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Website Quality and Profitability Evaluation in Ecommerce Firms Using Two-stage DEA Model

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Abstract

This paper decomposes ecommerce business process into website quality and profitability and measures the efficiency in each sub-stage and the whole process. By comparing with efficiency scores in CCR, BCC and Kao and Hwang (KH) (2008) model, this paper finds that CCR and BCC model overvalues efficiency scores in contrast to KH model, which also implicitly reveals the poor coordination among business processes. From a single sub-process, it is more critical to improve website quality than profitability based on either sub-stage efficiency scores or return to scale analysis, while the profitability plays a more important role in the whole stage. This paper thus gives managerial insight on resizing its scale and optimizing resource allocation.

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Keywords: Data Envelopment Analysis; Website quality; Ecommerce; Two-stage DEA model

1. Introduction

The increasingly popularity of e-business causes evolving strategies innovation and business model reform. Whatever strategy a firm takes, the ultimate purpose is to gain profit or good performance. However, since that the e-business is a new industry and its development brings the innovation and reform from firm level to organization level, even to the whole macroeconomic environment, different researches explore the key factors affecting e-business economic performance from different perspectives. Some consider that the website design

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is a critical aspect of e-business strategy and plays an important role in attracting and retaining customers [1, 2] . A high-quality website not only brings the huge web traffic but also affects the customers' purchasing decision [3] . The service quality, website design, information quality, process management and ease of use are considered as the 6 dimensions affecting consumer satisfaction [4] . For e-business websites, several authors identify that website navigation, information, content, security, privacy, ease of use, real-time support, reliability, design and ease search are the key dimensions [5, 6] . For example, in the face of massive information, users often are only interested in the top list of search results, and if the website is not easy to be searched, it is possible for the visitors to convert into other websites, and result in the consumer loss. Especially in the network economy, it is important to correctly manage technology and website information to win sustainable competitive advantage.

With the rise of the big data in the internet, data mining and machine learning have become powerful tools for internet marketing and strategy. For example, online multiple instance learning based on boosting algorithm for moving object detection contributes to overall and rich information and data collection [7] . Robust Twin Support Vector Machine (R-TWSVM) can deal with noise data efficiently [8] . Due to the development of information and technology and the increasing popularity of e-business, e-commerce website quality and profitability evaluation becomes more and more important.

According to Porter's generic competitive strategy, the profitability of enterprises depends on industry conditions and values they can create more than their competitors. The value creation in e-business mainly results from information exchange benefits, high reach and richness of information, and network effect [9] . Thus the value chain in e-business is divided into two stages. In the first stage, initial input is converted into website quality, and in the second stage, the website quality is converted into profitability. Through the efficiency decomposition as website quality and profitability, this paper aims to answer the following questions:

1. Which sub-stages cause the overall operations inefficiency in ecommerce?
2. How does website quality affect profitability?

In order to give accurate answers to the above questions, appropriate methods need to be constructed. Data envelopment analysis (DEA) is a popular approach for measuring performance and resource waste of decision making units (DMUs) using multiple inputs to generate multiple outputs. It was initially proposed by Farrell (1957) [10] , then extended by Charnes et al. (1978) [11] (CCR) & Banker et al. (1984) [12] (BCC) to the constant return to scale (CRS) in the CCR model and the variable return to scale(VRS) in the BCC model.

Both CCR and BCC models are used to measure the efficiency in a single stage. In order to explore the series relationship between the two-stage of production process or value chain, two-stage models were developed by several scholars [13-18] . Färe and Grosskopf (1996) [13] introduced a network DEA model, which contributed to a greater understanding of inner production process [19] . Seiford and Zhu (1999) [20] developed a two-stage DEA to evaluate the profitability and marketability of 55 US commercial banks. They used three independent DEA models to calculate the efficiencies of the first stage, second stage, and the whole production process respectively. Similarly, Zhu (2000) [21] analyzed the financial efficiency of the Fortune 500 companies. However, the above studies are still in the frame of internal intermediate conflicts to evaluate the performance. For example, the outputs in the stage1 should increase while it should reduce as the inputs of the stage 2. In order to correct this intermediate conflicts, Kao and Hwang (2008) [18] modified the standard DEA model by empirical studies on non-life insurance companies in Taiwan. And their studies show that the relational model not only give a better description on the relationship between the whole process and sub-processes, but also produce more reliable results in efficiency measurement compared with the independent model. Since the two-stage DEA model was introduced, it has also been applied to measure the efficiency in the fields of bank [22-25] , Container Ports [26] , Purchasing and Supply Management (PSM) [27] , supply chain [28, 29] and other physical entities.

Given production process of e-business firms as the first-stage (transit) efficiency and second-stage (financial) efficiency (see figure1), this paper uses the standard DEA model to evaluate the efficiency of website quality and profitability in each stage separately first, then used the network DEA model to measure their internal relationships. The aim is to explore how website quality affects e-business profitability, and find

the internal resource waste. At a managerial level, this paper wishes to give suggestions on how to optimize the production process and resource allocation.

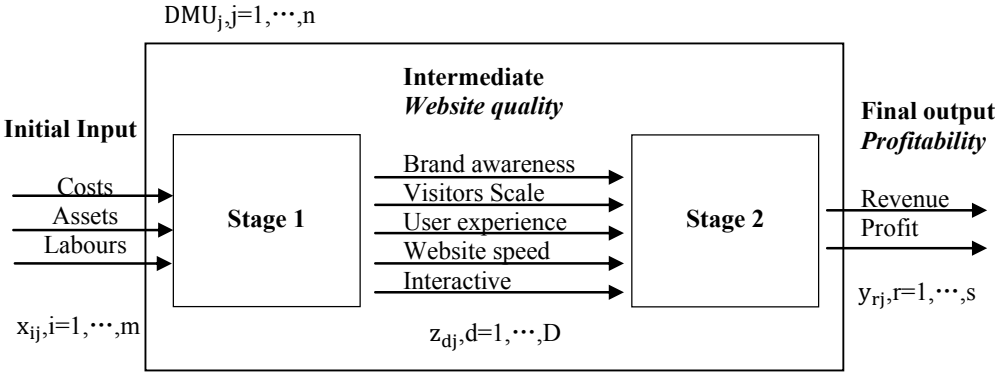

Fig1: Conceptual Framework of business process in pure ecommerce firms

The rest of the paper is organized as follows. Section 2 reviews the literature and describes methods. Section 3 presents empirical research results and discussions. Section 4 generalizes conclusions and further research.

2. Methods

2.1 Two-stage DEA

The most appropriate DEA models are those that are capable of measuring the conversion efficiency of initial input drivers into website quality (intermediate) while website quality converts into ultimate profitability. The two-stage DEA model, developed by Seiford and Zhu (1999) [20] to measure the profitability and marketability of 55 US commercial banks, is called as the standard two-stage DEA model. A common feature in the standard two-stage model is that the efficiency scores of various stages are independently calculated under CRS and VRS model. The following is the overall efficiency of the standard DEA model:

$$(D^{I}CCR)\begin{cases} min\theta = V_{C^2R} \leq 1 \\ \sum_{j=1}^{n} \mathrm{x_{ij}}\, \lambda_{ij} \leq \theta \mathrm{x_{i0}} \\ \sum_{j=1}^{n} \mathrm{y_{rj}}\, \lambda_{ij} \leq \mathrm{y_{r0}} \\ \lambda_{ij} \geq 0, j = 1, \dots, n; r = 1, \dots, s \end{cases} \tag{1}$$

Here x^1 is the initial input in the first stage, and $\mathrm{x_{ij}} > 0$. $\mathrm{z_{dj}}$ is the output in the first stage and also is the input in the second one, which is called intermediate indictors. Accordingly, y^3 represents the final (second) output. In CCR model, the status of returns to scale (RTS) can be determined by the sum of the optimal λ_{ij} values. Namely, for the $\mathrm{DMU_j}$, if $\sum_{j=1}^{n} \lambda_{ij}=1$, there is constant return to scale; if $\sum_{j=1}^{n} \lambda_{ij} > 1$, there is decreasing return to scale; and if $\sum_{j=1}^{n} \lambda_{ij} < 1$, there is increasing return to scale.It is same for respective two-stage CCR model .

$$P_{s_1}\begin{cases} max v^T z_{d0} = V_1 \le 1 \\ \omega^T \mathrm{x_{ij}} - v^T z_{d0} \ge 0, \\ \omega^T \mathrm{x_{ij}} = 1, \\ \omega \ge 0, v \ge 0 \\ i = 1, \dots m; j = 1, \dots, n; d = 1, \dots D \end{cases} \tag{2}$$

$$P_{s_2}\begin{cases} max \mu^T \mathrm{y_{rj}} = V_2 \le 1 \\ v^T z_{d0} - \mu^T \mathrm{y_{rj}} \ge 0, j = 1, \dots, n \\ v^T z_{d0} = 1 \\ v \ge 0, \mu \ge 0 \\ j = 1, \dots, n; d = 1, \dots D; r = 1, \dots s \end{cases} \tag{3}$$

Called "Black box", classic DEA model ignores the internal operations and linking activities. The network DEA model attempts to open the "Black box" from internal relationship perspectives, and attempts to correct the intermediate measures as the outputs in the first stage and the inputs in the second stage.

The above models (2) and (3) ignore the potential conflicts between the two stages arising from the intermediate measures [30] . Because intermediate variables are not only the outputs in the first stage but also the inputs in the second stage, and from the perspective of single production process, the intermediate (the outputs) in the first stage should be increased, meanwhile, as the inputs of the second stage, the intermediate should be reduced. In order to solve this internal conflicts, Kao and Hwang (2008) [18] introduced the two-stage DEA model by defining the whole-stage efficiency of $\mathrm{DMU_j}$ as the product of the two sub-stage efficiencies, namely $\theta_j = \theta_j^1 \times \theta_j^2$. Considering the internal linking and series relationship between the two stages, they assumed that $\eta_d^1 = \eta_d^2$ for d= 1, ⋯, D. And thus, the two-stage DEA model constructed for measuring the overall performance of each DMU is as follows:

$$(D^I KH)\begin{cases} \theta_0^* = Maximize \sum_{r=1}^{s} u_r y_{r0} \\ \sum_{i=1}^{m} v_i\, x_{io} = 1 \\ \sum_{d=1}^{D} \eta_d\, z_{dj} \le \sum_{i=1}^{m} v_i\, x_{ij}, j = 1, \dots, n \\ \sum_{r=1}^{s} \upsilon_r\, y_{rj} \le \sum_{i=1}^{m} v_i\, x_{ij}, j = 1, \dots, n \\ \sum_{r=1}^{s} \upsilon_r\, y_{rj} \le \sum_{d=1}^{D} \eta_d\, z_{dj}, j = 1, \dots, n \\ \eta_d, v_i, \upsilon_r \ge 0, \\ d = 1, \dots, D; i = 1, \dots, m; r = 1, \dots, s \end{cases} \tag{4}$$

Where $\mathrm{DMU_0}$ represents the DMU under evaluation, the two individual efficiency θ_0^1 and θ_0^2 can be calculated by the below equations [31] :

$$\theta_0^{1*} = \mathrm{Maximize} \sum_{d=1}^{D} \eta_d\, z_{dj}$$

$$\text{s.t.}\begin{cases} \sum_{i=1}^{m} v_i x_{i0} = 1 \\ \sum_{r=1}^{s} \upsilon_r\, y_{rj} - \theta_0^* \sum_{i=1}^{m} v_i\, x_{i0} = 0 \\ \sum_{r=1}^{s} \upsilon_r\, y_{rj} \le \sum_{i=1}^{m} v_i\, x_{ij}, j = 1, \dots, n \\ \sum_{d=1}^{D} \eta_d\, z_{dj} \le \sum_{i=1}^{m} v_i\, x_{ij},\ j = 1, \dots, n \\ \sum_{r=1}^{s} \upsilon_r\, y_{rj} \le \sum_{d=1}^{D} \eta_d\, z_{dj},\ j = 1, \dots, n \\ \eta_d, v_i, \upsilon_r \ge 0 \\ d = 1, \dots, D; i = 1, \dots, m; r = 1, \dots, s; \end{cases} \tag{5}$$

$$\theta_0^{2*}=\text{Maximize}\sum_{r=1}^{s} u_r y_{r0}$$

$$\text{s.t.}\begin{cases} \sum_{d=1}^{D} \eta_d z_{dj} = 1 \\ \sum_{r=1}^{s} \upsilon_r y_{r0} = \theta_0^* \sum_{i=1}^{m} \upsilon_i x_{i0} \\ \sum_{d=1}^{D} \eta_d z_{dj} \le \sum_{i=1}^{m} \upsilon_i x_{ij}, j = 1, \dots, n \\ \sum_{r=1}^{s} \upsilon_r y_{rj} \le \sum_{d=1}^{D} \eta_d z_{dj}, j = 1, \dots, n \\ \sum_{r=1}^{s} \upsilon_r y_{rj} \le \sum_{i=1}^{m} \upsilon_i x_{ij}, j = 1, \dots, n \\ \eta_d, \upsilon_i, \upsilon_r \ge 0 \\ d = 1, \dots, D; i = 1, \dots, m; r = 1, \dots, s \end{cases} \tag{6}$$

According to ecommerce development characteristics, the inputs are more controllable. Therefore, input oriented CCR and BCC models are used to measure the efficiency scores in each stage. For contrast, the relational two-stage DEA models by Kao and Hwang (2008) [18] are employed to find the internal operations and linking relations by calculating the overall and sub-stage efficiency scores. We aim to finding which stage caused the inefficiency and exploring how website quality affects the profitability in pure ecommerce firms.

2.2 Specification of input and output indicator

In DEA model, different variables combination can produce different efficiency scores. Thus it is important to choose appropriate indicators in efficiency measurement. Generally, an enterprise's development is contingent on the inputs of total operating expenses, total assets and the number of employee. Under the condition of ecommerce, attracting visitors, online transactions and logistics delivery are considered as the main business. The expenses of logistics, advertising and IT development account for more than 20% of total operations expenses according to the reports from Great Wall Securities of China, an organization of securities, futures and fund management. Therefore, we use total operating expenses, total assets and the number of employee as the initial inputs.

Understanding how website quality affects consumers' cognitive preference and purchasing decision can give some insights on how to improve e-business firms' financial performance. Compared with the traditional retail business, the customers do trading by the internet in ecommerce. A website is an important platform of transaction and information. The richness of information, online-service, easy to use, interactivities, users' experience, web traffic and reliability are the crucial factors affecting customers' purchasing decision. Thus, website quality is measured from four dimensions: brand, visitors, interactivities and speed in this study.

Considering external market competition, profitability measurement in ecommerce is divided into 3 parts: business revenue, operating profit and revenue market share, which respectively reflects sales force, profitability and market competiveness. The detail specification of intermediate (website quality) and final outputs (profitability) indicators is given in table 1.

Table1: Indicators specification of e-business website efficiency evaluation

Dimension	**Name**	**Definition**	**metrics**
Website quality	*Alexa traffic ranks*	Global rank is counted by the sum of daily average user visits and daily average page hits over the past three months.	How popular a site is relative to other sites?
	The total links	Counts the number of sites linking to this site.	Interactive with other sites

	The load time	The load time of an individual page is how long it takes for the DOM - the structure of the page - to be loaded.	How fast a page is loaded?
	Daily Time on Site per visitor	The metrics are updated daily based on the trailing 3 months. Daily Time on Site per visitor can estimate daily time on site (mm:ss) per visitor to the site.	users' experience
	Unique visitors	Unique visitors refer to the users with different IP address, which are counted by the mean in the past three months.	Website traffic and users' scale
Profitability	*Business Revenue*	Income that a company receives from its normal business activities, usually from the sale of goods and services to customers.	Sales force
	Operating Profit	Operating profit equals sales revenue minus cost of goods sold and all expenses except for interest and taxes. This is the surplus generated by operations.	Profitability
	Revenue market share	Revenue market share (%) = 100 * Sales Revenue ($) / Total Market Sales Revenue($)	Market competitiveness

2.3 Sample and data

The samples in this study are mainly from e-commerce/e-business quoted companies in the stock market of Shanghai, Shenzhen, Hong Kong, National Association of Securities Deal Automated Quotations (NASDAQ) and Taiwan. It is should note that e-commerce/e-business quoted companies in this sample only refer to the pure dot com companies rather than those companies with e-business application in a part of business. The reason why choose ecommerce website as the research sample is Chinese ecommerce market scale has realized the leap frog development in recent years. In 2013, e-commerce market scale in China achieved 99,000 billion Yuan, a 21.3% of year-on-year growth according to the reports of IResearch, a famous internet research consulting company in China. Under this background, this research hopes to provide some references and suggestions for ecommerce enterprises strategy development.

Financial data of e-business firms is collected from financial statements of quoted company in 2012, the company news and "China B2C online retailer Top50 Research Report", published by IResearch (www.iresearch.cn). Data of website quality is mainly got by Alexa (www.alexa.com) which is the leading provider of global web metrics.

3. Empirical results and discuss

3.1 Website quality and profitability conversion efficiency evaluation

Without considering the internal intermediate conflicts, ecommerce efficiency in each stage is respectively counted by the standard CCR model and BCC model. The results show the conversion efficiency in website quality is lower than that in profitability. Kao and Hwang (2008) [18] model reveals the same results. It means ecommerce websites do not fully take advantage of the characteristics of attracting users and marketing online, and thus there is still much room for website quality improvement.

To be specific, 3 DMUs achieve full efficiency in the first stage. Namely, only 12% websites in this

sample present the optimal resource allocation in website quality, they are respectively 300295.SZ (www.house365.com), 4965.TWO (www.pcstore.com.tw) and 002095.SZ (corp.netsun.com). However, these efficient DMUs in website quality do not achieve full efficiency in profitability. On the contrary, they have lower or poor efficiency scores in the second stage (profitability). It implicitly shows for these DMUs, it is profitability to cause technical inefficiency in the whole stage.

When it comes to profitability, 5 DMUs achieve full technical efficiency in the second stage (profitability), which is account for 20% of the sample. However, none of them is efficient in website quality. Please see table2. For these DMUs, website quality plays a critical role in causing technical inefficiency of the whole stage.

Taken into account internal operation and linking activities, the results of KH model indicate that the whole and sub-production stage efficiency in ecommerce are very low, which implicitly suggests that ecommerce efficient operation need consider the internal business process, organization structure and external market competitive environment. Namely, though e-business tools contribute to cost reduction and time saving, if there is no smooth production process, strong information technology supports and matched logistics and services, virtual operation in ecommerce firms will get failure. The mean of overall efficiency scores in standard DEA model (CCR and BCC) is far higher than that in KH model, which also identities the weak coordination among business processes.

Table2: efficiency score in standard DEA model and KH model

Code	**DMU Name**	**stage1 Website quality**			**stage2 Profitability**			**Overall Operation efficiency**		
		E_{CCR1}	E_{BCC1}	E_{KH1}	E_{CCR2}	E_{BCC2}	E_{KH2}	E_{CCR}	E_{BCC}	E_{KH}
AMZN.O	www.amazon.com/ir	0.277	1.000	0.011	1.000	1.000	1.000	1.000	1.000	0.011
DANG.N	www.dangdang.com	0.135	0.734	0.135	1.000	1.000	1.000	1.000	1.000	0.135
MCOX.O	www.m18.com	0.042	0.046	0.030	0.234	1.000	0.224	0.715	0.715	0.007
VIPS.N	www.vipshop.com	0.082	1.000	0.060	1.000	1.000	0.235	0.933	1.000	0.014
EBAY.O	www.ebay.com	0.279	1.000	0.017	1.000	1.000	0.637	0.770	1.000	0.011
AWAY.O	www.homeaway.com	0.159	0.618	0.119	0.038	0.509	0.031	0.682	0.682	0.004
EJ.N	www.ehousechina.com	0.007	0.007	0.003	0.578	1.000	0.173	0.515	0.518	0.000
300295.SZ	www.house365.com	1.000	1.000	1.000	0.000	0.519	0.007	1.000	1.000	0.007
000503.SZ	www.emedchina.cn	0.307	1.000	0.043	1.000	1.000	1.000	1.000	1.000	0.043
BITA.N	www.bitauto.com	0.841	1.000	0.537	0.338	0.580	0.081	1.000	1.000	0.044
CTRP.O	www.ctrip.com	0.023	0.163	0.022	1.000	1.000	0.854	0.909	1.000	0.019
LONG.O	www.elong.com	0.065	0.282	0.054	0.485	0.911	0.391	0.672	0.684	0.021
EXPE.O	www.expediainc.com	0.005	0.009	0.005	1.000	1.000	1.000	0.748	0.752	0.005
NFLX.O	www.netflix.com	1.000	1.000	0.131	0.506	0.785	0.221	1.000	1.000	0.029
PCLN.O	www.priceline.com	0.070	0.191	0.031	1.000	1.000	1.000	1.000	1.000	0.031
TRIP.O	www.tripadvisor.com	1.000	1.000	0.181	0.243	1.000	0.124	1.000	1.000	0.022
4965.TWO	www.pcstore.com.tw	1.000	1.000	1.000	0.000	0.522	0.000	1.000	1.000	0.000
ATV.N	ir.chinadrtv.com	0.053	0.062	0.014	1.000	1.000	1.000	0.788	0.789	0.014
GRPN.O	www.groupon.com	0.315	0.530	0.072	0.350	0.733	0.166	0.934	0.940	0.012
LITB.N	www.lightinthebox.com	0.320	1.000	0.250	0.145	0.708	0.087	1.000	1.000	0.022
GSOL.O	www.globalsources.com	0.342	0.810	0.291	0.190	0.745	0.134	1.000	1.000	0.039
8292.HK	www.hc360.com	0.200	1.000	0.098	0.233	0.529	0.176	0.950	0.955	0.017
002315.SZ	www.focuschina.com	0.543	0.565	0.435	0.000	0.939	0.045	1.000	1.000	0.020

002095.SZ	corp.netsun.com	1.000	1.000	1.000	0.000	0.658	0.035	1.000	1.000	0.035
300226.SZ	www.mysteel.com	0.477	1.000	0.130	0.001	0.535	0.017	0.582	0.626	0.002
mean		**0.382**	**0.681**	**0.227**	**0.494**	**0.827**	**0.386**	**0.888**	**0.906**	**0.023**

3.2 Return to scale analysis in each stage

Return to scale (RTS) measurement is very useful in DEA application. In a view of production theory, it gives the insights on how scale affects operations efficiency. Input oriented RTS analysis is done to find how to improve operations efficiency by resizing a DMU's scale in each sub-production stage and the whole stage.

The results in table3 show that most inefficient DMUs present decreasing return to scale in the first stage. Namely, the proportionate rise in the inputs overpasses that in the outputs. Accordingly, in the first stage, the initial inputs should be reduced, while the websites' functions (outputs in the first stage) such as attracting visitors, online advertising and marketing, interactive service with consumers etc., need to be improved.

Interestingly, in the second stage, all inefficient DMUs show increasing return to scale. It means that the proportional rise of inputs in website quality is less than that in profitability, so it needs to improve website quality to achieve constant return to scale. The results in both the first stage and the second stage emphasize the importance of website quality improvement.

Return to scale in the overall efficiency without intermediate factors indicates that most inefficient DMUs exhibit decreasing return to scale, which means there is a shortage of profitability improvement in the conversion from the initial inputs to the final outputs. Therefore, it is necessary to enhance the profitability in the overall production process.

Table 3: Return to scale analysis in two-stage business process of ecommerce firms

DMU No.	Code	DMU Name	stage1 Input-oriented RTS	stage2 Input-oriented RTS	overall Input-oriented RTS
1	AMZN.O	www.amazon.com/ir	Decreasing	Constant	Constant
2	DANG.N	www.dangdang.com	Decreasing	Constant	Constant
3	MCOX.O	www.m18.com	Increasing	Increasing	Decreasing
4	VIPS.N	www.vipshop.com	Decreasing	Constant	Decreasing
5	EBAY.O	www.ebay.com	Decreasing	Constant	Decreasing
6	AWAY.O	www.homeaway.com	Decreasing	Increasing	Increasing
7	EJ.N	www.ehousechina.com	Increasing	Increasing	Decreasing
8	300295.SZ	www.house365.com	Constant	Increasing	Constant
9	000503.SZ	www.emedchina.cn	Decreasing	Constant	Constant
10	BITA.N	www.bitauto.com	Decreasing	Increasing	Constant
11	CTRP.O	www.ctrip.com	Decreasing	Constant	Decreasing
12	LONG.O	www.elong.com	Decreasing	Increasing	Decreasing
13	EXPE.O	www.expediainc.com	Increasing	Constant	Decreasing
14	NFLX.O	www.netflix.com	Constant	Increasing	Constant
15	PCLN.O	www.priceline.com	Decreasing	Constant	Constant
16	TRIP.O	www.tripadvisor.com	Constant	Increasing	Constant
17	4965.TWO	www.pcstore.com.tw	Constant	Increasing	Constant

18	ATV.N	ir.chinadrtv.com	Increasing	Constant	Decreasing
19	GRPN.O	www.groupon.com	Decreasing	Increasing	Increasing
20	LITB.N	www.lightinthebox.com	Decreasing	Increasing	Constant
21	GSOL.O	www.globalsources.com	Decreasing	Increasing	Constant
22	8292.HK	www.hc360.com	Decreasing	Increasing	Decreasing
23	002315.SZ	www.focuschina.com	Increasing	Increasing	Constant
24	002095.SZ	corp.netsun.com	Constant	Increasing	Constant
25	300226.SZ	www.mysteel.com	Decreasing	Increasing	Decreasing

4. Conclusions and future work

Increasing popularity of ecommerce makes it become growingly important for website quality and profitability evaluation in ecommerce firms. By decomposition ecommerce business process into website quality and profitability, we get some interesting and suggestive findings.

First, in standard two-stage DEA (CCR and BCC) measure, both sub-stage and overall efficiency in ecommerce are higher than that in KH model taken into account internal series relationship and linking activities. In other words, efficiency score in standard two-stage DEA is overvalued in contrast to that in KH model, which also reveals the poor coordination among business processes. From a managerial view, virtual operation in ecommerce firms needs to focus on e-business application match with organization structure and internet strategy so that it can take advantage of cost saving to increase overall operation efficiency.

Secondly, either in CCR, BCC or KH model, website quality is the main factor resulting in operation inefficiency. As an important transaction and communication platform, a website needs to take better use of the characteristics of attracting visitors and online marketing for the efficiency improvement. Of course, profitability is as important as website quality, any change between the two will cause efficiency changes.

Thirdly, when it comes to how to optimize resource allocation by resizing the scale, return to scale analysis in sub-stage and overall production process is done. The results indicate that there is decreasing return to scale in the first stage and increasing return to scale in the second stage, and accordingly decreasing return to scale in the whole production stage. It implicitly suggests it is more urgent to improve website quality in the two sub-stages. In contrast, profitability plays a more important role in overall operation efficiency improvement.

The above findings provide interesting insights to how to improve operation efficiency according to website quality and profitability. However, there are also some limitations in this study. First, the total inputs of operations cost, assets and employee can be shared with the two sub-stages. Secondly, the sample is very small due to the nature of emerging industry. The above limitations can be further solved by the data and methods improvement in the future works.

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