Turkish Journal of Computer and Mathematics Education Vol.12 No.13 (2021), 6162-6168

Research Article

An Economy Efficiency Analysis of Non Pearl River Delta Region and nearby cities in Guangdong of China

Jia-Zheng Lin[a], Dr. Hyung-Ho Kim[b]

[a]Assistant Professor of Business College, Guangdong Business and Technology University, China
[b]Professor, Department of Air Transport and Logistics, Sehan University, Korea

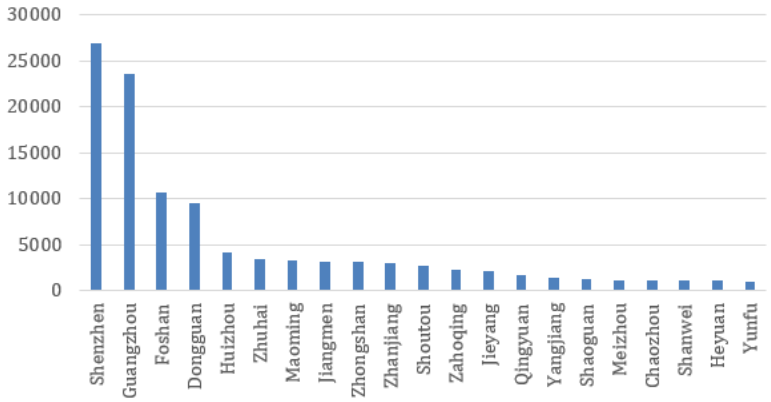
Abstract: The Non Pearl River delta region is the weak zone of economy development in Guangdong province and it's lack of discussion about economic efficiency all the time. The purpose of this study is aim to evaluate the economy efficiency of Non Pearl River Delta Region cities relatively, so the nearby cities such as Foshan, Huizhou, Zhongshan, Jiangmen and Zhaoqing were brought in, by analyzed the data from Guangdong year book in 2014-2018 with DEA-Malmquist and SSBM analysis method, the results show that the efficiency of economic development difference between each city is bigger, north region and east region is generally low and some problems had be found. In this study three aspects were presented according the analysis result, such as the allocation of resources, scientific and technological innovation, coordinated development between regions. Those recommendations would be useful for the region's manager to make an efficient decision of economy development and balance the development level of the cities in Guangdong province China.

Keywords: Economy efficiency, DEA-Malmquist, SSBM, Non Pearl River Delta Region

1. Introduction

In 2019, Guangdong's GDP reached 1.0777107 trillion Yuan, an increase of 6.2 percent over the previous year, ranking first in China for 31 consecutive years. This means that Guangdong has become the first province in the country to squeeze into the "ten trillion Yuan club" of GDP. However, after 40 years of rapid development of reform and opening up, the development of 21 cities in Guangdong province is still extremely uneven, especially the imbalance of economic development efficiency between cities in Pearl River Delta Region and Non Pearl River Delta Region, as shown in Figure.1 below.

Figure.1 GDP of each city in Guangdong in 2019.



In recent years, the government of Guangdong province are increasing spending on infrastructure in the region, the pearl river delta region of Guangdong province is becoming another important Guangdong economic growth pole, therefore, this paper selected the pearl delta region of Guangdong province and the surrounding a total of 17 cities (DMU) as the research object, using the method of Data Envelopment Analysis (DEA) to economic efficiency comparison analysis between the cities, economic development has the efficiency of the city become more aware of their own development advantages, at the same time, the lack of efficiency of economic development of the city to provide experience for reference, in order to promote regional coordination synchronization in Guangdong.

2. Theoretical Background

2.1.DEA model

DEA (Data Enveloping-analysis Method) was mostly used to evaluate efficiency, It is widely used in government, schools, hospitals and other non-profit public institutions. It is a statistical method of relative efficiency comparison **(H. G. Choi & Y.Y.You.2014).** Through DEA analysis, not only can we know the reason why DMU has efficiency, but also can we analyze the improvement of non-efficiency DMU to achieve efficiency **(J. H. Han.2013)**. There are various DEA analysis methods, among which the Malmquist analysis method at different time points is the most representative. The Malmquist production index (MPI) derived based on the distance function (Metric Function) can measure the total production efficiency at more than two time points. The main factors influencing MPI index can be divided into internal influencing factors (TCI) and external influencing factors (TECI) **(N. Chao & J. W. Jeon & H. H. Kim.2019).**

2.2.literature review

At present, there are researches based on the efficiency of economic development in relevant literatures about the economic development of cities in Guangdong province **(L. H. Peng.2017)**, there are also studies based on the quality of urban development **(H. P. Wang et al.,2019)**, and studies based on coordinated development **(J. Feng.2010)**. However, the research objects of the above papers are all aimed at the urban agglomeration in the pearl delta region of Guangdong province. Currently, only Jingman‘s study aim to the urban agglomeration in the non-pearl delta region, the purpose of this paper is to analyze the urban competitiveness factors of 12 cities in the non-pearl delta region **(M. Jing and X. Liao.2010)** The important reason for choosing non-pearl delta urban agglomeration as DMU in this study is to fill the gap in theoretical research in this field. In addition, DEA method is used to study and explore the economic efficiency of cities, which can be used to compare the relative economic efficiency of non-pearl river delta cities.

3. Methodology

3.1. SSBM-DEA and Malmquist

SSBM-DEA(Super-efficiency Slacks-Based Measure) model with weighting preference. Through this model, not only the overall efficiency of DMU can be measured, but also the specific influencing factors of efficiency or non-efficiency of each DMUs can be analyzed in detail. This method can avoid the occurrence of large-scale efficiency of DMUs decision making units in CCR analysis using DEA method alone, which makes it difficult to rank, and the most efficient decision making units cannot be identified[8]. SBM-DEA model can measure the comprehensive efficiency, pure technical efficiency and scale efficiency of DMU decision making unit, and perform static analysis at a single time point, but cannot measure the trend of efficiency value in time series. In this study, DEA-Malmquist was used to analyze the economic efficiency of 17 cities in and around the non-pearl delta (DMU). Efficiency Score=1 appeared in most of the cities. In order to rank the economic efficiency of each city and determine the cities with the optimal efficiency, DEA-Malmquist and SSBM methods were used for the analysis **(N. Tian and S. Tang, A. Che, P. Wu. 2019).**

3.2. Input and Output indicators

In the analysis of urban economic efficiency, DEA analysis method is used in most studies. And usually will consider when choosing indicators closely related with the city's economic development factors, such as da-chun fang in the central city of the Yangtze river economic belt economy efficiency compared study, the labor input of fixed assets investment, energy consumption, fiscal revenue, GDP, per capita disposable income as the indexes such as **(D. C. Fang and T. Wang. 2019)**. When studying the quality of economic development in Jiangsu province, he listed GDP, fixed assets investment, population, urbanization rate, per capita income of residents, tax revenue, retail sales of social consumer goods and residents' deposit balance as the research indicators **(F. H. Shu. 2019)**.Through the research and analysis of the previous literature, combined with the Chinese urban competitiveness report No.17: housing, relationship between the country and the home jointly released by the institute of financial strategy, Chinese academy of social sciences and economic daily in 2019, **Chinese urban competitiveness report (2019)** mentioned that "the level of opening to the outside world and the innovative development of cities have a significant impact on the improvement of the comprehensive economic competitiveness of cities". Increased investment in science and technology and R&D is conducive to the improvement of urban efficiency **(Y. X. Zhou and J. W. Jeon and H. H. Kim. 2019)**. The most competitive economic core regions in the world are all regions where the spatial structure achieves globalization and cultural diversification, and the core cities of large city clusters are often the first choice for the headquarters of multinational companies **(D.D. Lu. 2017)**. Therefore in this paper, "R&D

expenditure" and "foreign direct investment" are added as the research indicators. The input and output indicators are summarized as table 1.

Table.1. Input and Output indicators

Item	Indicators	Unit
Input	Fixed Investment	100million Yuan
	Number of workers	People
	Foreign Direct Investments	USD 10000
	R&D Expenditure	100million Yuan
Output	GDP	100million Yuan
	Per Capita Disposable Income	Yuan

4. Empirical analysis

4.1. Efficiency analysis result

By using DEA-SOLVER-LV8 program with expected outputs and the super efficiency evaluation input-output Index system determined in this study. The descriptive statistics of Non Pearl River Delta Urban and nearby cities(Total 17cities) in Guangdong province of China in 2018 are as follows (Shown in Table 2). In the Input Index, the maximum, minimum , average and standard deviation of the Fixed Investment are 4504.67 (100 million Yuan), 518.08 (100 million Yuan), 1467,97 (100 million Yuan）, 971,62(100 million Yuan). The maximum, minimum, average and standard deviation of Foreign Direct Investments are 634700 (USD 10000), 10798 (USD 10000), 175761.05 (USD 10000), 206444.73 (USD 10000). The maximum, minimum, average and standard deviation of R&D Expenditure are 235.17 (100 million Yuan), 2.57 (100 million Yuan), 33.47 (100 million Yuan), 55.79 (100 million Yuan). It can be see that there is a very large gap among Non Pearl River Delta Urban and nearby cities. In the Output Index the maximum, minimum, average and standard deviation of GDP are 9935.88 (100 million Yuan), 849.13 (100 million Yuan), 2514.78 (100 million Yuan), 2101.67 (100 million Yuan), Which also showed great differences.

Table.2. Descriptive Statistic of Input and Output

Index	Max	Min	Avg	SD
I-1 Fixed Investment	4504.67	518.08	1467.97	971.62
I-2 Number of workers	440.90	120.75	222.27	85.38
I-3 Foreign Direct Investments	634700	10798	175761.05	206444.73
I-4 R&D Expenditure	235.17	2.57	33.47	55.79
O-1 GDP	9935.88	849.13	2514.78	2101.67
O-2 Per Capita Disposable Income	49629.52	19239.13	26021.51	8886.82

4.2. Malmquist Analysis

Malmquist index (MPI) represents total factor productivity, which can be divided into technological efficiency change (TECI) and technological change (TCI). It can be used to analyze the productivity of city's economy development efficiency. In order to catch up the variation trend and influence factors of Non Pearl River Delta Urban and nearby city's economy development efficiency, Malmquist index method was used in this study. As Table 3 shown, for the analysis results of economy productivity of Non Pearl River Delta Urban and nearby cities from

2014 to 2018. First, the overall productivity analysis results of the Non Pearl River Delta Urban and nearby cities show that the MPI of the economy efficiency has been in a state of growth in 2014-2015 and 2015-2016, with an average from 1.014 to 1.077, an increase of 6.2%. The average value from 2016-2017 was 1.016, however the average value from 2017-2018 was 0.967, decrease 4.8%. Although many of the MPI index of these cities are >1 ,but the growth of Non Pearl River Delta Urban and nearby cities are no consecutive.

The change of MPI can be seen by the value of TECI and TCI directly. Figure.2 shows the mean changes of MPI, TECI and TCI of each cities in Non Pearl River Delta Urban and nearby. From 2014 to 2015, the value of TCI >1 had 14 cities in 17, it's 82.35%, from 2015 to 2016 and 2016-2017 the value of TCI >1 had 13cities in 17, it's 76.47%. from 2017 to 2018, the value of TCI >1 had 12cities in 17, it's 70.58%.

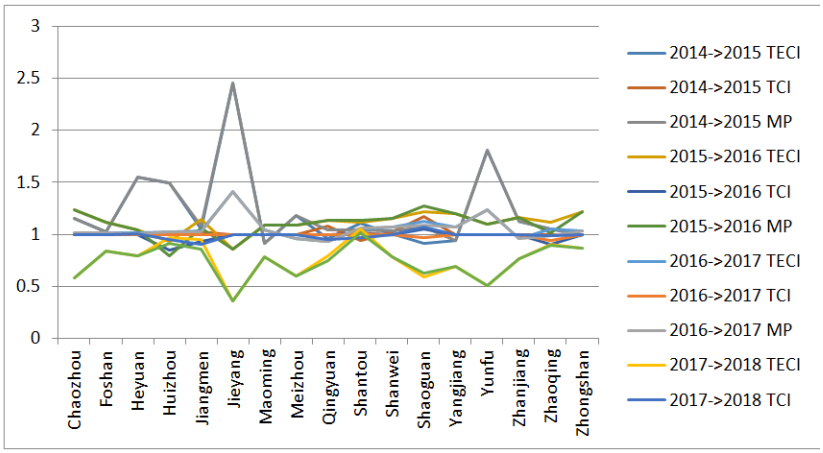
Table.3. Descriptive Statistic of Input and Output

City	2014->2015			2015->2016			2016->2017			2017->2018		
	TECI	**TCI**	**MPI**	**TECI**	**TCI**	**MPI**	**TECI**	**TCI**	**MPI**	**TECI**	**TCI**	**MPI**
Chaozhou	1	1	1	1	1	1	1.035	1	1.035	1	1	1
Foshan	1.034	1	1.034	1.153	1	1.153	0.993	1	0.993	0.785	1	0.785
Heyuan	1	1	1	1.044	1	1.044	1.029	1	1.029	1.043	1	1.043
Huizhou	0.992	1	0.992	0.920	0.896	0.825	1.046	0.978	1.023	0.939	0.934	0.878
Jiangmen	1.004	1.058	1.063	1.207	0.885	1.069	1.062	0.967	1.027	0.927	0.879	0.815
Jieyang	1.076	1	1.076	1.030	1	1.030	1.007	1	1.007	0.943	1	0.943
Maoming	0.920	1	0.920	1.086	1	1.086	1.042	1	1.042	1.100	1	1.100
Meizhou	1	1	1	1.111	1	1.111	1.043	1	1.043	1.042	1	1.042
Qingyuan	0.993	1.054	1.047	1.133	1	1.133	0.942	1	0.942	1.029	0.965	0.993
Shantou	1.055	1	1.055	1.116	1	1.116	1.060	1	1.060	1.030	0.978	1.008
Shanwei	1	1	1	1	1	1	1	1	1	1.038	1	1.038
Shaoguan	0.882	1.235	1.089	1.182	1.033	1.221	1.089	1	1.089	1.011	1	1.011
Yangjiang	0.940	1	0.940	0.983	1	0.983	0.989	1	0.989	1	1	1
Yunfu	1.049	1	1.049	1	1	1	1	1	1	1	1	1
Zhanjiang	0.926	1	0.926	1.173	1	1.173	0.957	1	0.957	1.040	1	1.040
Zhaoqing	1.057	1	1.057	1.106	0.936	1.036	1.062	0.956	1.016	0.936	0.988	0.925
Zhongshan	0.988	1	0.988	1.321	1	1.321	1.027	1	1.027	0.823	1	0.823
Average	0.995	1.020	1.014	1.092	0.985	1.077	1.022	0.994	1.016	0.982	0.985	0.967

The total factor productivity of six cities in Foshan , Maoming, Qingyuan, Shaoguan, Zhanjiang Zhaoqing, all show to varying change with big differences. As Figure.2 shown it means that almost all of the cities are efficiency, but it's difficult to rank and evaluate how many cities are really efficiency relatively. It's also hard to see which city

is the most highest efficiency city. Therefor it's necessary to analyze forward a single step with SSBM model.

Figure.2 Linear graph of Malmquist analysis .



4.3. SSBM-DEA result analysis

Based on urban economic efficiency is facing the reality of shortage of resources and environmental constraints, the results as shown in table 4.

Overall, the non pearl river delta of Guangdong province and the nearby cities of generally high economic efficiency, the efficiency is greater than 1 in Maoming, Yangjiang, Foshan, Zhongshan, Yunfu, Jieyang, Meizhou, Zhanjiang, Heyuan, Shanwei 10 cities, Maoming had the highest economic efficiency (1.565), while Jiangmen had the lowest (0.560). To sum up, the economic efficiency of the Non Perl River delta and nearby cities in Guangdong province is generally good, but the unbalanced development of various cities is prominent, especially the cities such as Qingyuan, Zhaoqing and Shantou in the north, west and east of Guangdong province are obviously low in economic efficiency, which requires attention. In addition, DEA method is measured by the relative efficiency, efficiency is not absolute, calculated result ranking has a certain relativity, it will be affected by the sample data selection and decision making units. Therefore, need to influence the urban economic efficiency of input and output indicators for concrete analysis, especially need to focus on the slack of inputs and outputs in the process to pursuit economic efficiency. The results of the analysis as shown in table 5.

Table.4. Rank of SSBM analysis result

Rank	DMU	Score
1	Maoming	1.565
2	Yangjiang	1.286
3	Foshan	1.186
4	Yunfu	1.172
5	Zhongshan	1.164
6	Chaozhou	1.159
7	Jieyang	1.105
8	Meizhou	1.068
9	Zhanjiang	1.048
10	Heyuan	1.013
11	Shanwei	1.002
12	Shaoguan	0.834
13	Qingyuan	0.713
14	Shantou	0.655
15	Huizhou	0.651
16	Zhaoqing	0.581
17	Jiangmen	0.560

Table.5. Slack of Input indicators

2018	I (1)	I (2)	I (3)	I (4)
Shantou	1211.09	0	32269.47	7.15
Shaoguan	103.44	0	4059.19	6.46
Heyuan	0	6.66	0	0.02
Meizhou	59.38	0	0	0.54
Shanwei	0	1.03	0	0
Yangjiang	87.22	21.20	0	3.03
Zhanjiang	0	0	0	1.59
Maoming	576.30	73.33	26239.89	0
Qingyuan	7.10	42.98	50181.84	3.29
Chaozhou	233.94	23.14	0	0
Jieyang	0	0	4538.42	0
Yunfu	16.60	57.94	5802.39	0
Foshan	0	328.25	0	0
Huizhou	532.93	0	459086.0	39.39
Zhongshan	352.95	83.13	0	0
Jiangmen	673.49	0	371739.7	36.62
Zhaoqing	607.54	5.59	65078.55	13.07

5.Conclusions and Recommendation

This study first used the DEA-Malmquist index method to calculate the panel data of 17 cities from 2014 to 2018, and reached the following conclusions: ①According to the static analysis results, among the 17 cities in the non-pearl delta region and surrounding cities, the cities with the MPI > 1 accounted for 58.8%, indicating that the overall economic efficiency of the non-pearl delta region and surrounding cities was effective. ②According to the data in Table3, from 2014 to 2018, the cities with TCI > 1 took up an average of 76.46%, indicating that the efficiency of scientific and technological innovation in economic development was generally high. However, relatively few cities of TECI > 1 account for, indicating that technological efficiency inhibits the growth of economic development efficiency, and technological progress is the driving force to promote the growth of economy efficiency.

To sum up, Recommendation as follow:

- The development of urban economy needs the coordinated allocation of multi-party resources, and the optimized allocation of resources is an important symbol to test the level of urban management. The management decision makers should set the input proportion of each factor scientifically to ensure the effective utilization of each factor.
- The ability of scientific and technological innovation is the fundamental driving force to maintain the vitality of urban economy. When scientific and technological innovation is not a result of large amount of capital investment, scientific and technological innovation lies in education and professional personnel training.
- Cities in the Pearl River delta region, such as Guangzhou, Shenzhen, Dongguan and Huizhou, have experienced rapid economic development and huge economic scale. Therefore, Non-pearl delta cities should analyze their own advantages, draw lessons from successful experience, at the same time, innovate their own economic development model, to create their own characteristics and competitiveness of the city image.

6. Acknowledgement

This study was supported by the Sehan University Research fund in 2021.

References

A. H.G.Choi & Y.Y.You.(2014). An Efficiency Analysis for the Public Activities Support Projects of Non-Profit Private Organizations using DEA, Journal of Digital Convergence, 12(6), 181-192.
B. J. H. Han.(2013).A Study on Eco-efficiency in power plants using DEA Analysis. Journal of Digital Convergence, 11(5), 119-133.
C. N. Chao & J. W. Jeon & H. H. Kim.(2019). An Efficiency Analysis of Science and Technology Budget in Provinces and Autonomous Regions in China. Journal of Digital Convergence, 17(12), 129-137.
D. L. H. Peng(2017). Comparative Study on Economic Efficiency of Pearl River Delta Urban Agglomeration-Based on the Three-Stage DEA Model. Jiangsu Commercial Forum, 17(5), 84-89.
E. H. P. Wang and J. You and C. P. Yuan(2019). Quality Analysis of Guangdong's Economic Development-Based on Super Efficiency DEA. The Journal of Guangdong Peizheng College,19(4), 1-5.
F. J. Feng(2010). An empirical study on the coordinated development of Pearl River delta city clusters-Based on the analysis of the regional economy. Guide to Business, 10(4),162-163.
G. M. Jing and X. Liao(2010). A Study on Urban Competitiveness factors analysis of China Guangdong province non Pearl River Delta cities, Market Enconomy& Price, 10(6), 27-30.
H. N. Tian and S. Tang, A. Che, P. Wu(2019). Measuring regional transport sustainability using super-efficiency SBM-DEA with weighting preference. Journal of Cleaner Production , 242.
I. D. C. Fang and T. Wang(2019).Comparative Analysis of Economic Efficiency of Central Cities in the Yangtze River Economic Belt-Based on Three-stage DEA Model. Journal of Hunan University of Finance and Economics, 35(182), 26-35.
J. F. H. Shu(2019). Analysis of Jiangsu's Economic Development Quality Based on Super-efficiency DEA, Journal of Jiangsu Second Normal University, 52-57+123.
K. Chinese urban competitiveness report(2019). No.17: housing, relationship between the country and the home jointly, Institute of financial strategy & Chinese academy of social sciences & Economic daily in 2019.

L. Y. X. Zhou and J. W. Jeon and H. H. Kim(2019). A Study on Urbanization Efficiency analysis of China's 31 provinces and cities. Journal of Digital Convergence,17(12), 147-157.
M. D.D. Lu(2017). Development of Pearl River Delta Metropolitan Group and Pan-Pearl River Delta Economic Cooperation Zone. Economic Geography,37(4), 1-4.