International Journal of Social Science And Human Research

ISSN(print): 2644-0679, ISSN(online): 2644-0695

Volume 04 Issue 10 October 2021

DOI: 10.47191/ijsshr/v4-i10-27, Impact factor-5.586

Page No: 2847-2854

Analysis on Operating Efficiency of Chinese Securities Companies Based on Super Efficiency DEA and DEA-Malmquist Index Method

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ABSTRACT: With the expansion of China's securities market scale, securities companies as an important participant in the securities market have also developed rapidly. Under the influence of the global epidemic, the transaction volume of securities companies continued to decline, the profit prospects of securities firms increased, liquidity continued to be loose, and the overall policy budget was surplus. Through the efficiency analysis of securities companies, we can understand the resource utilization and industry conditions of securities companies, find out the gaps and deficiencies, and then improve, and improve the operating efficiency of the industry. In order to evaluate the operating efficiency of securities companies more scientific and objective, this paper adopts DEA-Malmquist index and super-efficiency DEA method, based on the financial statement data disclosed by 25 securities companies in 2016~2020, establishes an evaluation index system, analyzes the operating efficiency of securities companies, calculates and analyzes the operating efficiency of securities companies and reveals their internal reasons. The research results show that (1) steady improvement of operating productivity; (2) technical progress is the main factor; operating efficiency of (3) with different securities companies, scale efficiency weakly hinders technical efficiency; (4) Large securities companies should pay attention to control scale, develop innovative business, strengthen cost management, risk control and risk response ability.

KEYWORDS: Securities Company, super-efficiency DEA, Malmquist index, operating efficiency,COVID-19,Technological progress, the efficiency of scale.

1. THE FOREWORD

At the end of 2019, due to the sudden outbreak of COVID-19, all institutions had unsatisfactory expectations for the equity market, and their activity fell. Under the impact of the global epidemic, CSI 300 fell 7.9% in the first half of the year, the transaction volume continued to fall, the uncertainty of the profit prospects of the brokerage increased, liquidity continued to loose, the overall policy over budget, failed to hedge the major contradiction. Securities companies act as the subject and the important organizer of the securities market, and the operating efficiency can be used to measure the changes in the production and operation of securities companies. This paper uses ultra-efficiency DEA and M index from the perspective of operating efficiency to analyze the management and capital operation status of securities companies, as well as the changes in operating efficiency, and to analyze various factors that may affect their efficiency to obtain preliminary optimization path and improvement measures.

2. LITERATURE RESEARCH AT HOME AND ABROAD

The earliest application of efficiency measure in the financial industry is in foreign countries, and the earliest financial industry in China is mainly in banking, insurance and other fields, and then extended to the securities industry, trust industry, investment

companies and other fields, which is becoming more and more widely used. So far, the relevant literature at home and abroad has been studied as follows:

Charnes, Cooper, and Rhodes (1978) expanded the Farrell (1957) single input / output technical efficiency evaluation method to an evaluation of relative efficiencies between multiple input / output of the same type of decision units, namely the CCR model, which is used to compare relative efficiencies between providing homogeneous service units. Since then, the DEA model has been widely used for efficiency measurement in different industries and sectors such as industry and finance. Banker (1984) believed that the CCR model was too strict, which improved the model and constructed the BCC model with variable scale remuneration. The DEA method has been developed rapidly in theoretical research and practical applications. Andersen and Niels (1993) proposed the "super-efficiency" DEA model to evaluate the efficiency between effective decision units under the CCR model. Qu and Gao (2020) mentioned that the diversified income of securities companies has been steadily increasing with the improvement of their own specialization, and there is no difference in the threshold of the efficiency of state-owned brokerages and non-state-owned brokerages. Research by Ma and Zhou (2016) shows that the impact of external environments such as economic and financial development on the efficiency of city firms is significant. There are regional differences between the efficiency of operation and the growth rate of efficiency. The external environment has a significant impact on efficiency; The overall level of scale efficiency is low and the differentiation phenomenon is serious. The overall level of pure technical efficiency is high but there is a tendency to decline; The low scale efficiency is the main reason for the low efficiency of comprehensive technology. Therefore, we should pay attention to the influence of external environmental factors, optimize cost control, improve the equity structure, pay attention to the quality of scale expansion and reduce the dependence on scale expansion path. Chen (2018) Using the three-stage DEA-Malmquist index method to analyze the time change trend of the total factor productivity of the city commercial bank, it is concluded that the change of the total factor productivity of the city commercial bank is greatly affected by the change of scale efficiency. Ning and Xie (2017) found that the opening of China's stock or bond markets alone had a negative impact on financial stability, but that the overall opening of China's securities market helped promote financial stability. Zhao (2013) through China's 100 securities companies in 2007-2011 annual report data empirical analysis found that diversification may not bring the risk of securities companies to reduce and improve efficiency, its effect and asset size and other corporate characteristics. Zhou and Yu (2017) mentioned that the sustainable polarization of listed securities companies in different years; comprehensive efficiency is low, scale efficiency is relatively good, and the improvement of comprehensive efficiency depends on pure technical efficiency; the improvement of productivity is mainly affected by technological progress. Zhu and Liu (2008) proposed the improvement of total factor productivity represented by the Malmquist productivity index of securities companies; the reduction of production productivity prevented the further growth of total factor productivity. Song (2017) mentioned that the use of data envelope analysis method to compare the operating efficiency between securities companies helps securities companies to find out the gap between each other and take effective measures for problems.

3. METHODS OF STUDY

3.1. Ultra-Efficiency DEA Method

Traditional DEA models include a scale-of-invariant (CCR) model and a variable benefit of scale (BCC) model. The comprehensive efficiency values of the evaluated unit can be calculated using the CCR model, and the pure technical efficiency value to obtain the evaluated cell scale efficiency value. The comprehensive efficiency value of the decision unit is equal to 1, and the DEA is considered valid. If the comprehensive efficiency of the decision unit is effective, it is effective in both pure technical efficiency and scale efficiency. However, the efficiency evaluation results obtained by the traditional DEA model are all between 0~1. When there are many decision units, multiple efficiency values of 1 will appear, which cannot be further compared, so the super-efficiency DEA. is introduced. The super-efficiency model can exclude each effective unit to generate new sets of production possibilities, and further compare the size of efficiency between effective decision units.

Assuming the presence of n decision units, each with m input and s outputs, as expressed by the input variable x and the output variable y, respectively, the expression of the super-efficiency DEA model is:

$$\min[\theta-\varepsilon(\sum_{i=1}^{m}s_i^{-}+\sum_{r=1}^{s}s_r^{+})]$$

$$s.t.\sum_{j=1.j\neq k}^{n}x_{ij}\lambda_{j+si}=\theta x_0$$

$$\sum_{(j=1,j\neq k)}^{n}y_j\lambda_j-s_r^{-}=y_0$$

$$\lambda_j\geq 0;\ j=1,2,...,k-1,k+1,n;$$

$$s_i^{-}\geq 0;s_r^{+}\geq 0$$

In the formula, θ, the efficiency value of the decision unit, s^+ and s^- the relaxation variable, is the weight vector corresponding to each decision unit, x_{ik} indicating the i input variable of the k, y_{jk} decision unit and the j output variable of the k decision unit.

3.2. DEA-Malmquist Index Method

The traditional DEA model is a static analysis of efficiency, which can only compare the efficiency values of different decision units under the same period conditions, and can not compare the changes of efficiency values in different periods. Common with constant CCR(scale benefit) model and variable BCC(scale benefit) models. The data-based decision unit DMU dynamic efficiency analysis mainly focuses on the Malmquist total factor production change index (TFP), the DEA-Malmquist model proposed by Fare, Grosskopf, and Norris (1994), which combines the Malmquist index theory with DEA to realize the description of the dynamic change of efficiency.

Assuming the presence of n decision units, each obtained s output with m species input during t phase.

$x_j^t=(x_{1j}^t,x_{2j}^t,...,x_{mj}^t)^T$ Represents the input index value of the j decision unit in phase t,

$y_j^t=(y_{1j}^t,y_{2j}^t,...,y_{mj}^t)^T$ Represents the output index value of the j decision unit in t phase, and are all positive, t=1,2,...,T.

Suppose (x^t , y^t) indicates the input and output of phase t, (x^{t+1} , y^{t+1}) indicates the input and output of phase t+ 1, $D_c^t(x^t,y^t)$ and $D_c^{t+1}(x^{t+1},y^{t+1})$, respectively, is the output distance function under the technical conditions of the corresponding period, where table c below indicates that the scale remuneration is unchanged. The Malmquist index can be represented by the following formula:

$$tfp=M^{t+1}(x^{t+1},y^{t+1},x^t,y^t)=[\frac{D_c^t(x^{t+1},y^{t+1})}{D_c^t(x^t,y^t)}\times\frac{D_c^{t+1}(x^{t+1},y^{t+1})}{D_c^{t+1}(x^t,y^t)}]^{\frac{1}{2}}$$

The change of TFP can be divided into technical efficiency and technological progress, in which the change of scale efficiency and pure technical efficiency change constitute the technical efficiency change, expressed in the formula, TECH represents the technical progress index from t to t+ 1; PECH indicates the pure technical efficiency change from t to t+ 1, and SECH represents the change of scale efficiency from t to t+ 1.There are two methods of DEA-Malmquist index, input-to-output and output-oriented,

namely how to minimize (maximize) input (output) under conditions determined at the output (input) level. Since the input elements of securities companies are controllable elements, the output-based DEA-Malmquist index method is adopted.

3.3 Selection of the Index System

This paper randomly selected 25 Chinese securities companies as samples. The efficiency evaluation index system is divided into two indicators: input index and output index. From previous studies, securities companies selected total assets (x1), total liabilities (x2), employee compensation (x3) and operating cost (x4) as input indicators; operating income (y1), total profit (y2) and net profit (y3) were used as output indicators, as in Table 1.The relevant index data are from the annual financial reports of securities companies published on the official website of the Securities Association of China. The consolidated financial statements are extracted from group companies, all statements and statements are audited and provided by accounting firms, and the data sources have strong reliability.

Table-1. Input and output index of operating efficiency of securities companies.

Indicator type	Indicators	Variables	Unit
Investment indicators	Total assets	X1	Ten thousand yuan
	Total liabilities	X2	Ten thousand yuan
	Employee compensation	X3	Ten thousand yuan
	Operating costs	X4	Ten thousand yuan
Output indicators	Operating income	Y1	Ten thousand yuan
	Total profit	Y2	Ten thousand yuan
	Net profit	Y3	Ten thousand yuan

4. EMPIRICAL ANALYSIS

Aysis 2020 input and output index data collected from 25 sample securities companies, The statistical analysis of the index data is shown in Table 2.

Table-2. Statistical analysis of the index data.

Indicator name	Observations	Means	Median	Maximum value	Minimum value
Total assets（x1）	25	239300050201.86	6763034.0	105296229.4	2520735.1
Total liabilities(x2)	25	187167973697.88	4509015.9	86707955.8	1428378.1
Employee compensation(x3)	25	7230314445.78	168265.4	9665884.6	20948.4
Operating costs(x4)	25	7915684716.93	372857.1	3374448.4	76244.0
Operating income(y1）	25	13292083818.27	606280.1	5438273.0	165785.8
Total profit(y2)	25	5346013856.37	185474.3	2047045.8	78548.7
Net profit(y3)	25	4214366776.59	145155.6	1551654.1	61135.0

Data source: audit annual report of securities companies.

Among them, the input and output index variables are all set in ten thousand yuan. It can be seen from the comparison of the sample data, even if the same securities company, whether the output index or the input index, the gap between the height is very huge, the maximum value is dozens of times the minimum value. For example, in the investment index of total assets, CITIC Securities has the largest investment, invested 1,2962,294 million yuan, the least investment is China Fortune Securities, invested 25207.351 million yuan. The total assets of CITIC Securities are 41 times that of the total assets of Huaxin Securities, which shows that different securities companies still have great differences in their operating efficiency. In order to make a more objective analysis

of the operating efficiency of Chinese securities companies, this paper selects 25 securities companies from 2016-2020 to analyze the operating efficiency of securities companies by using ultra-efficiency DEA and DEA-Malmquist index. The sample data of this study came from the annual financial reports of the securities companies published on the official website of the Securities Association of China, extracting the consolidated financial statements of the group companies.

The DEA analysis method can be divided into input-oriented and output-oriented analysis methods. This paper selects the investment-oriented analysis method in the empirical analysis. From the perspective of securities companies, the investment control is a practical method to improve its business efficiency.

4.1. Analysis of Super-Efficiency DAE Results of Securities Companies

This paper obtained the operating efficiency value θ. of Chinese securities companies in 2020.The results are shown in Table 3.

Table-3. Operating Efficiency Assessment Form of the 25 securities companies.

DMU	Integrated efficiency values (STE) / CCR	Technical Efficiency Value (TE) / BCC	Income of scale value (R) / CCR	Ultra-efficiency DEA-value	Efficiency ranking
Huatai Securities	1.0000	1.0000	1.0000	1.27656377	1
Guotai Junan Securities	0.9224	0.9247	0.8088	0.00001477	17
Minsheng Securities	0.9901	0.9952	1.2174	0.00000131	22
Ping An Securities	1.0000	1.0000	1.0000	0.00000707	20
Nanjing Securities	0.9929	1.0000	1.2892	0.00005531	12
Open source securities	0.9869	1.0000	1.1978	0.00343113	4
First start a business	0.9892	0.9979	1.2161	0.00423607	3
Dongguan Securities	0.9986	1.0000	1.2343	0.00005081	13
Yangtze river securities	0.9873	0.9908	1.1280	0.00014139	9
China Merchants Securities	0.9347	0.9352	0.9876	0.00060531	7
CITIC Securities	0.0000	1.0000	0.0000	0.00000000	25
China Galaxy Securities Co., Ltd.	0.9738	0.9738	0.8913	0.00003301	15
Bank of China International	0.9951	1.0000	1.2412	0.00000008	24
Founder Securities	1.0000	1.0000	1.0000	0.00110585	6
Capital securities	0.9937	1.0000	1.3028	0.00010629	10
Guodu Securities	0.9893	1.0000	1.3336	0.00001322	18
Haitong Securities	0.8613	0.8676	0.6833	0.00000414	21
Financial Tong Securities	1.0000	1.0000	1.0000	0.00247571	5
Guosen Securities	0.9126	0.9158	0.8831	0.00017868	8
Guangfa Securities	0.8290	0.8374	0.6952	0.00001310	19
Guojin Securities	0.9695	0.9717	1.0854	0.00000013	23
Hongta Securities	0.9687	0.9818	1.0405	0.00003781	14
Huaxin Securities	0.9881	0.9968	1.2980	0.00006558	11
Huachuang Securities	0.9936	1.0000	1.2120	0.00002113	16
Bohai Securities	0.9906	1.0000	1.2944	0.99058340	2

From the ultra-efficiency DEA results, In 2020, Securities companies operating efficiency from high to low ranking for Huatai securities, Bohai securities,First start a business, Open source securities,Financial Tong Securities, Founder securities, China

merchants securities, Guosen Securities , Yangtze river securities, Capital Securities, Huaxin securities, Nanjing securities, Dongguan securities, Hongta securities, China Galaxy Securities Co., Ltd., Huachuang securities, Guotai Junan securities,Guodu Securities, Guangfa securities, Ping An Securities, Haitong securities, Minsheng Securities ,Guojin Securities, Bank of China International, CITIC Securities, Huatai Securities, which has the first arrangement, The efficiency value is 1.27656377, The last securities company listed is CITIC Securities, Efficiency value is 0, The operating efficiency value difference between the two securities companies is 1.27656377.Through the analysis of the super efficiency value, it can be seen that in 2020, the top and last securities companies will differ greatly, which shows that the operating efficiency development of China's securities companies is unbalanced. While the rapid development of China's securities industry, there is still a problem of unbalanced development.

4.2. Analysis of the Malmquist Index Results of Securities Companies

The Malmquist index can reflect the changes in the operating efficiency of Chinese securities companies. Use software to decompose and analyze the operating efficiency productivity of 25 securities companies from 2016 to 2020. The operating efficiency Malmquist index of the sample securities companies is shown in Table 4.

Table-4. Malmquist Index and decomposition of the operating efficiency of Chinese securities companies.

	effch	**tech**	**pech**	**sech**	**tfp**
2016-2017	0.918	1.260	1.023	1.071	1.176
2017-2018	0.881	1.176	1.032	1.040	1.057
2018-2019	0.998	1.057	1.025	1.009	1.060
2019-2020	1.069	1.038	1.007	1.028	1.111
mean value	0.975	1.107	1.048	1.019	1.084

It can be seen from Table 4, the average M index of operating efficiency of Chinese securities companies in 2016-2020 is 1.084, and the Malmquist productivity increased by 8.4%. The total factor productivity in the stage studied in this paper is greater than 1, which shows that the operating efficiency of China's securities companies tends to rise steadily. By further splitting TFP into technological progress index and technical efficiency index, As can be seen: (1) The technical efficiency index decreased by 9.4%, While the Technology Progress Index rose 6.9%, Therefore, technological progress is the key reason for improving the operating efficiency of Chinese securities companies, And the technical efficiency has played a certain role in hindering the improvement of the business efficiency of securities companies; (2) Pure technical efficiency index was less than 1 from 2016 to 2020, The scale efficiency index shows a fluctuating and changing trend, Overall, the pure technical efficiency index fell 4.1%, The scale-efficiency index rose 0.9%, It shows that the pure technical efficiency index has some inhibitory effect on the improvement of the technical efficiency index. The Malmquist index and its specific decomposition of the operating efficiency of Chinese securities companies are as follows.

Table-5. Malmquist Index and decomposition of the operating efficiency of Chinese securities companies.

DMU	effch	tech	pech	sech	tfp
Huatai Securities	0.987	1.087	1.020	1.022	1.077
Guotai Junan	0.984	1.116	1.021	1.025	1.103
Minsheng Securities	0.995	1.089	1.019	1.024	1.087
Ping An Securities	0.994	1.089	1.018	1.026	1.086
Nanjing Securities	0.996	1.089	1.019	1.025	1.088
Open source securities	0.990	1.089	1.020	1.024	1.082
First start a business	0.997	1.122	1.060	1.029	1.102
Dongguan Securities	0.980	1.122	1.025	1.027	1.104
Changjiang Securities	0.976	1.123	1.024	1.029	1.101

China Merchants Securities	0.995	1.059	1.017	1.024	1.057
CITIC Securities	0.992	1.058	1.017	1.024	1.054
China Galaxy Securities Co., Ltd.	0.993	1.059	1.018	1.025	1.056
Bank of China International	0.993	1.057	1.018	1.022	1.054
Founder Securities	0.981	1.121	1.024	1.027	1.105
Capital securities	0.993	1.088	1.018	1.025	1.084
Guodu Securities	0.985	1.119	1.024	1.025	1.108
Haitong Securities	0.984	1.088	1.021	1.024	1.074
Financial Tong Securities	0.975	1.123	1.024	1.029	1.100
Guosen Securities	0.984	1.115	1.021	1.025	1.103
Guangfa Securities	0.983	1.120	1.024	1.026	1.106
Guojin Securities	0.985	1.117	1.022	1.025	1.105
Hongta Securities	0.985	1.090	1.022	1.023	1.078
Huaxin Securities	0.991	1.087	1.020	1.022	1.081
Huachuang Securities	0.984	1.088	1.020	1.023	1.074
Bohai Securities	0.972	1.123	1.024	1.029	1.097
mean value	0.978	1.098	1.022	1.025	1.087

It can be seen from Table 5, the total factor productivity index of all securities companies from 2016 to 2020 is greater than 1, indicating that the operating efficiency of China's securities companies is constantly improving with a good momentum of development. Among them, the operating efficiency productivity of Guodu Securities has increased the most, with an increase of 10.8% in five years. The operating efficiency productivity of Founder Securities and Guojin Securities have both reached 10.5%, and the operating efficiency productivity of Bank of China International and CITIC Securities is the lowest, only 5.4%.

From the decomposition can be seen from Malmquist index: (1) The technical efficiency of Chinese securities companies is less than 1, It shows that the technical efficiency hinders the productivity of the operating efficiency, Technological progress has promoted the improvement of business efficiency and productivity; (2) Bohai Securities' technical progress index rose 12.3%, While its technical efficiency index fell by 2.8%, It shows that the improvement of total factor productivity of Bohai Securities is mainly caused by technological progress, Technical efficiency plays a negative effect on the improvement of business efficiency; (3) Guodu Securities' operating efficiency increased by 10.8%, Its technical efficiency is less than 1, It shows that the improvement of business efficiency is caused by technological progress, Technical efficiency plays the opposite role in operating efficiency, The pure technical efficiency index and scale efficiency are greater than 1, It shows that the scale efficiency and pure technical efficiency are some reasons for improving the operation efficiency of Guodu Securities; (4) The situation of Bohai Securities is the opposite of Capital Securities, The technological progress of Bohai Securities is greater than the reaction of technical efficiency, Further leads to the improvement of business efficiency and productivity, However, the decline in technical efficiency has a weak impact on the pure technical efficiency scale efficiency.

To sum up, different securities companies operating efficiency changes and the reasons are some different, technical progress is the main cause of business efficiency, unreasonable resource allocation to improve the obvious inhibitory effect, the securities companies can improve resource allocation, management efficiency to improve management efficiency.

5. CONCLUSIONS

Through empirical research on the operating efficiency of 25 securities companies in 2020, (1) fluctuating operating efficiency value from 2016-2020, steadily improved operating efficiency productivity; (2) technical progress is the main reason for promoting operating efficiency, greater than that of technical efficiency; different range and influencing factors; (4) Large securities companies should pay attention to control scale and intensive development. Develop innovative business, reduce the dependence of traditional

business mainly based on brokerage business, and develop business diversification. Strengthen cost management and improve the internal control of cost management. Pay attention to risk control, establish a perfect internal audit system, and improve the risk response ability.

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