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Efficiency Evaluation of E-Commerce Websites

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Abstract— This study suggests a model of a new set of evaluation criteria that will be used to measure the efficiency of real-world E-commerce websites. Evaluation criteria include design, usability and performance for websites, the Data Envelopment Analysis (DEA) technique has been used to measure the websites efficiency. An efficient Web site is defined as a site that generates the most outputs, using the smallest amount of inputs. Inputs refer to measurements representing the amount of effort required to build, maintain and perform the site. Output is amount of traffic the site generates. These outputs are measured as the average number of daily hits and the average number of daily unique visitors.

Keywords— Data Envelopment Analysis, E-commerce, Efficiency.

I. Introduction

As the number of Internet users has increased, so has the variety of websites. Websites nowadays include various types, such as those for trading physical products and those for online network games. E-commerce is the most pervasive and prominent type. It is the business process of selling and buying the products, goods and services by on-line communications. It can be highly beneficial in reducing business costs and in creating opportunities for new or improved customer services, customers feel convenience to order and are able to collect plenty of information to compare analogous products which are manufactured from the different vendors. Vendors can trade globally and find new market with cut down investment; financial facilities like bank can reduce transaction cost [1].

Regardless of those motivating benefits, some barriers interrupt the promotion of E-commerce websites. Those are abuse and misuse of information and failures of systems. The sources of such risks come from several factors such as less of performance, design, security and usability. If those risks are realized, we face several big and small losses: direct financial loss, loss of customer confidence, loss of business opportunity, etc.

As the variety of websites increases and usefulness of E-commerce, it gets more important to have a set of evaluation criteria that should meet three requirements. First, we need evaluation criteria that have strong theoretical backgrounds so that we can be sure that they are comprehensive and that they do not miss any important aspects of the usability of websites. Second, we need empirical validation for the evaluation criteria in order to be sure that they are relevant to what they intended to, and they produce a reliable result regarding the outcomes of the websites. Third, the criteria should be applicable to different types of websites [2].

This study will be present in five sections. Section II review a website metrics, section III review DEA, section IV review data collection, section V review results and section VI review the conclusions.

II. Website Metrics

From the above discussions, it is clear that we must pay careful attention to the web measurements in E-commerce. Fig. 1 illustrates the website measurements [3].

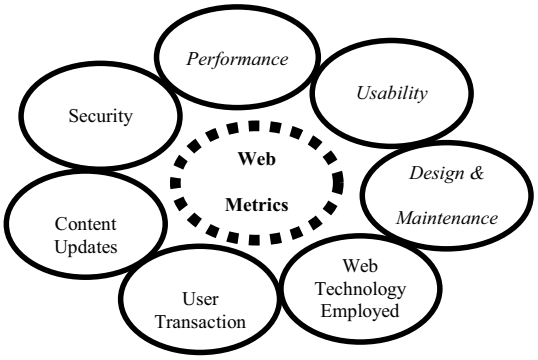

Fig. 1 How Web Sites Get Measured and Managed

This study will be focused on the design, usability and performance of E-commerce websites.

A. Design and usability

Poor of design and usability of Websites can lead to lost productivity and revenue. The question of how to improve the design of informational Web sites is thus of critical importance. Information, navigation, graphic, and experience are the design components can be further refined into the aspects depicted in Fig. 2 The bottom levels correspond to information, navigation, and graphic design (for example, text

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elements and formatting reflect the information design); the top levels correspond to experience design. The figure shows that text, link, and graphic elements are the building blocks of Web interfaces. Aspects on the next level address the formatting of these building blocks, and the subsequent level addresses page formatting. The top two levels address page performance and site architecture [4]. By using a Maxamine™ web analyst tool [5], we can use these components to assess a website design.

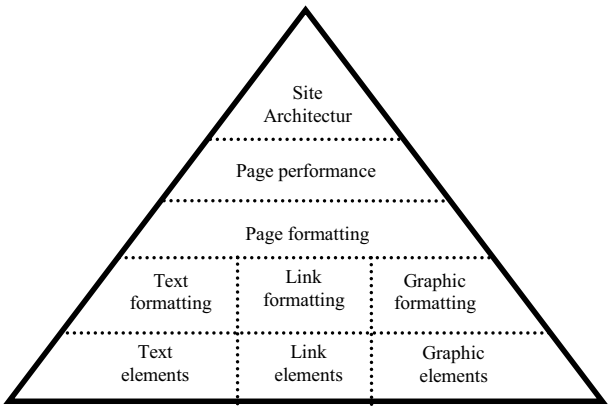

Fig. 2 Web site structure, Text, link, and graphic elements are the building blocks of a Web interface, Page and site level features use these elements to improve the user's experience.

A. Website performance

Website performance can be measured by response time. Response time represents the time (often an average) that elapses between the issue of a request and the return of the requested data. When your server is processing a large number of requests (under full load), requests may take longer to complete than if the server were unloaded. For user requests, this can result in increased response time for clients. If the server is under an excessive load, users may perceive the server as slow or unresponsive.

Human beings don't like to wait. We don't like waiting for Web pages to load. The home page is the interface of a site and it is very useful because:

1- The home page needs to be designed with particular care as this page is akin to the cover of a magazine or company report.
2- An in-depth evaluation of an entire Web site including its entire links is very time consuming and difficult.
3- The home page tends to set the tone and theme of the Web site [6].

For these reasons, the home page represent a very important factor for evaluating the website, Equation (1) represent a page response time [7]. From the equation (1) the page response time depends on the following variables: Page size is measured in Kbytes, the larger the page, the longer it takes to download. Minimum bandwidth is defined as the bandwidth of the smallest pipe between the end user and its ISP, Since today a large percentage of people are still connecting to the Internet using 56.6K modems, Round trip time (RTT) is the time lag, between the sending of a request from the user's browser to the Web server and the receipt of the first few bytes of data from the Web server to the user's computer. The term turns defines the number of TCP connections required to completely download a page, the last factor in the response time formula is the processing time required by the server and the client to put together the required page so it can be viewed by the requester.

B. Website traffic

The Website traffic considered a very useful web metric to

$$Page\ \mathrm{Re}\ sponse\ Time = \frac{\text{Page size}}{\text{Minimum Bandwidth}} + \begin{pmatrix} \text{Round} \\ \text{Trip} \\ \text{Time} \end{pmatrix} \text{x } Turns + \begin{pmatrix} Server \\ \mathrm{Pr}\ oces\ \mathrm{sin}\ g \\ Time \end{pmatrix} + \begin{pmatrix} Client \\ \mathrm{Pr}\ oces\ \mathrm{sin}\ g \\ Time \end{pmatrix} \quad (1)$$

evaluate a site, several web traffics put themselves forward as candidates for inclusion in the study; examples are: ''unique visitors'', ''page hits'', ''time spent'', and ''loyalty''. The unique visitors and page hits were chosen to evaluate the sites in this study [8].

II. Data Envelopment Analysis

DEA is one of operations research tool that is used to evaluate multi-criterion problems and it is because of this property, DEA is used to improve the efficiencies of the Decision Making Units (DMU's). It is a powerful quantitative, analytical tool for measuring and evaluating performance. It has been successfully applied to a host of different entities engaged in a wide variety of activities in many contexts worldwide [9].

The model implemented in this study is the input oriented, constant returns to scale, envelopment form of the DEA (Charnes, Cooper and Rhodes (CCR)) [10]. Assuming that there are n DMU's, each with m inputs and s outputs, the relative efficiency score of a test DMU p is obtained by solving the model (2).

$$\begin{aligned} Max \quad & \frac{\sum_{k=1}^{s} v_k y_{kp}}{\sum_{j=1}^{m} u_j x_{jp}}, \\ subject\ to \quad & \frac{\sum_{k=1}^{s} v_k y_{ki}}{\sum_{j=1}^{m} u_j x_{ji}} \le 1 \qquad \forall i \\ & v_k, u_j \ge 0 \qquad \forall k, j \end{aligned} \quad (2)$$

where:
$k = 1$ to s, $j = 1$ to m, $i = 1$ to n,
y_{ki} = amount of output k produced by DMU i,
x_{ji} = amount of input j utilized by DMU i,
v_k = weight given to output k,
u_j = weight given to input j.

The fractional program shown in equation (2) can be converted to a linear program as shown in the following system of equation (3).

$$\begin{aligned} &Max \quad \sum_{k=1}^{s} v_k y_{kp}, \\ &subjecto \quad \sum_{j=1}^{m} u_j x_{jp} \\ &\sum_{k=1}^{s} v_k y_{ki} - \sum_{j=1}^{m} u_j x_{ji} \le 0 \quad \forall i \qquad (3) \\ &v_k, u_j \ge 0 \quad \forall k, j. \end{aligned}$$

This problem may run n times in identifying the relative efficiency scores of all the DMU's. Each DMU selects input and output weights that maximize its efficiency score. In general, a DMU is considered to be efficient if it obtains a score of 1. However, a score of less than 1 implies that it is inefficient.

I. Data Collection

The data in this study has been collected at months July, August and September, year 2004 in order to avoid any distortion that might be introduced by the Christmas period.

Table I lists the new criteria that measure the efficiency of the e-commerce websites, Table II lists the websites domain and description and Table III lists Input and Output Data that collected by using a Maxamine™ web analyst tool [5].

TABLE I
PROPOSED WEBSITE INPUTS AND OUTPUTS

Inputs	Outputs
– Home page response time – Average page size (kB) – Total number of pages – Distinct number of foreign sites referenced – Percent of pages requiring two or more links to reach – Percent of pages greater than 60 kB	– Average daily hits – Average daily unique visitors

TABLE II
WEBSITES DESCRIPTION

	Website Name	Website Description	Website URL
1	EL-KATTAN	carpets	www.elkattan.com
2	WOOD STEEL	furniture	www.woodsteel.com
3	BSBUTIL	data security and communication	www.bsbutil.com
4	JUHAYNA	milk and juices	www.juhayna.com
5	JUMBO-BEKA	home service tools	www.jumbo-beka.com
6	NOVA	household appliances	www.nova-eg.com
7	STYLE TEAM	decorative light fittings and traditional lamps	www.styleteam.com
8	COMPU MAGIC	computer accessories	www.compumagic.com
9	ASFOUR	crystals and antiques	www.asfour.com

TABLE III
INPUT AND OUTPUT DATA

	Website Name	Inputs							Outputs
		HRT	PZ	NP	NFS	PPL	PPS	DH	DUV [a]
1	ELKATTAN	8.18	48.4	10	3	46.67	20	520	21
2	WOOD STEEL	12.09	227.7	84	18	82.02	100	471	7
3	BSBUTIL	21.21	216.2	5	5	27.27	100	547	16
4	JUHAYNA	8.48	76.8	29	1	0	86.2	360	23
5	JUMBO-BEKA	3.52	98.2	33	0	91.6	75.76	255	17
6	NOVA	15.48	44.7	9	2	44.45	33.33	301	26
7	STYLE TEAM	7.39	33.5	16	0	30	25	1030	41
8	COMPU MAGIC	35.4	219.3	26	2	6.45	96.15	210	19
9	ASFOUR	18.82	65.1	37	1	81.58	59.46	347	17

[a]where: HRT= home Page Response Time, APZ= Average Page Size, TNP=Total Number of Pages, NFS= distinct Number of Foreign Sites referenced, PPL= Percentage of Pages requiring two or more Links to reach, PPS= Percentage of Pages Size greater than 60 KB, ADH= number of Average Daily Hits, DUV= number of average Daily Unique Visitors.

V. Results

Using the data listed in Table III, a CCR, output oriented DEA approach was used to analyze the 9 Web sites. The DEA analysis results in four sites being rated as efficient and five sites are rated inefficient (<100%). Table IV list the sites efficiency. It is clear that the site name STYLE TEAM is the most efficient DMU and the least efficient DMU is the site name ASFOUR.

TABLE IV
EFFICIENCY SCORES

	Website	Rating
1	ASFOUR	21.34%
2	WOOD STEEL	27.93%
3	COMPU MAGIC	71.14%
4	EL-KATTAN	81.17%
5	JUMBO-BEKA	87.14%
6	BSBUTIL	100.00%
7	JUHAYNA	100.00%
8	NOVA	100.00%
9	STYLE TEAM	100.00%

Fig. 3 illustrates the websites efficiency in Table IV.

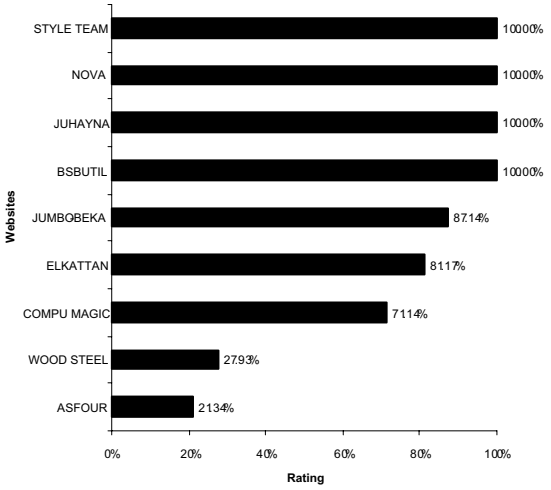

Fig. 3 Efficiency Scores

Fig. 4 illustrates the comparison between STYLE TEAM (the most efficiency website) and ASFOUR (the least efficiency website).

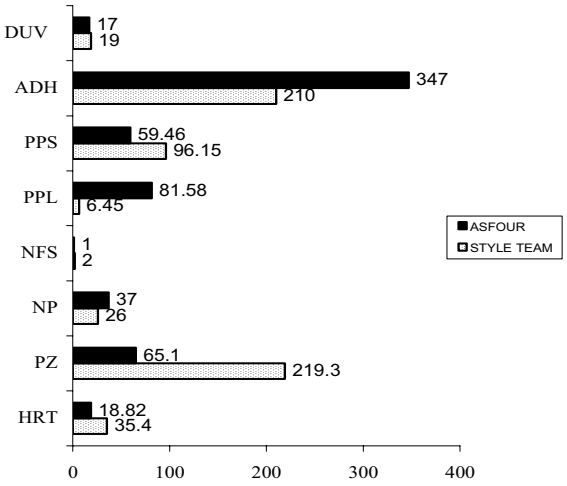

Fig. 4 ASFOUR Comparison with STYLE TEAM

ASFOUR website, with an overall efficiency rating of 21.34% suggests significant potential improvement for all inputs and outputs. Although a goal of this analysis is to understand the factors contributing to the maximization of outputs, Table V list the potential improvement analysis for ASFOUR website.

It seems like this could be the case for its high rate of Home page response time, Percentage of Pages requiring two or more Links to reach and Percentage of Pages Size greater than 60 KB, with potential improvement ratings of 83.51%, 84.8% and 82.52% respectively. Also number of Average Daily Hits may be increased, given its rating of 23.08% for this output variable, after applying potential improvements in ASFOUR website, the efficiency will be high to 100%. By applying the potential improvements to all inefficient sites in the study, these sites will be improved to efficiency 100%.

TABLE V
ASFOUR POTENTIAL IMPROVEMENT ANALYSIS

Input/Output	Actual	Target	Potential Improvement
HRT	18.8	3.1	-83.51%
PZ	65.1	13.9	-78.65%
NP	37	6.6	-82.165%
NFS	1	0	-100%
PPL	81.6	12.4	-84.8%
PPS	59.5	10.4	-82.52%
ADH	347	427.1	23.08%
DUV	17	17	0%

V. CONCLUSIONS

Implications of this study relate to a new model of a set of criteria that used to measure the efficiency of the design, usability and performance of websites, a home page response time is a very important factor used in this study, traffic used in this study as an outputs and it obtained from the websites server log files of the firms, the Effective analysis operations research technique (DEA) used to evaluate websites efficiency.

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