

## Construction and Simulation of Competitiveness Evaluating Model for E- commerce Enterprise Based on DEA

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### **Abstract**

*Recently, with the rapid development of e-commerce businesses, each business is more competitive, an import problem exists in the development of E-business is that the efficiency of enterprises is not increasing as soon as the increasing of the investment. The reason is that the efficiency between input and output can't be evaluated exactly. So, in order to solve this problem with quantitative methods, two DEA models are established based on input data and output data of 11 e- commerce enterprises from 2011 to 2013. Input data includes marketing costs, number of employees and the total assets. Output data includes the number of network member and operating incomes. Static BCC model is established based on VRS firstly. The development status of each enterprise in three years and the overall development trends of all enterprise are analyzed. Dynamic DEA-Malmquist model is set up based on VRS too. The Dynamic data are analyzed. Finally, in view of the change trend of different enterprises in three years, developing shortcomings are pointed out, reason are analyzed, further enterprise development strategy and methods are put forward.*

**Keywords:** *e-commerce, relative efficiency, data envelopment analysis, quantitative analysis*

### **1. Introduction**

In recent years, with the rapid development of electronic commerce, more and more enterprises want to develop their competitiveness in this way. IResearch paper shows that in 2013, the deal transaction size of China's e-commerce market is 9.9 trillion Yuan, and the increasing rate is 21.3%. At the same time, e-commerce enterprises met with the bottleneck, costs continued increasing and the profits felt sharply. So How to improve the operating efficiency of e-commerce enterprises has become an important issue.

Identify relative efficient business by analyzing the enterprise's operating efficiency, and this not only allows enterprises to find themselves' inadequate to promptly improve it, but also can provide a reference sample for other enterprise when they make decisions.

### **2. Main Models of DEA**

#### **2.1. CCR**

In 1978, charms, cooper and rhodes farrell proposed the CCR model which named by their own names, and CCR model became the first DEA model<sup>[1]</sup>. By using the linear programming techniques and the production frontier determined by assessment of each unit, CCR model can calculate the relative efficiency of the value of each DMU from the input and output<sup>[2]</sup>. Suppose there are n DMUs, each type of DMU has m inputs ( $X_j$ ), n outputs ( $Y_j$ ) and slack variables S<sup>[3]</sup>. From the output angle, CCR model means under the same input level, the output is increased as much as possible. In other words, the increase in output not directly accounted for by extra inputs of capital and labour. CCR

model is shown as follows:

$$\left\{ \begin{array}{l} \max_{\lambda, OS, IS} [\alpha - \varepsilon(MI'OS + SI'IS)] \\ \text{st } X_{jo} - \sum_{j=1}^n \lambda_j X_j - IS = 0 \\ \alpha Y_{jo} - \sum_{j=1}^n \lambda_j Y_j + OS = 0 \\ \varepsilon > 0, \lambda_j \geq 0, j = 1, \dots, n \end{array} \right.$$

$$\begin{aligned} X_j &= (x_{1j}, x_{2j}, \dots, x_{mj})^T \\ Y_j &= (y_{1j}, y_{2j}, \dots, y_{sj})^T \\ IS &= (s_{1I}, s_{2I}, \dots, s_{mI})^T \text{ is input slacks} \\ OS &= (s_{1O}, s_{2O}, \dots, s_{sO})^T \text{ is output slacks} \\ \lambda_j &\text{ is a } N \times 1 \text{ vector of constants} \\ MI &= (1, 1, \dots, 1)_{1 \times m}^T \\ SI &= (1, 1, \dots, 1)_{1 \times s}^T \end{aligned}$$

## 2.2. BBC

CCR model is based on the assumption of constant returns to scale, which is inconsistent with the actual situation of enterprises. So in 1984, Banker, Charnes and Cooper conducted a BCC model [4]. Based on the CCR model, adding an assumption

terms which is  $\sum_{j=1}^n \lambda_j = 1$ . Output-Orientated model is shown as follows:

$$\left\{ \begin{array}{l} \max_{\alpha, \lambda} \alpha \\ \text{st } \sum_{j=1}^n \lambda_j X_{ij} \geq X_{ijo} \\ \sum_{j=1}^n \lambda_j Y_{rj} \leq \alpha Y_{rjo} \\ \sum_{j=1}^n \lambda_j = 1 \\ \lambda_j \geq 0, i = 1, \dots, m, r = 1, \dots, s, j = 1, \dots, n \end{array} \right.$$

$$\begin{aligned} X_{ij} &= (x_{1j}, x_{2j}, \dots, x_{mj})^T \\ Y_{rj} &= (y_{1j}, y_{2j}, \dots, y_{sj})^T \\ \lambda_j &\text{ is a } N \times 1 \text{ vector of constants} \end{aligned}$$

Assumption of BCC model is changed from constant returns to scale to variable returns to scale [5]. So "pure" technical efficiency (PTE) can be calculated by BCC. Many studies decomposed the technical efficiency (TE) obtained from a CCR into two components, one is the scale efficiency (SE) and another one is PTE. The difference between these two TE is that TE in BCC is put down the scale efficiency. That is  $TE = PTE \times SE$ .

### 2.3. Malmquist Model

Though CCR model and BCC model can calculate the relative efficiency of different enterprise, but they only can be applied to the cross-sectional data and cannot evaluate the efficiency of the dynamic changes in the decision-making unit. So in 1994, Rolf Fare combined Malmquist index which developed by Malmquist in 1953 with data envelopment analysis and constructed an output-based Malmquist total factor productivity<sup>[6]</sup>. It use a input-based or output-based Malmquist TFP index to measure productivity change, and decompose this productivity change into technical change and technical efficiency change. which is shown as follow:

$$\begin{aligned}
 No(x_{t+1}, y_{t+1}, x_t, y_t) &= \left[ \frac{d_n^t(x_{t+1}, y_{t+1})}{d_n^t(x_t, y_t)} \times \frac{d_n^{t+1}(x_{t+1}, y_{t+1})}{d_n^{t+1}(x_t, y_t)} \right]^{1/2} \\
 &= \frac{d_n^{t+1}(x_{t+1}, y_{t+1})}{d_n^t(x_t, y_t)} \times \left[ \frac{d_n^t(x_{t+1}, y_{t+1})}{d_n^{t+1}(x_{t+1}, y_{t+1})} \times \frac{d_n^t(x_{t+1}, y_{t+1})}{d_n^{t+1}(x_t, y_t)} \right]^{1/2} \\
 &= Effch \times Techch = Pech \times Sech \times Techch
 \end{aligned}$$

Effch is the change index of technique and efficiency, Techch is change index of technique progress, Pech is the pure change index of technique, Sech is the change index of scale efficiency.

## 3. Empirical Analysis of DEA

### 3.1. Indicators and Data Selection

11 e-commerce businesses are selected; they are Suning, Guomei, Amazon, Jingdong, Vipshop, Dangdang, Mcox, Huicong, Focus Technology, Global Sources, Shengyibao. All selected business is the performed better e-commerce businesses, which basically represent the development of e-commerce industry. Generally, twice the sum of inputs and outputs should less than the number of DMU. Therefore, according to the selected 11 DUM, the total number of input and output indicators should less than 5.

In accordance with common ruler of the number of input and output indicators, combines the characteristics of e-commerce businesses, " turnover " ( thousand) and " member " ( one hundred thousand ) are selected as output indicators, " Marketing costs " (thousand) , "Technology and content " (thousand) , " number of employees " ( a ) act as the inputs of the model.

The members means registered member, Their data comes from the 11 listed enterprises in 2011-2013 annual report from Baidu Google and other search engines<sup>[7]</sup>. There are four enterprises' annual reports calculate in U.S. dollars , and which are translated with the end of each year of the Bank of China announced about the U.S. dollar.

### 3.2. Static Efficiency Analysis

**3.2.1. Tool of DEA:** With DEAP 2.1 software tool, the BCC(VRS) model based on output (under the same circumstances, how to expand output and maximize the output) is used in order to obtain the efficiency of specific circumstances of 11 e-commerce business from 2011 -2013. Model results are shown in Table 1.

**3.2.2. Three Years Data Analysis:** some changes will be found in the efficiency of enterprises 2011-2013 through analyzing Table 1.

In 2011, four enterprises' business efficiency is effective, namely: Suning, Amazon, vip shop, dangdang, and the remaining six's business efficiency is keeping in decline. The

reason that enterprise efficiency declines mostly because the lower efficiency of enterprise scale.

In 2012, five enterprises' business efficiency is effective, namely: Suning, Amazon, the only product, dangdang, McCaw, and the remaining five enterprises' efficiency are invalid, among these 11 enterprises, nine enterprises are keeping technically valid, and only five's enterprise -scale is effective. Therefore, we can see that the scale efficiency is an important factor for the efficiency of enterprises.

Similarly, analyze 2013 five enterprises are effectively, and there're eight enterprises which are in technology effectively, five enterprise are in scale effective. From 2011 to 2013 the overall efficiency of e-business was being declining, and the overall average dropped to 0.657 from 0.743 <sup>[8]</sup>. And the corresponding pure technical efficiency and scale efficiency declined, either, the moderate scale dropped to 0.828 from 0.84, while the pure technical efficiency decreases rapidly from 0.866 to 0.803.

The reason why the overall efficiency is low is that pure technical is inefficient, the use of technology has low efficiency, and the emerging scientific management methods and techniques are not used, such as: technology integrated processing and analysis of data on consumer spending is weak, cannot form an effective big data analysis, cannot grasp the user 's spending habits, which make it impossible to develop appropriate marketing strategies , resulting in lower corporate pure technical efficiency .

As the e-commerce transaction scale is expanded after 2011, e-commerce enterprises want to expand the scale and achieve increased business efficiency, but due to the appropriate technical support cannot keep up, the larger the scale, the more cost in investment, and without corresponding output, which leads to the current status of e-commerce businesses overall efficiency is not high . In B2B, for example, according to iResearch research institutions, the proportion of the annual turnover of B2B e-commerce business in 2011 represents a slight decrease of 1.7 percentage points compared with 2010 transactions, various enterprises accelerate the expansion of the market, but did not increase their efficiency, thus see that blind expansion of business scale in order to seize the market enterprises is not advisable.

**Table 1. Analysis Data by Deap2.1**

| firm             | 2011  |       |       |                         | 2012  |       |       |                         | 2013  |       |       |                         |
|------------------|-------|-------|-------|-------------------------|-------|-------|-------|-------------------------|-------|-------|-------|-------------------------|
|                  | crste | vrste | scale | Return<br>s to<br>scale | crste | vrste | scale | Return<br>s to<br>scale | crste | vrste | scale | Return<br>s to<br>scale |
| Suning           | 1     | 1     | 1     | -                       | 1     | 1     | 1     | -                       | 1     | 1     | 1     | -                       |
| Guomei           | 0.734 | 1     | 0.734 | drs                     | 0.794 | 1     | 0.794 | drs                     | 0.49  | 1     | 0.49  | drs                     |
| Amazon           | 1     | 1     | 1     | -                       | 1     | 1     | 1     | -                       | 1     | 1     | 1     | -                       |
| JD               | 0.527 | 1     | 0.527 | drs                     | 0.298 | 1     | 0.298 | drs                     | 0.447 | 1     | 0.447 | drs                     |
| VIPS             | 1     | 1     | 1     | -                       | 1     | 1     | 1     | -                       | 1     | 1     | 1     | -                       |
| Dang             | 1     | 1     | 1     | -                       | 1     | 1     | 1     | -                       | 1     | 1     | 1     | -                       |
| Mcox             | 0.245 | 0.374 | 0.655 | drs                     | 1     | 1     | 1     | -                       | 1     | 1     | 1     | -                       |
| Huicong          | 0.61  | 0.78  | 0.782 | drs                     | 0.271 | 0.276 | 0.983 | irs                     | 0.193 | 0.227 | 0.851 | drs                     |
| Focus Technology | 0.718 | 0.758 | 0.946 | irs                     | 0.334 | 1     | 0.334 | irs                     | 0.253 | 0.283 | 0.893 | irs                     |
| DSOL             | 0.42  | 0.618 | 0.679 | drs                     | 0.283 | 0.291 | 0.973 | irs                     | 0.286 | 0.32  | 0.894 | irs                     |
| shengyibao       | 0.921 | 1     | 0.921 | irs                     | 0.678 | 1     | 0.678 | irs                     | 0.555 | 1     | 0.555 | irs                     |
| mean             | 0.743 | 0.866 | 0.84  |                         | 0.696 | 0.87  | 0.824 |                         | 0.657 | 0.803 | 0.83  |                         |
| effective number | 4     | 7     | 4     |                         | 5     | 9     | 5     |                         | 5     | 8     | 5     |                         |

### 3.3. Business Type Analysis

From Table 1, the efficiency value of enterprises is one, such as Suning, Amazon, The vip shop, Dangdang, Mocw, and they are all B2C business, their technical efficiency, pure technical efficiency and scale efficiency are higher than most of the other B2B business.

**3.3.1. B2C:** the reason why B2C business efficiency is higher than other modes businesses mainly dues to the rapid development of e-commerce market , turnover from 2011's 7 trillion to 2012's 8.1 trillion, in 2013 the trade volume grows to 9.9 trillion, and the average annual growth rate reaches 31.8%. Online shopping market share has continued to climb, the share in B2C market increases rapidly, from 2011 to 2013, the proportion rose to 29.7 percent from 20 percent and then to 35.1%, increased 28.3% every year, B2C online shopping market will continue to be the main driving force for this industry. Now people's awareness of online shopping strengthens, comparing shopping in the store, people are more willing to enjoy the benefits and convenience of online shopping, so online shopping transaction volume continues to increase? B2B enterprises do not monopolize, all enterprises can diversify expansion, completed the transformation scale. Guomei and Jingdong should adjust the size of the construction; the present model does not match the e-commerce market. They have been in a state of diminishing returns, because they have lower efficiency; the direct reason is the low scale efficiency.

**3.3.2. B2B:** B2B e-commerce enterprises in this article were assigned as B2B SME by iResearch organizations, from 2011, onwards SME B2B market grew slowly of 35.7%, in 2012, growth fell by 26.5%, in 2013, the growth rate continued to decline to 25.8%. Meanwhile B2C market is growing rapidly, in 2013, China B2C online shopping market grew 68.4%, the online shopping market share continued to enhance, crowded SME B2B market share. HC B2B enterprises operated worst, the lowest efficiency of pure technical, scale efficiency was in the lower level, and invested more , but less revenue, and this year it continued to decline. This may be due to its market share reduced in B2B e-commerce industry, the competition increased, and the rapid development of Alibaba. The enterprises should restructure, upgrade, maintain the original market position, and develop new models and improve market share based on existing core strengths of business to change this status. Enterprises should increase investment in research and technology, restructure the enterprises to accelerate profit model innovation to match enterprise size and facilities.

In short, the technical efficiency of enterprises is low, B2C enterprises efficiency scale can't keep pace with the development of e-commerce scale, and B2B enterprises are mainly caused by pure technical inefficiency, which is caused by the bottleneck encountered by development of enterprises, and they develop the scale of development without developing the appropriate technology dues to their technology efficiency low. E-commerce enterprises can expand market share to seize the customers and Expand market share with profits, one side, they put in a lot of advertising for publicity, in another side, they use lower prices and price competition, results the low scale.

## 4. Malmquist DEA Construction

### 4.1. Malmquist Dynamic Analysis

These are the technical efficiency analysis on e-commerce business, this analysis is comparative analysis which is conducted from a static point of view, and certainly there are dynamic changes in business development, while the analysis based on DEA Malmquist index can analyze the technology and production index separately, resulting in the trend analysis of the development of various enterprises in different years<sup>[9]</sup>. Input three years of data of The 11 e-commerce businesses into DEA-Malmquist panel model, the value of average change of 11 e-business for three years can be obtained, and the data is shown in Table 2.

**Table 2. Average Annual Change in 11 E-commerce Enterprises from 2011 to 2013**

| MALMQUIST INDEX SUMMARY OF FIRM MEANS (three years) |       |        |       |       |       |
|---|-------|--------|-------|-------|-------|
| firm  | effch | techch | pech  | sech  | tfpch |
| 1   | 1     | 0.891  | 1     | 1     | 0.891 |
| 2   | 0.817 | 0.952  | 1     | 0.817 | 0.778 |
| 3   | 1     | 0.875  | 1     | 1     | 0.875 |
| 4   | 0.922 | 1.316  | 1     | 0.922 | 1.213 |
| 5   | 1     | 1.075  | 1     | 1     | 1.075 |
| 6   | 1     | 1.029  | 1     | 1     | 1.029 |
| 7   | 2.019 | 2.165  | 1.634 | 1.236 | 4.371 |
| 8   | 0.563 | 1.97   | 0.539 | 1.043 | 1.108 |
| 9   | 0.594 | 2.062  | 0.611 | 0.972 | 1.225 |
| 10  | 0.826 | 1.414  | 0.72  | 1.147 | 1.167 |
| 11  | 0.776 | 1.779  | 1     | 0.776 | 1.38  |
| mean  | 0.903 | 1.335  | 0.917 | 0.984 | 1.205 |

#### 4.2. Corporate Perspective

During 2011 to 2013, the total factor productivity index declined enterprises are only Suning and Gome and all other enterprises had growth differently in 11 e-commerce enterprises. The reason why the productive forces of these two enterprises declined is mainly regressed technology. Specifically there is no innovation in the business, no introduction of new products, new services, and all these have been maintained in the current model, and only expand the scale <sup>[10]</sup>. Like Gome, Suning such traditional enterprise 's core strength lies in doing electrical supply, but they also should address the legitimate online business orientation, and make the appropriate operational strategies to meet consumer demand timely in order to develop better. This is a warning, if you only focus on the scale e-commerce businesses, increase promotional advertising investment, access to short-term benefits, rather than continue to improve and innovate, and then the productivity will decline, and affect operational efficiency.

From the table, other enterprises' 'tfpch' increases mostly due to the increased 'techch'. Specifically business-to-business restructuring now, the introduction of new services, such as: Global Resources and Huicong enterprises try to teamed up electricity supplier enterprises to open B2B and B2C model of cooperation and achieve win-win business. And ShengYiBao conducts B2B payment platform through the whole industry chain. Amazon and Dangdang develop their own logistics and distribution system. Jingdong, Dangdang and other electricity providers have expanded open platform to attract merchants settled, and make strategic layout for the whole category of electricity providers and so on. These measures have improved the changes of technological progress, also improved 'tfpch'.

Although, the major electricity supplier enterprises through various forms of promotion to dig online shoppers' consumption potential, which led to the rapid growth of online shopping market, their effectiveness increased, but the efficiency of these three techniques is declining, the main reason is the static analysis like the front , with the rapid growth of e-commerce transactions, e-commerce enterprises want to quickly occupy the market, so they only focus on the blind expansion of the scale by investing in advertising, promotion, while ignoring their own resources integration, operation mode, internal structure, and the application of advanced technology.

### 4.3. Relative Change in Three Years

Similarly, Table 3 shows relative change data of 11 e-commerce enterprise market for three years.

**Table 3. Relative Change in the Value of E-commerce Business Efficiency from 2011-2013**

| MALMQUIST INDEX SUMMARY OF ANNUAL MEANS (every year) |       |        |       |       |       |
|--|-------|--------|-------|-------|-------|
| year   | effch | techch | pech  | sech  | tfpch |
| 2011-2012  | 0.883 | 1.629  | 0.952 | 0.927 | 1.439 |
| 2012-2013  | 0.923 | 1.093  | 0.884 | 1.044 | 1.009 |
| mean   | 0.903 | 1.335  | 0.917 | 0.984 | 1.205 |

As Table 3, comprising the average efficiency indicators of 2011, in 2012, effch, techch, pech were all declining, while the sech, tfpch were both growing, overall productivity efficiency was growing. Analyzing the reasons, we can know that B2B business efficiency was declining from 2011 to 2012, in addition to the European debt crisis intensified, the U.S. economic recovery is slow, accelerate the pace of global economic contraction macroeconomic outside, after B2B e-commerce has developed for more than ten years, the original business model platform met bottlenecks. Therefore, B2B enterprises participated in every step in trading links between businesses and provided convenient financial services, security services to create electricity supplier B2B ecosystem. B2B enterprises' 'techch' grew by making industry consolidation, restructuring, upgrading and innovating, researching and developing new products and new services, innovating business model. However, rapid advances in technology cannot bring technology efficiency improvement, so 'effch' decreased by 11.7%.

Even with the declining of 'effch' and 'pech' from 2012 to 2013, while 'techch', 'sech' and 'tfpch' were rising. By analyzing the reasons, we can know that in 2013, the economy improves, enterprises expand the scale and increase investment to seize the market, but it is a step backward for 'pech', and business efficiency decreases. And enterprises haven't large-scale innovative projects, so 'techch' increases by 9.3%, but the rate is less than which in 2011-2012. However, because the operating efficiency is rising, so it indicates that technological progress growing slowly in operating efficiency.

From 2011 to 2013, 'tfpch' has increased which mainly due to 'techch' meets up the lack of 'effch', and the lack of 'effch' causes in the reason that 'pech' and 'sech' have backwards. During these three years, the average 'effch' of all commercial enterprises declined by 9.97 % per year. 'techch' increases of 33.5% per year, so 'tfpch' grows by 20.5 % per year. Although 'tfpch' increased, but the decline has been hampered by technical efficiency of the development of productive forces. Thus, enterprises improve their science and technology by restructuring the enterprises in order to adapt the current market, and finally improve business efficiency.

## 5. Conclusion

This article takes e-commerce data of 11 listed enterprises as DUM, using Deap software to establish a panel of BBC and DEA-Malmquist model, get both static and dynamic analysis of the operational efficiency of e-commerce enterprises. Analysis from the static angle shows that, e-business enterprises' overall 'effch' is always low, the reason is that 'pech' and 'sech' are not high, and B2B business enterprise operates better than B2C; from dynamic analysis, the e-commerce businesses' overall 'tfpch' grows for these three years because of the continued increasing 'techch', but because of the lack of 'effch', the increased tfpch has been hampered. So if enterprise want to enhance e-commerce businesses' tfpch, this article recommends that enterprises should not expand

blindly, they should adjust the size of the enterprise to match the enterprise's strength and market, besides, they should make rational use of existing resources, make use of advanced management and operating model, develop innovative models and the vertical category and ancillary services, develop core competitiveness, expand product categories, rich product line and strengthen the supply chain, improve logistics and distribution system, and continuously improve operational efficiency, overcome the bottleneck of e-commerce. Finally, the steady development of e-business enterprises can come true.

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