backend systems varies from one vendor to another, transactional websites can be considered as the last stage of development for a commercial website. The cost of developing and mai-

ntaining commercial websites increases as advanced functionalities are added, running anywhere between the tens and the hundreds of thousand dollars for a static website and anywhere between the hundreds of thousand dollars to millions of dollars for a transactional website [17] [19]. Typically, websites that only support the identification phase have the lowest cost whereas transactional websites are the most complex and the most expensive to develop.

The value of commercial websites can be assessed from the perspective of vendors who deploy such systems or of buyers who use them to support their procurement process. In general, advantages of electronic business-to-business transactions include operational and strategic benefits for both vendors and buyers [18]. In the specific case of electronic procurement, the identification and the selection functionalities of commercial websites can help reduce buyers' search costs as it becomes easier and faster for users to contact more potential suppliers and decide on the "best" one [2] [3]. The execution and the post sale functionalities can help users reduce processing costs for their transactions by eliminating paperwork, reducing data re-entry, improving information accuracy and reducing lead times [11] [18].

Depending on their functionalities, commercial websites can support, in whole or in part, electronic transactions. As a result, the availability and usage of such functionalities have different repercussions on vendors' and buyers' business processes hence supported and shaped. Business process redesign (BPR) refers to an information technology-enabled fundamental rethinking of business processes that helps achieve dramatic improvements in performance [5] [9] [10]. Electronic commerce (on vendors' side) and electronic procurement (on buyers' side) offer the opportunity to redesign business processes. El Sawy [7] has provided eleven principles that can be used as guidelines for BPR efforts in the context of World Wide Web-based electronic commerce. The eleven principles can be grouped in four categories: the first one focuses on streamlining a business process and removing valueless activities, the second on restructuring it to allow for a faster and a flexible execution of that process, the third on capturing, "moving" and generating information around a process, and the fourth on creating and managing knowledge around a process. Commercial websites typically include electronic catalogs, shopping carts, payment systems and order tracking systems that can support the redesign of vendors' order fulfillment and/or buyers' procurement processes through the implementation of the BPR principles related to the first three categories presented above. Other systems can be developed to build repositories and further analyze data, allowing for the management of knowledge around the

transactions commercial websites can support.

The objective of this paper is to analyze how functionalities of commercial websites deployed by vendors are used in the context of electronic procurement and how such usage affects operations of both buyers and vendors. Such investigation is based on a Data Envelopment Analysis (DEA) model that identifies the minimum functionalities that create the maximum value for buyers. The rest of the paper is organized as follows. Section 2 presents the basics of DEA, Section 3 the research model and Section 4 the methodology. Findings are presented in Section 5. The discussion and the implications of this research conclude this paper.

II. DEA Basics

DEA is used to establish a best practice group amongst a set of observed units and to identify the units that are inefficient when compared to the best practice group. DEA also indicates the magnitude of the inefficiencies and improvements possible for the inefficient units. Consider n Decision Making Units (DMUs) to be evaluated, DMU_j (j=1,2…n) that consumes the amounts $X_j = \{x_{ij}\}$ of m different of inputs (i=1, 2, …, m) and produces the amounts $Y_j = \{y_{rj}\}$ of r outputs (r=1 ,…, s). The input oriented efficiency of a particular DMU_0 under the assumption of variable returns to scale (VRS) can be obtained from the following linear programs (input-oriented VRS mode):

$$\min_{\theta,\lambda,s^+,s^-} \quad z_0 = \theta - \varepsilon \cdot \vec{1}s^+ - \varepsilon \cdot \vec{1}s^- \qquad (1)$$

$$s.t. \quad Y\lambda - s^+ = Y_0$$

$$\theta X_0 - X\lambda - s^- = 0$$

$$\vec{1}\lambda = 1$$

$$\lambda, s^+, s^- \geq 0$$

where s^+ and s^- are the slacks in the system.

Performing a DEA analysis requires the solution of n linear programming problems of the above form, one for each DMU. The optimal value of the variable θ indicates the proportional reduction of all inputs for DMU_0 that will move it onto the frontier which is the envelopment surface defined by the efficient DMUs in the sample. A DMU is termed efficient if and only if the optimal value θ* is equal to 1 and all the slack variables are zero. This model allows variable returns to scale. The dual program of the above formulation is illustrated by:

$$\max_{\mu,\nu} \quad w_0 = \mu^T Y_0 + u_0 \qquad (2)$$

$$s.t. \quad v^T X_0 = 1$$

$$\mu^T Y - v^T X + u_0 \vec{1} \leq 0$$

$$-\mu^T \leq -\varepsilon \cdot \vec{1}$$

$$-v^T \leq -\varepsilon \cdot \vec{1}$$

$$u_0 \text{ free}$$

If the convexity constraint ($\vec{1}\lambda = 1$) in (1) and the variable u_0 in (2) are removed, the feasible region is enlarged, which results in the reduction in the number of efficient DMUs, and all DMUs are operating at constant returns to scale (CRS). The resulting model is referred to as the CRS model.

In summary, each DEA model seeks to determine which of the n DMUs define an envelopment surface that represents best practice, referred to as the empirical production function or the efficient frontier. Units that lie on the surface are deemed efficient in DEA while those units that do not, are termed inefficient. DEA provides a comprehensive analysis of relative efficiencies for multiple input-multiple output situations by evaluating each DMU and measuring its performance relative to an envelopment surface composed of other DMUs. Those DMUs forming the efficient reference set are known as the peer group for the inefficient units. As the inefficient units are projected onto the envelopment surface, the efficient units closest to the projection and whose linear combination comprises this virtual unit form the peer group for that particular DMU. The targets defined by the efficient projections give an indication of how this DMU can improve to be efficient.

III. Research Model

From vendors' perspective, the cost of developing and maintaining commercial websites increases as features supporting the selection and the transactional (i.e., the execution and the tracking) phases of the procurement process are added to informational websites [17] [19]. This research analyzes how functionalities of commercial websites are used to support the procurement process and to link them to benefits buyers report. A DEA model using websites' functionalities as inputs and websites' usefulness, reduced search costs and reduced processing costs as outputs was created accordingly. The proposed model can provide vendors with guidelines on how to design efficient commercial websites based on ratings from buyers who use them to carry out their procurement tasks. In this context, the proposed DEA model can minimize the functionalities (and therefore the cost) of commercial websites and maximize the benefits as perceived by buyers.

Figure 1 presents the model used for this research. The inputs and outputs were measured from the perspective of buyers using the deployed commercial websites. A survey of corporate buyers helped collect data related to the

functionalities and the benefits of the general commercial websites they interact with when carrying out their procurement tasks. From this perspective, each rating related to the functionalities and benefits of commercial websites respondents generally access is considered as a DMU.

FIGURE 1 HERE

Input orientation was selected for the DEA model in this research as vendors deploying commercial websites would be more interested in minimizing the cost subject to attaining the desired output levels. Both types of envelopment surfaces, BCC and CCR will be used and scale efficiency issues will be examined.

IV. Methodology

To collect data used in this research, a questionnaire was sent to all the 988 corporate buyers members of the "Corp-oration des Approvisionneurs" in the province of Quebec, an organization affiliated to the Purchasing Management Association of Canada. Respondents were surveyed about their general perspectives regarding the functionalities and the usefulness of the commercial websites they generally access to carry out their procurement tasks. Respondents were also surveyed about the perceived performance improvements related to such usage. Among the 114 corporate buyers who returned a usable questionnaire, 88 reported accessing commercial websites to carry out their procurement tasks. The sample spanned corporate buyers working for over 80 different organizations doing business in a wide range of industries.

Seven-point Likert (1=Strongly disagree, 7= Strongly agree) scales were used to measure the inputs (or functionalities of commercial websites) and outputs (i.e., usefulness of commercial websites, reduced search costs and reduced processing costs) of the DEA model. Whenever possible, pre-existing instruments were used because normally they have been tested for reliability and validity properties: the measure of the functionalities was based on Leenders et al. [13]; usefulness was measured using a four item-scale by Karahanna et al. [12]; the assessment of reduced search costs was based on Bakos [2] and Barua et al. [3] whereas the measurement of reduced processing costs was based on Jones and Beatty [11].

After the survey, the validity of the instrument was assessed using a factor analysis. The well-known criterion of eigenvalue greater than one was applied. A factor loading greater than .50 with the theoretically correct sign was required for the assignment of an item to a factor. The principal components method with Varimax rotation was used to extract the factors. The reliability of the instrument was assessed using the Cronbach's alpha. Findings from the factor analysis show support for the validity of the scale. The Cronbach's alpha varied from .67 to .93 showing acceptable level of reliability of the scales. No item significantly deflated alpha, so all items were kept for

analysis. The score for each of the five factors retained equaled the mean score of its retained items and was used as inputs and output scores in the model. Table 1 summarizes the validity and the reliability analyses performed is presented.

TABLE 1 HERE

V. Findings

Descriptive statistics based on a seven-point scale show that respondents use commercial websites to support to a greater extent their identification (Mean = 6.1) and their selection (Mean = 4.1) tasks and to a lesser extent their execution (Mean = 2.5) and their post-sale tasks (Mean = 3.4). Furthermore, respondents consider accessing commercial websites to be useful (Mean = 5.3) for the procurement process and report on average a greater improvement in search costs (Mean = 5.3) than in processing costs (Mean = 3.3).

DEA findings are first used to analyze the link between the functionalities commonly used and the benefits for buyers. The DEA results summarized in Table 2 show that the model identifies 92% technical efficiency. Scale efficiency can be calculated as the ratio of the CCR and BCC scores. If the frontiers of the CCR and the BCC models are very close, one can conclude that the DMUs operate at constant returns to scale. Otherwise, there is significant scale inefficiency. Comparison of the BCC scores with CCR scores shows that most of the units are operating under constant returns to scale since the scale efficiency is very close to 1. Thus, the CCR efficiency score will be used in the following analysis unless otherwise stated.

TABLE 2 HERE

It is observed that most of the ratings are efficient; however, results show that buyers can use a reduced number of functionalities without reducing the level of benefits they report.

DEA results are further used to analyze the effect of different functionalities on the efficiency of users' ratings. The DEA model divided the data set into efficient and inefficient groups. Table 3 presents the average rating on each functionality for the efficient and the inefficient group. Findings show that the two groups have different input mixes and that the inefficient group of ratings reports a higher level of usage of the functionalities that support the execution and the post-sale activities. This indicates that reducing the level of access to these functionalities can lead to a greater efficiency in ratings. Results show however that a higher level of usage of functionalities that support the identification and selection activities is critical for the benefits reported. Results from Mann-Whitney tests at the confidence level of .95 confirmed the significant differences in functionalities usage between the two groups of ratings.

TABLE 3 HERE

Overall, findings suggest that the identification and selection functionalities are the most important factors affecting the benefits buyers get from accessing commercial websites to carry out their procurement tasks. Further analyses examined the non-response bias and the possible confounding factors. Findings showed support for the representativeness of the sample and for the independence between respondents' profile and DMUs' efficiency.

VI. Discussion and Implications

Findings from this study suggest that buyers logging onto commercial websites to carry out their procurement tasks tend to use them essentially for the identification and the selection of suppliers. They suggest also that more advanced functionalities of commercial websites such as the online ordering system, the online payment systems or the online tracking system does not add much benefit as perceived by users of such systems. As a result, buyers accessing vendors' websites tend to report more important reductions in search costs than in processing costs.

Possible explanations as to why using the transactional functionalities of commercial websites present less interest for corporate buyers include the perceived lack of security regarding web-based transactions and a personal preference for more traditional ways (phone calls, on-site visits, paper-based) to do business with suppliers.

Findings from this study have implications for both vendors deploying commercial websites and buyers using them. Vendors who are interested in new channels to sell their products and services must balance their business strategy and operations between "pure play" electronic commerce and "brick and mortar". The "bricks and clicks" in the middle of such continuum requires that vendors provide both channels and synchronize the "physical" and the "digital" business processes [1] [7]. However, findings from this research suggest that vendors may experience a somewhat reduced volume of transactions executed through their websites, hence limiting the effect online order fulfillment systems can have on the redesign of front-office operations and their integration to back-office operations. From the perspective of El Sawy's [7] set of BPR principles, informational websites and electronic catalogs only help implement two of the eleven principles identified (namely streamlining and losing wait) allowing for a limited streamlining and a very limited restructuring of front-office operations but not allowing for any management of the information and of the knowledge around such processes. Moreover, vendors concerned with balancing the cost of developing and maintaining their companies' commercial websites and the benefits of such systems as perceived by potential buyers can opt for websites that just support the identification and the selection phase of the procurement

process. Such websites may offer the maximum usefulness given their limited functionalities and therefore, given the costs they involve.

The implication of our findings on buyers' side is that, although commercial websites have the potential to support the entire procurement process, they are essentially used to establish communication channels with suppliers. In this context, commercial websites help reduce the time and effort (the so-called search costs) needed to identify and select a supplier for a given transaction. Findings from this study show however that commercial websites are rarely used to order inputs, pay for them or to check the status of such orders. Corporate buyers tend to opt for other means (probably more traditional means) to execute their transactions, which limits any improvement in processing costs and any dramatic redesign of the procurement process.

The objective of this research was to investigate the range (and the extent to which each) of functionalities of commercial websites buyers use to support the procurement process. The implications of our findings on related business operations and on the design of such websites were discussed. Future research can investigate such relationships for specific commercial websites in specific industries. Future work should measure the inputs from the perspective of organizations that deploy commercial websites and take into account several outputs related to the benefits of commercial websites' functionalities for organizations that implement them and for customers who use them.

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Figure 1. Proposed DEA model

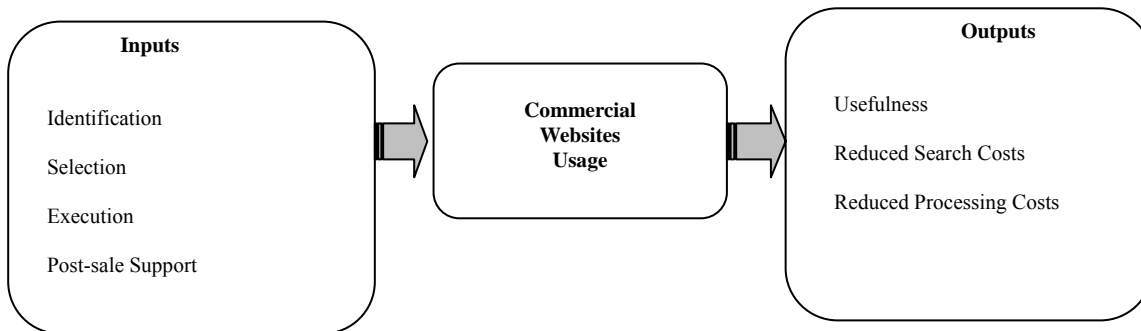Table 1. Validity and reliability analysis

:	FACTORS						
	Identif. (α=.67)	Select. (α=.84)	Execut. (α=.79)	PostSale (α=.86)	Useful. (α=.93)	RSC* (α=.83)	RPC** (α=.91)
Identify potential suppliers	.775						
Get information from different suppliers	.863						
Evaluate product offerings		.880					
Compare seller prices		.822					
Select a supplier		.728					
Make bids		.729					
Place orders			.768				
Make payments			.920				
Track the status of orders				.850			
Track the status of shipments				.923			
Accomplish my tasks more quickly					.870		
Improve the quality of my work					.934		
Enhance my effectiveness on the job					.870		
Make my job easier					.935		
Contact more suppliers						.888	
Make it easier to locate potential suppliers						.866	
Make better selection of suppliers						.772	
Reduce paperwork							.893
Reduce clerical error							.784
Increase speed of order transmission							.816
Reduce lead times							.903
Extraction method: Principal Component Analysis (Rotation method: Varimax) Showing coefficients with absolute values greater than .50							
*RSC = Reduced Search Costs **RPC = Reduced Processing Costs							

Table 2. DEA Results

	BCC	CCR
Technically Efficient		
Average Score	0.92	-
Standard Deviation	0.11	-
Technically & Scale Efficient		
Average Score	-	0.85
Standard Deviation	-	0.16
Maximum Efficiency Score	1	1
Minimum Efficiency Score	0.63	0.15
Scale efficiency	0.924	

Table 3. Average input scores for efficient and inefficient commercial websites

	Efficient group (N = 32)	Inefficient group (N=56)	Asymp. Sig. (2-tailed)
Identification	6.06	6.15	0.936
Selection	3.84	4.34	0.151
Execution	1.63	3.08	0.000
Post-sale support	2.53	3.95	0.001