Evaluation of Urban Development Efficiency in Fujian Province under the Constraint of Unexpected Output Based on Super-SBM Model and Malmquist Luenberger Index Model

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Keywords: Urban Development Efficiency, Super-SBM Model, Malmquist-Luenberger Index.

Abstract: The new development concept brings regional economic concern about the urban development efficiency. This study takes high-quality development transcendence as perspective, evaluates dynamically and statically the urban development efficiency of nine cities in Fujian Province by using the Super-SBM model of unexpected output and Malmquist Luenberger index model. The results indicate that the super efficiency level of urban development in Fujian Province has a high spatial correlation: it decreases from coastal areas to inland mountainous areas on the whole and decreases from southern Fujian, central Fujian and Fuzhou to Western Fujian, Northern Fujian and Ningde specially. The main reason for the deterioration of urban development efficiency is due to the deterioration of TC and the unchanging EC.

1 INTRODUCTION

In the new era, some changes have taken place in China's regional economic development. Adhering to improving the quality and efficiency of economic development and promoting the strategic adjustment of economic structure is the logic that China's economy and society must cross a higher stage of development. Based on this logic, Fujian Province unswervingly implements the new development concept, closely adheres to the theme of high-quality development, speeds up the construction of a new development pattern, and makes every effort to promote higher quality, more efficient, fairer, more sustainable and safer development. In order to achieve high-quality development, all cities in Fujian Province should take the implementation path of strengthening scientific and technological innovation, deepening reform and opening up, promoting common prosperity, accelerating green transformation and establishing bottom line thinking.

In this context, it is of great practical and theoretical significance to evaluate the urban development efficiency of Fujian Province: the urban development efficiency reflects the high-quality development of cities. By comparing the urban development efficiency of Fujian Province, we can objectively evaluate the urban development of Fujian Province, so as to promote the high-quality development of various cities in Fujian in an all-round way and promote the competition among cities, it provides a reference for catching up and surpassing.

Fare and Grosskopf (1983) (Fare, 1983) established a data envelopment analysis model (DEA) to measure urban total factor productivity, urban development efficiency and production effectiveness. Chinese scholars F.Z. Li and H.K. Fu (2016) (Li, 2016) and Chinese Taiwanese scholar Wen et al. (2016) (Wen, 2016) used different DEA models to evaluate the efficiency of cities in different regions of China based on different standards. In the new era, domestic scholars began to integrate the concept of high-quality development into the evaluation index system of urban development efficiency: X.L. Yuan et al. (2020) (Yuan, 2020) and J.Y. Zhang et al. (2021) (Zhang, 2021) all took high-quality development as a research perspective to calculate the urban development efficiency of different regions in their respective articles.

To sum up, the theoretical and empirical analysis results of urban development efficiency have been relatively rich, but there is no research on urban development efficiency from the perspective of high-quality development transcendence. By constructing the transcendence evaluation system of urban high-quality development, taking the relevant economic

Zhang, W. and Lei, H.
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DOI: 10.5220/0011732500003607
In *Proceedings of the 1st International Conference on Public Management, Digital Economy and Internet Technology (ICPDI 2022)*, pages 179-184
ISBN: 978-989-758-620-0

data of 9 prefecture level cities in Fujian Province from 2008 to 2019 as the empirical object, using the Super-SBM model under unexpected output in DEA and Malmquist-Luenberger index, this paper calculates the high-quality development level of urban economy in Fujian Province from static and dynamic aspects, analyzes the evaluation results.

2 SUPER EFFICIENCY MODEL OF URBAN DEVELOPMENT IN FUJIAN PROVINCE

2.1 Super-SBM Model Under Undesired Output Constraints

In the study of urban development, the traditional DEA model has limitations. With the implementation of the new development concept, unexpected outputs such as pollution emissions have been included in the efficiency evaluation system. To make up for the deficiency, Tone proposed the SBM model in 2002 (Tone, 2001), and Tone (2003) (Tone, 2002) introduced the super efficiency model into the SBM model to reevaluate the DMU with efficiency value of 1.

Suppose there are n DMUs, consists of M inputs, t_1 expected outputs and t_2 unexpected outputs. Based on constant CRS, the expression of Super-SBM model is as follows:

$$\rho = \min \frac{1-\frac{1}{m}\sum_{i=1}^{m}\left(\frac{\bar{s_i}}{x_{ic}}\right)}{1-\frac{1}{t_1+t_2}\left(\sum_{i=1}^{t_1}\frac{s_r^{g+}}{y_{rc}{}^{g}}+\sum_{i=1}^{t_2}\frac{s_r^{b-}}{y_{rc}{}^{b}}\right)} \quad (1)$$

2.2 Malmquist Luenberger Index Model

The Malmquist Luenberger index model proposed by Chung (1997) (Chung, 1997) is used to study the dynamic efficiency of urban development. When ML index is greater than 1, the urban development efficiency is improved; When it is equal to 1, the urban development efficiency remains unchanged; When it is less than 1, the urban development efficiency decreases.

The ML index model from t to t + 1 is:

$$\mathrm{ML}_t^{t+1} = \left(\frac{1+D_0^t(x^t,y^t,b^t,y^t,-b^t)}{1+D_0^{t+1}(x^{t+1},y^{t+1},b^{t+1},y^{t+1},-b^{t+1})} \Big/ \frac{1+D_0^{t+1}(x^{t+1},y^{t+1},b^{t+1},y^{t+1},-b^{t+1})}{1+D_0^{t+1}(x^t,y^t,b^t,y^t,-b^t)}\right)^{\frac{1}{2}} \quad (2)$$

After decomposition, it can be decomposed into technical efficiency change (EC)and technological progress (TC).

$$\mathbf{ML}_t^{t+1} = \mathbf{EC}_\mathbf{t}^{\mathbf{t+1}} \times \mathbf{TC}_\mathbf{t}^{\mathbf{t+1}} \quad (3)$$

2.3 Index Selection

2.3.1 Input Index

Select urban fixed assets (10,000 yuan) as the capital investment index. The number of urban employees at the end of the year (10,000 people) is selected as the manpower input index. R&D expenditure (10,000 yuan) is selected as the innovation investment index. The electricity consumption of the whole society (100 million kwh) is selected as the energy input index.

2.3.2 Output Index

1) Expected output: the annual urban real GDP (10,000 yuan) is selected as the regional GDP index. The annual number of invention patent applications (pieces) is selected as the innovation achievement.

2) Undesired output: the number of registered urban unemployment (persons) is selected as the unemployment index. Select industry SO_2 emission (ton) is used as the environmental pollution index.

2.4 Data Sources

The data comes from Fujian statistical yearbook from 2008 to 2019, EPS database and statistical yearbooks of 9 prefecture level cities and 11 county-level cities in Fujian.

3 EMPIRICAL ANALYSIS

3.1 Static Analysis of Urban Development Efficiency Based on Super-SBM Model

From the mean value (Table 1 and Table 2): except 2008-2010 and 2017-2018, which did not reach DEA effectiveness (efficiency value is greater than 1), all other years reached DEA effectiveness; The overall trend is: it increased from 0.97 in 2008 to 0.99 in 2009, then decreased to 0.94 in 2010, then increased to 1.10 of the peak in 2014 from 1.03 in 2011, then decreased to 0.85 of the valley in 2017, and finally increased year by year to 1.07 in 2019.

It is worth noting that the mean value of super efficiency decreased greatly from 2016 to 2017, which was caused by the large unexpected output (unemployment and environmental pollution) in Nanping and Longyan in 2017; Then, from 2017 to

Table 1: Super efficiency of urban development in various cities of Fujian Province from 2008 to 2014.

City	Static super efficiency of urban development I						
	2008	2009	2010	2011	2012	2013	2014
Fuzhou	1.14	1.16	1.20	1.17	1.14	1.10	1.05
Longyan	1.02	1.01	0.74	1.01	1.01	1.02	1.05
Nanping	0.50	0.43	0.41	0.54	0.65	1.01	1.01
Ningde	1.15	1.40	1.18	1.21	1.03	1.06	1.04
Putian	1.08	1.06	1.07	1.08	1.07	1.08	1.10
Quanzhou	1.17	1.17	1.18	1.12	1.12	1.14	1.11
Sanming	0.49	0.45	0.50	0.58	0.57	0.64	1.01
Xiamen	1.12	1.14	1.12	1.51	1.48	1.48	1.47
Zhangzhou	1.03	1.04	1.05	1.05	1.06	1.04	1.03
mean	0.97	0.99	0.94	1.03	1.02	1.06	1.10

Table 2: Super efficiency of urban development in various cities of Fujian Province from 2015 to 2019.

City	Static super efficiency of urban development II					
	2015	2016	2017	2018	2019	mean (2008-2019)
Fuzhou	1.06	1.09	1.06	1.03	1.02	1.10
Longyan	1.05	1.04	0.21	1.04	1.01	0.93
Nanping	0.62	1.01	0.21	0.25	1.01	0.64
Ningde	1.05	0.44	0.30	0.48	0.54	0.91
Putian	1.07	1.06	1.05	1.02	1.07	1.07
Quanzhou	1.14	1.13	1.04	1.30	1.18	1.15
Sanming	1.03	1.03	1.29	0.37	1.02	0.75
Xiamen	1.45	1.74	1.43	1.74	1.79	1.46
Zhangzhou	1.03	1.03	1.03	1.00	1.03	1.04
mean	1.06	1.06	0.85	0.93	1.07	

2019, the average value of super efficiency increased greatly. Especially since the establishment of the two coordinated development zones of Southwest Fujian and northeast Fujian in 2018, high-efficiency cities such as Xiamen and Fuzhou have vigorously promoted industrial cooperation and ecological protection, reducing the unexpected output of cities such as Nanping and Longyan, thus improving the overall super efficiency value of Fujian Province.

Figure 1 reflects the urban development efficiency level through the color depth according to the average value of super efficiency. The darker the color, the higher the development efficiency level. Therefore, the urban development efficiency level is divided into five levels: very high level (Xiamen), high level (Quanzhou, Fuzhou), general level (Zhangzhou, Putian), low level (Longyan, Ningde) and very low level (Sanming, Nanping).

In terms of spatial distribution, the mean value of super efficiency in coastal areas of Fujian is higher than that in inland mountainous areas; Specifically, Fuzhou, Southern Fujian (Zhangzhou, Xiamen and Quanzhou), central Fujian (Putian) (the mean value of super efficiency is greater than 1) is greater than that in Western Fujian (Longyan and Sanming), Northern Fujian (Nanping) and Ningde (the mean value of super efficiency is less than 1). It can be seen that the super efficiency level of urban development in Fujian Province is not randomly distributed, but has a high spatial correlation: on the whole, it decreases from coastal areas to inland mountainous areas; Specifically, the super efficiency value decreases from southern Fujian, central Fujian and Fuzhou to Western Fujian, Northern Fujian and Ningde.

Figure 1: Average value of super efficiency of urban development of cities at all levels in Fujian Province (Jinmen county is not included in the statistical category).

3.2 Dynamic Analysis of Urban Development Efficiency Based on Malmquist Luenberger Index

Limited by space, the panel data of urban development dynamic efficiency in Fujian Province in 2008-2009, 2012-2013 and 2018-2019 are intercepted to analyze its ML index and its decomposition:

From 2008 to 2009, the ML of all cities in Fujian Province was greater than 1, and the urban development efficiency was improved; Among them, the EC of Nanping and Sanming is less than 1, and the TC value is greater than 1. The deterioration of technical efficiency affects technological progress and deteriorates urban development efficiency; The EC Value of other cities is 1, and the TC value is greater than 1. The improvement of technological progress plays a major role in the improvement of urban development efficiency.

From 2012 to 2013, the ML value of Longyan and Ningde was less than, the EC value was 1, and the TC value was less than 1. The deterioration of technological progress led to the deterioration of urban development efficiency; The ML value of Sanming is greater than 1, the EC value is greater than 1, and the TC value is less than 1. The deterioration of technological progress affects the technical efficiency and improves the urban development efficiency; The ML value, EC Value and TC value of Nanping are greater than 1. The improvement of technical efficiency and technological progress jointly promote the improvement of urban development efficiency; The ML value of other cities is greater than 1, the EC value is 1, and the TC value is greater than 1. The improvement of technological progress plays a major role in improving the efficiency of urban development.

From 2018 to 2019, the ML value of Fuzhou and Quanzhou is less than 1, the EC value is 1, and the TC value is less than 1. The deterioration of technological progress leads to the deterioration of urban development efficiency; The ML value of Nanping is less than 1, the EC value is greater than 1, and the TC value is less than 1. The improvement of technical efficiency can not make up for the impact of the deterioration of technical progress, resulting in the deterioration of urban development efficiency; The ML value of Ningde is greater than 1, EC value is less than 1, TC value is greater than 1, the deterioration of technical efficiency affects technological progress and improves urban development efficiency; The ML value of other cities is greater than 1, the EC value is 1, and the TC is greater than 1. The improvement of technological progress plays a leading role in the improvement of urban development efficiency.

To sum up, in the selected period, the development efficiency of most cities has been improved, but there is a single source of improvement (EC / TC improvement, TC / EC unchanged), and there is little phenomenon that technical efficiency and technological progress jointly promote the improvement of urban development efficiency; In the

Table 3: ML index and its decomposition of dynamic efficiency change of urban development in Fujian Province (2008-2009,2012-2013).

City	2008-2009			2012-2013		
	ML	EC	TC	ML	EC	TC
Fuzhou	1.17	1.00	1.17	1.01	1.00	1.01
Longyan	1.09	1.00	1.09	0.99	1.00	0.99
Nanping	1.01	0.94	1.07	1.06	1.02	1.04
Ningde	1.52	1.00	1.52	0.96	1.00	0.96
Putian	1.01	1.00	1.01	1.04	1.00	1.04
Quanzhou	1.06	1.00	1.06	1.02	1.00	1.02
Sanming	1.09	0.99	1.11	1.03	1.06	0.98
Xiamen	1.29	1.00	1.29	1.20	1.00	1.20
Zhangzhou	1.11	1.00	1.11	1.01	1.00	1.01

Table 4: ML index and its decomposition of dynamic efficiency change of urban development in Fujian Province (2018-2019).

City	2018-2019		
	ML	EC	TC
Fuzhou	0.86	1.00	0.86
Longyan	1.06	1.00	1.06
Nanping	0.99	1.05	0.94
Ningde	1.04	0.95	1.09
Putian	1.13	1.00	1.13
Quanzhou	0.81	1.00	0.81
Sanming	1.01	1.05	0.96
Xiamen	1.13	1.00	1.13
Zhangzhou	1.15	1.00	1.15

case of the deterioration of urban development efficiency, the deterioration source is basically single (EC / TC deterioration, TC / EC unchanged or EC / TC deterioration, TC / EC unchanged). Among them, TC deterioration and EC unchanged mainly lead to the deterioration of urban development efficiency. Efforts to improve technological progress should be strengthened.

4 CONCLUSION

In order to evaluate the urban development efficiency in Fujian province, this study constructs the transcendence evaluation system and takes panel data of nine prefecture-level cities in Fujian, which uses the Super-SBM model under unexpected output in DEA and Malmquist-Luenberger index. This paper calculates the high-quality development level of urban economy in Fujian Province from static and dynamic aspects, analyzes the evaluation results.

From a static perspective, the super efficiency level of urban development in Fujian Province has a high spatial correlation: it decreases from coastal areas to inland mountainous areas on the whole and decreases from southern Fujian, central Fujian and Fuzhou to Western Fujian, Northern Fujian and Ningde specially. Fujian province should strengthen the cooperation between mountainous and coastal areas in various fields, and Xiamen, Quanzhou and Fuzhou should play central cities as a role.

From a dynamic perspective, the main reason for the deterioration of urban development efficiency is due to the deterioration of TC and the unchanging EC. Efforts to improve technological progress should be strengthened by increasing investment in innovation.

ACKNOWLEDGMENT

1.Project of Xiamen Federation of Social Sciences (XMSK2021C03)

2.Project of the National Ethnic Affairs Commission(2020-GMD-033)

REFERENCES

C.Y. Wen, Y. M. Lee,J. L. Hu.(2016). Urban sustainability assessment of Taiwan based on data envelopment analysis [J]. Renewable and Sustainable Energy Reviews, 61(5):342-352

F.Z Li, H.K. Fu. (2016) Research on the efficiency of China's coastal open cities[J]. Business research, (12): 80-87

J.Y.Zhang, X.L.Yuan, J.Wang, D.M. Ma ei.(2021) Urban efficiency evaluation of the Yellow River Basin from the perspective of high-quality development[J]. Statistics and decision making, 37 (11): 98-102

K.Tone (2001). A slacks-based measure of efficiency in data envelopment analysis[J]. European Journal of Operational Research, 130(3), 498-509.

K.Tone (2002). A slacks-based measure of super-efficiency in data envelopment analysis[J]. European Journal of Operational Research, 143(1), 32-41.

R. Färe, S. Grosskopf (1983). Measuring congestion in production [J]. Ztschrift Für Nationalkonomie, 43(3), 257-271.

X.L.Yuan, J.Wang, J.Y.Zhang.(2020). Urban efficiency evaluation under high-quality development -- An Empirical Study from 19 sub provincial and above cities [J]. Urban development research,27 (06): 62-70

Y.H. Chung; R. Färe; S. Grosskopf (1997). Productivity and Undesirable Outputs: A Directional Distance Function Approach [J]. Journal of Environmental Management. 51(3), 229–240.