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Technical Efficiency and Its Influencing Factors of the Three Major Urban Agglomerations in Eastern China

—Based on DEA-Tobit Model

Qianyu Wang*, Zhiyuan Chang

Business School, China University of Political Science and Law, Beijing, China
Email: *wqy0161@126.com

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Abstract

In recent years, the development of metropolitan region not only contributes to the transformation of China's economic growth model, but also becomes an increasingly important way to build a new double-cycle pattern. Among them, the Beijing-Tianjin-Hebei Metropolitan Region, Yangtze River Delta and Pearl River Delta urban agglomerations, as the core strategic area of national economic growth and an important part of regional coordinated development, effectively improve the allocation efficiency of various production factors, promote their technical efficiency, and play an important role in leading the high-quality economic development of the region and even the whole country. Based on the input-output data of relevant provinces from 2010 to 2020, this paper adopts DEA model and Malmquist index method to carry out static and dynamic evaluation on the technical efficiency level of the three city agglomerations. In addition, Tobit model is used to examine the influencing mechanism of the technological efficiency of each province and city in the three urban agglomerations by adopting five factors including government support, technological innovation ability, quality of laborers, wage status of employed personnel and informatization level, and put forward countermeasures and suggestions for further improving the technological efficiency of each urban agglomerations.

Keywords

Three Chinese Urban Agglomerations, Technical Efficiency, Influence Factor

1. Introduction

China's 14th Five-Year Plan puts forward that it will take promoting the devel-

opment of urban clusters as the starting point to form a strategic urbanization pattern featuring "two horizontal and three vertical axes" in an all-round way. Urban clusters or urban agglomerations is a result in the middle of the realization of new urbanization and regional coordinated development in China. Driven by policy planning and development needs, they have been gradually replacing the development pattern of traditional provincial economy and forming a firm basis for China's future regional economic development (Sun, Li, & Liu, 2021).

According to the Opinions of the CPC Central Committee and the State Council on Establishing a New Mechanism for More Effective Balanced Regional Development released in November, 2018, the urban clusters of the Beijing-Tianjin-Hebei region, Yangtze River Delta, Guangdong-Hong Kong-Macao Greater Bay Area, Chengdu-Chongqing region, Pearl River Delta, the Central Plains, the Guanzhong Plain, among others, will promote the strategic integrated development of major areas in China. However, there is a big gap in the development level of the major urban agglomerations, and their input-output efficiency differs significantly (Li, 2018). In particular, the urban clusters of Pearl River Delta, Yangtze River Delta and Beijing-Tianjin-Hebei region have become model regions with high-level opening up and economic development in China by virtue of policy dividends, location conditions and other development advantages, so they are regarded as China's most developed three major urban agglomerations. Obviously, the technological innovation capabilities of a single province or city in one of these urban agglomerations cannot effectively cope with the complex competitive environment, but the cities can collaborate with each other to improve the degree of regional integration, so that they can make efficient use of economic resources in all production links of the urban agglomeration, and achieve in-depth development by learning from each other. At present, the three major urban agglomerations along the eastern coast of China account for 8.6%, 23.9% and 10.9% of the national GDP respectively, which is up to 43.4% in total. The pattern of the three major urban agglomerations supporting China's economic development has become increasingly prominent. Therefore, improving the technical efficiency in the economic development of the three major urban agglomerations in east China, promoting the flow of technology and knowledge between regions, and realizing the integration of innovation resources will raise China's overall level of technical efficiency and development potential.

Undoubtedly, improving the allocative efficiency of factors of production of the three major urban agglomerations not only plays a leading role in China's regional economic and social development, but also largely determines their international position in the competition with mature urban agglomerations in developed countries. According to theoretical research, China's urban agglomerations are gradually taking on differentiated development paths, but excessive regional disparities will lead to the imbalance of regional development, thus exerting a great

impact on China's economic growth. Therefore, an in-depth study on the allocative efficiency of factors of production of the said three urban agglomerations is of referential significance for summarizing the experience and lessons gained from the development and construction of urban agglomerations in China and discussing the policies and measures to drive their development in China.

The article is organized as follows. After this introduction, section 2 gives a brief review of the relevant literature studies. Section 3 discusses the research method and indicator selection in the analysis. Section 4 presents the results of the differences in technical efficiency and the influencing factors. Finally, conclusions and countermeasures are given in Section 5.

2. Related Work

The existing research on the efficiency measurement of the three major urban agglomerations along the eastern coast is mainly conducted from the perspectives of science-technology finance (sci-tech finance) efficiency and innovation efficiency. Sun Zhongyan measured the sci-tech finance efficiency of the urban clusters of the Yangtze River Delta, Pearl River Delta and Beijing-Tianjin-Hebei region in the period of 2009-2018 using the data envelopment analysis (DEA) based Malmquist measurement model (Sun, 2020). The results show that obvious differences exist in the efficiency of the three major economic circles, and the efficient allocation of resources has not been achieved in their sci-tech finance. Based on the BCC-based super-efficiency model, Ye Tanglin measured the overall innovation efficiency of the three major urban agglomerations and of each city in them during the period of 2010-2018, investigated the innovation efficiency gap among cities within each urban agglomeration by using the coefficient of variation, and explored the impact of internal gap on the overall innovation efficiency of the urban agglomerations as well as related factors (Ye, Li, & Wang, 2021).

Technical efficiency is a reflection of the economic development of an urban agglomeration and the level of allocative efficiency of factors of production. It also reflects the ability of an urban agglomeration to transform various economic inputs into economic outputs. The improvement of technical efficiency refers to the point of actual production moving to the production possibility frontier (PPF) in the production process, i.e., the increase of the output-to-input conversion ratio under the condition of unchanged technical level. As the problem of efficiency becomes increasingly significant, the literature on regional economy from the perspective of technical efficiency has been emerging. Fan Aijun used the DEA method to measure the technical efficiency level of 30 provinces and cities in China based on their input-output data in the period of 2001-2007, and found that the technical efficiency increase of the eastern, central and western regions showed a significant converging trend (Fan & Wang, 2009). Discussing the regional differences among the said three urban agglomerations from the perspective of technical efficiency will help promote their realization of high-

er-quality development.

To sum up, there have been relatively mature research ideas and methods on the efficiency of the three major urban agglomerations along the eastern coast, which is of referential significance to the further discussion on the technical efficiency of the three economic circles. However, with the in-depth implementation of the 14th Five-Year Plan and the outline development plans of the urban agglomerations, the variation characteristics and development trends of technical efficiency of the three major urban agglomerations become more complicated. With respect to regional differences in technical efficiency, the existing research have not reached a consistent conclusion.

Based on relevant literature studies, from the perspective of regional differences in the technical efficiency of the three major urban agglomerations, this work mainly uses the DEA method and its extension model based on provincial economic input-output data of the three major urban agglomerations in eastern China in the period of 2010-2020, measures and analyzes the differences in technical efficiency among the these urban agglomerations, and then analyzes their internal mechanisms and influencing factors, with the purpose of putting forward countermeasures and suggestions to further improve their allocative efficiency of resources.

3. Research Method and Indicator Selection

3.1. Research Method

In 1978, Charnes, Rhode and Cooper proposed an analytical method, namely the DEA model, to evaluate the effectiveness of decision making units (DMUs) with the same type of multiple inputs and multiple outputs based on relative efficiency. Through the sustained efforts of scholars, the application of the DEA model has become increasingly flexible, as shown by the not strictly limited form of DMUs and selection of indicator units such as input and output units. Furthermore, the weight of each index can be automatically determined and allocated according to the given value, which excludes the disadvantages brought by subjective weighting, thus making the evaluation results more accurate (Ma, Huang, & Yao, 2011). After the continuous improvement of scholars, in reality, the DEA model can help decision makers not only to judge whether the point corresponding to the DMU is on the effective production frontier, but also to analyze which input-output items of the evaluated unit have deficiencies compared with the best DMUs, so as to find out the best way to improve efficiency. Therefore, the DEA model is selected in this paper for the study on the technical efficiency of the three major urban agglomerations (Chen, 2016).

Malmquist index was first put forward by Swedish economist Sten Mamquist. Caves et al. used Malmquist index to evaluate the productivity change over time. Later, it was combined with the DEA model and has become widely used (Shi & Xu, 2015). As the DEA model cannot make vertical comparisons of consecutive periods, the allocative efficiency of factors of each region in each period is com-

parable for the model, but the allocation status in different periods is not. To analyze the technical efficiency change of each province and city in the three major urban agglomerations in two consecutive periods, Malmquist index is adopted in this paper to evaluate and analyze the productivity change of a DMU in the period of $t-t+1$. If the index value is greater than 1, it means that the productivity shows an increasing trend, and vice versa.

3.2. Indicator Selection and Data Processing

The selection of input and output indexes is the basic premise of using the DEA method to measure economic efficiency. From the perspective of economics, labor and capital are usually the basic factors of production. The technical efficiency level in economic development is measured by changing the input of the two basic factors. Therefore, based on the "input-output" process of economic operation, following the principle of using a small number of efficiency evaluation indicators in the DEA model, and considering the representativeness and availability of data indicators, for the technical efficiency evaluation indicator system of the three major urban agglomerations, the physical capital stock and the number of employees at the year-end are selected as the capital input and labor input variables, and the actual regional GDP as the output variable. In order to have a more accurate examination of regional differences, in this paper, the eight provinces and cities in the three major urban agglomerations of the Beijing-Tianjin-Hebei region, Yangtze River Delta and Pearl River Delta, namely Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Anhui and Guangdong, are taken as the research unit, and their input-output data in 2010-2020 have been collected. The research data are mainly from the 2000-2020 statistical yearbooks of each region, and some missing data are supplemented by the interpolation method. The data are processed as follows:

Economic output. The actual regional GDP of each province and city is taken as the indicator to measure the total output. Due to the long time span, to eliminate the influence of price factors, the GDP deflator is used in the paper to deflate the regional GDP index with 2000 as the base year.

Labor input. According to the existing statistical data, the number of employees at the year-end in each province is selected as the proxy variable for labor input.

Capital input. According to the existing research, the physical capital stock is selected as the indicator of capital input, but these data do not exist in the actual statistics, so the perpetual inventory method is employed for the estimation of the physical capital stock, and the formula is $K_t = I_t / P_t + (1+\delta_t) K_{t-1}$. Using this method involves the capital stock in the base year, the gross fixed capital formation and the capital depreciation rate. To eliminate the influence of price factors, the fixed asset price deflator is used to deflate the gross fixed capital formation K with 2000 as the base year. The depreciation rate of fixed capital is selected by reference to the practice of Zhang Jun (Zhang & Zhang, 2003), using

$\delta = 9.6\%$.

4. Result Analysis

4.1. Regional Differentiation of Technical Efficiency of the Three Major Urban Agglomerations in China

In this section, DEAP2.1 program is used for calculation, and the overall evaluation of technical efficiency of the eight provinces and cities in the three major urban agglomerations in eastern China is presented in Table 1.

First, in terms of comprehensive technical efficiency, this indicator of the said eight provinces and cities decreased slightly from the highest figure 0.801 in 2010 to 0.771 in 2020. On the whole, the average value of this indicator basically fluctuates around 0.78, which is at a high level. When the efficiency value of the DMU is 1, it means few regions have reached technical efficiency. Among the eight regions, only Shanghai had reached DEA efficiency in the whole period, and Guangdong Province was in the state of DEA efficiency from 2010 to 2015, indicating that they realized the optimal allocation of factors of production in the corresponding period of time.

Secondly, from the perspective of pure technical efficiency, during 2010-2020, pure technical efficiency fluctuations were small in general, but the value of efficiency was remarkably higher than that of technical efficiency. There is a large and relatively constant number of provinces and cities whose DMU efficiency value is 1. Beijing, Shanghai and Guangdong Province had been in the state of technical efficiency, and the pure technical efficiency of Tianjin and Anhui Province was also at a high level.

Thirdly, from the perspective of scale efficiency, during 2010-2020, the overall scale efficiency declined slightly from 0.863 in 2010 to 0.823 in 2020. In the middle

Table 1. Overall evaluation of technical efficiency of eight provinces and cities in the three major urban agglomerations in 2010-2020.

DEA efficiency	Characteristics of efficiency values	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Comprehensive technical efficiency (TE)	Average value	0.801	0.796	0.789	0.792	0.787	0.783	0.781	0.775	0.769	0.765	0.771
	TE = 1 Number of cities	2	2	2	2	2	2	1	1	1	1	1
Pure Technical Efficiency (PTE)	Average value	0.928	0.928	0.928	0.927	0.918	0.915	0.918	0.923	0.931	0.936	0.941
	PTE = 1 Number of cities	5	5	5	5	5	5	5	5	5	5	5
Scale Efficiency (SE)	Average value	0.863	0.858	0.852	0.856	0.857	0.855	0.851	0.840	0.829	0.821	0.823
	SE = 1 Number of cities	2	2	2	2	2	2	1	1	1	1	1
returns to scale	Progressive increasing	5	5	5	5	5	5	4	4	4	4	4
	Progressive decreasing	1	1	1	1	1	1	3	3	3	3	3
	Unchanged	2	2	2	2	2	2	1	1	1	1	1

Data source: Based on DEAP calculation results.

years, the efficiency value was on the rise, and the average scale efficiency was above 0.8. Among the regions, there is a small number of provinces and cities whose DMU efficiency value is 1, which corresponds to the results by comprehensive technical efficiency, i.e., only Shanghai has reached technical efficiency during the whole period, and Guangdong Province had reached technical efficiency in 2010-2015.

Finally, from the perspective of returns to scale, during 2010-2015, the returns to scale of the eight regions in the three major urban agglomerations largely increased. However, in the period of 2015-2020, there was an increased number of provinces and cities with diminishing returns to scale, indicating that with the increase of physical capital stock and labor input, the increase of economic output decreased.

From the above analysis of the technical efficiency of the three major urban agglomerations in China, the two typical periods are 2010-2015 and 2016-2020. In this paper, two representative years, 2011 and 2018, are chosen for concrete analysis. The results are listed in Table 2.

As can be seen from Table 2, Shanghai's production input had been technically efficient, indicating that the output was at the production frontier, i.e., compared with other provinces and cities, Shanghai's input and output were in the best state, and the output under the given input had been maximized. This was attributed to the long-term development and accumulation of Shanghai as an international metropolis, and to the improved management level of economic operation by gathering specialized talent and strengthening the management mechanism, which helped Shanghai realize the effective allocation of physical capital and human capital in economic activities. Guangdong's comprehensive technical efficiency value had been kept above 0.9, so with a slight adjustment to the input and output, its efficiency would reach the level of 1. This indicates that Guangdong's allocation capacity and utilization efficiency of factors of production

Table 2. DEA-BCC measurement results of the eight provinces and cities in the three major urban agglomerations in 2011 and 2018.

Year	Indicator	Beijing	Tianjin	Hebei Province	Guangdong Province	Shanghai	Jiangsu Province	Zhejiang Province	Anhui Province
2011	TE	0.820	0.510	0.520	1.000	1.000	0.847	0.794	0.877
	PTE	1.000	1.000	0.632	1.000	1.000	0.959	0.833	1.000
	SE	0.820	0.510	0.823	1.000	1.000	0.883	0.953	0.877
	Status of Returns to Scale	irs	irs	irs	-	-	drs	irs	irs
2018	TE	0.766	0.399	0.510	0.939	1.000	0.861	0.828	0.851
	PTE	1.000	0.984	0.606	1.000	1.000	1.000	0.854	1.000
	SE	0.820	0.510	0.823	1.000	1.000	0.883	0.953	0.877
	Status of Returns to Scale	irs	irs	irs	drs	-	drs	drs	irs

Data source: Based on DEAP calculation results.

were at the leading level. However, Beijing, Jiangsu Province, Zhejiang Province and Anhui Province failed to achieve sustainable and efficient allocation of factors of production in most years, but their overall technical efficiency was relatively stable. There is room for development and improvement in pure technical efficiency and scale efficiency.

In the urban agglomeration of Beijing-Tianjin-Hebei region, the technical efficiency of Tianjin and Hebei is at the bottom of the three economic circles, so their input and output have not reached the best state, and it is necessary to make long-term adjustment from the perspective of technical efficiency and scale efficiency. Pure technical efficiency is the production efficiency affected by management and technology, which can effectively reflect the utilization of actual resources. However, the pure technical efficiency of Hebei was low in both 2011 and 2018, indicating that in addition to the scale factor, the improper management of economic operation by local governments and market players or the lack of technological innovation led to the waste of production resources. Hebei and Anhui were close in economic volume, but the former's technical efficiency in economic development lagged far behind Anhui's. Hebei should pursue improving the quantity of economic development, and meanwhile pay more attention to the quality and structure of development. It should standardize production management and attach importance to talent introduction and technological innovation, so as to maximize the output with the given input and improve the input-output efficiency. Scale efficiency is the production efficiency affected by scale factors, which means the optimal state between inputs and outputs. In comparison, the scale efficiency of Tianjin was low in the two years, indicating that the proportion of input increase was less than that of output increase. The main reason for Tianjin's low comprehensive efficiency is that the scale did not match the input and output. It should increase the efforts to attract investment and open wider to the outside world, expand production and realize economies of scale.

From the perspective of spatial differentiation, the regional differences in the technical efficiency of the three urban agglomerations are significant. The technical efficiency of the Yangtze River Delta and the Pearl River Delta was at a high level, while the overall technical efficiency of the Beijing-Tianjin-Hebei region was low with obvious internal gap. The Yangtze River Delta and Pearl River Delta should continue to cultivate new drivers of high-quality development and promote regional coordinated and innovative development. The large regional differences between Beijing, Tianjin and Hebei have restricted Beijing's role in driving the development of Tianjin and Hebei. To promote the high-quality development of Beijing-Tianjin- Hebei region, the priority should be to promote the economic transformation of Tianjin and Hebei (Lu, 2015).

4.2. Dynamic Evolution of Technical Efficiency of Three Major Urban Agglomerations in China

Efficiency change analysis is to calculate total factor productivity change index

(Tfpch), technical efficiency change index (Effch), technical change index (Techch), pure technical efficiency change index (Pech) and scale efficiency change index (Sech) based on Malmquist index. For the sake of research convenience, the period is evenly divided into three stages. In this section, the annual data in the period of 2010-2019 are selected, and the DEA-Malmquist index model is employed to calculate the average value and decomposition value of the Malmquist indexes of the eight major provinces and cities in the three major urban agglomerations in different stages. The technical efficiency of the three economic circles is dynamically evaluated and individual differences are analyzed. The calculation results are shown in Table 3.

The DEA-Malmquist index model measures and calculates the dynamic change of total factor productivity (TFP) of each DMU, and the results can be seen from the value of Tfpch in Table 3. When the Malmquist index is greater than 1, it indicates that the corresponding provinces and cities have increased TFP in the period of $t-t+1$, and vice versa. According to the calculation results, the average Malmquist indexes of the three urban agglomerations in 2010-2013 and 2013-2016 were all less than 1, showing that the TFP of the three urban agglomerations did not achieve significant growth, i.e., the TFP of economic growth driven by labor and fixed capital investment exhibited a declining trend. However, in 2016-2019, the average Malmquist indexes of the three urban

Table 3. Measurement results of the eight provinces and cities in the three major urban agglomerations by the DEA-Malmquist index model.

Year	Indicator	Beijing	Tianjin	Hebei	Guangdong	Shanghai	Jiangsu	Zhejiang	Anhui	Mean value
	Tfpch	0.996	0.947	0.950	0.975	1.004	1.000	0.996	0.964	0.979
2010	Effch	0.997	0.946	0.988	1.000	1.000	1.005	1.005	1.003	0.993
|	Techch	1.000	1.001	0.961	0.975	1.004	0.995	0.991	0.961	0.986
2013	Pech	1.000	0.999	0.969	1.000	1.000	1.024	0.995	1.000	0.998
	Sech	0.997	0.947	1.020	1.000	1.000	0.982	1.010	1.003	0.995
	Tfpch	1.027	0.991	0.966	0.970	1.032	0.993	0.987	0.965	0.991
2013	Effch	0.978	0.965	0.997	0.997	1.000	1.008	1.008	0.996	0.994
|	Techch	1.050	1.027	0.969	0.973	1.032	0.985	0.979	0.969	0.998
2016	Pech	1.000	0.976	0.993	1.000	1.000	1.000	1.001	1.000	0.996
	Sech	0.978	0.989	1.004	0.997	1.000	1.008	1.007	0.996	0.997
	Tfpch	1.019	1.005	1.007	0.970	1.029	0.985	0.999	0.989	1.000
2016	Effch	0.989	0.998	1.011	0.974	1.000	0.989	1.003	0.993	0.994
|	Techch	1.030	1.008	0.996	0.996	1.029	0.996	0.996	0.996	0.996
2019	Pech	1.000	0.973	0.991	0.974	1.000	0.989	0.986	0.996	0.998
	Sech	0.989	1.005	1.007	0.970	1.029	0.985	0.999	0.989	0.995

Data source: Based on DEAP calculation results.

agglomerations were equal to 1, indicating that the TFP of the three urban agglomerations showed no increase or decrease, and the TFP of economic growth driven by labor and fixed capital investment was stable, i.e., the TFP of the technical efficiency of the three urban agglomerations was in a declining-stable development trend on the whole. From the perspective of the said provinces and cities, according to the above table, except Shanghai, Beijing and Jiangsu, the Malmquist indexes of other provinces and cities in the three major urban agglomerations were less than 1 in 2010-2013 and 2013-2016, indicating that the fluctuation trend of TFP of economic growth driven by labor and capital investment was consistent with the overall development trend, while the Malmquist index of Shanghai was greater than 1 in all the three stages, showing that since 2010, the overall TFP of Shanghai's economic growth had increased steadily.

Malmquist index can be divided into technical efficiency change index (effch) and technical change index (techch). When the technical efficiency change index is greater than 1, it indicates that the corresponding provinces and cities have improved technical efficiency in economic development, and their input-output of factors of production is approaching the production frontier. When the technical change index is greater than 1, it indicates that the technological research promotes technological progress and innovation in the corresponding regions, which then optimizes the input of economic resources and drives economic growth, thus pushing the production frontier to move outward. As can be seen from the calculation results in 2010-2019, Zhejiang's technical efficiency change index was greater than or equal to 1, indicating that its existing technology utilization efficiency had been continuously improved, which promoted the increase of TFP. Shanghai's technical efficiency change index was always 1, indicating that Shanghai's technical efficiency remained unchanged. The reason may be that as Shanghai was in a technically efficient state, the utilization rate of existing technologies had achieved saturation. The average value of Hebei's technical efficiency change index in 2010-2016 was less than 1, and in 2016-2019 the average value was greater than 1, indicating that its existing technology utilization efficiency was gradually improved. The average value of the technical efficiency change index of Tianjin, Anhui and other regions was less than 1 in 2010-2019, and the technical efficiency showed a negative growth, indicating that the gap between the technical efficiency change index and the production frontier composed of the optimal DMUs had widened. Hebei had not effectively utilized and exploited its existing technical capacity, and failed to reach the optimal resource allocation level, and there was a waste of factor inputs. From the perspective of technical change index, the average value of technology change index in Beijing, Tianjin and Shanghai was greater than 1, which was related to the good local atmosphere of technological innovation and continuous scientific research funding. However, the average value of technical change index in other regions in the table was less than 1, meaning stagnated technological research and development, so more achievements need to be made with respect to technological

innovation and introduction of technology for economic development in these regions.

The research results obtained from the DEA-BCC model and DEA-Malmquist index model both show that there are significant inter-provincial differences in technical efficiency in economic development of the eight provinces and cities of the three major urban agglomerations from both static and dynamic perspectives. This regional imbalance is not conducive to the long-term coordinated development of the urban agglomerations in the Beijing-Tianjin-Hebei region, Yangtze River Delta and Pearl River Delta. Therefore, analyzing the factors that affect the economic growth efficiency of the three major urban agglomerations and building an indicator system for the influencing factors of technical efficiency of the three urban agglomerations are of great significance to reduce the regional disparities in their technical efficiency and realize their coordinated development.

4.3. Influencing Factor Analysis of Technical Efficiency of the Three Major Urban Agglomerations

The technical efficiency of a region's economic development depends not only on the input-output combination of factors of production such as capital and labor and resource allocation, but also on external factors such as government policies and scientific research funding. Therefore, based on the selection of existing indexes in relevant research, this paper mainly analyzes the impact of five external factors, namely, government support, technological innovation capability, labor quality, wage of employees, and informatization level, on the technical efficiency of each province and city in the three major urban agglomerations.

First, government support (X_1): scientific and technological innovation involves high risks, and government financial expenditure is particularly critical to improve the level of innovation and realize the transformation of scientific and technological achievements. So the proportion of local public financial expenditure on science & technology to the general government budget of each province and city is selected as the indicator to evaluate government support.

Second, technological innovation capability (X_2): Science and technology constitute the foremost productive forces. With the improvement of the scientific and technological innovation ability of a region, the technical efficiency also increases correspondingly. So the proportion of granted patents in the local region to the number of granted patents nationwide is selected as the indicator to evaluate technological innovation capability.

Third, labor quality (X_3): High-quality labor is the key factor influencing the efficiency of regional economic growth. So the number of college students per hundred people is selected as the indicator to evaluate labor quality.

Fourth, wage of employees (X_4): The increase of wage level will enhance the competitiveness of the region and attract talent to gather in the region. So the average wage of active employees is selected as the indicator to evaluate wage level.

Fifth, informatization level (X_5): the popularization and application of information technology can improve the allocative efficiency of factors of production and increase the vitality of economic growth. The per capita telecom business volume is selected as the the indicator to evaluate informatization level.

In this paper, the evaluation indicator data of factors influencing technical efficiency of the provinces and cities in the three major urban agglomerations are cited from the website of the National Bureau of statistics and the statistical yearbooks and annual reports of those provinces and cities in 2010-2020. Then they are sorted and processed for the further research.

To analyze the impact of the above factors on technical efficiency, the comprehensive technical efficiency is taken as the explained variable and introduces the random-effects panel Tobit model as constructed below:

$$E_{it} = \alpha_i + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \delta_{it} \quad (1)$$

where E_{it} represents the comprehensive technical efficiency in the economic development of a region, α and β are the parameters to be estimated that affect each factor, and δ_{it} is the stochastic disturbance term.

Table 4 presents the descriptive statistics of the main variables including mean, sd, min, max and number of observations. Table 5 shows that government support, labor quality and informatization level have a significant impact on the comprehensive technical efficiency in economic development. First, there

Table 4. Descriptive statistical results.

variable	N	mean	sd	min	max
E	88	0.78	0.19	0.4	1
X_1	88	0.04	0.02	0.01	0.07
X_2	88	0.08	0.07	0.01	0.23
X_3	88	2.18	0.67	1.37	4.13
X_4	88	80,148	33,268.61	32,306	185,026
X_5	88	3797.15	3448.37	556.5	14,836.1

Table 5. Regression results of factors influencing comprehensive technical efficiency in the economic development of the three major urban agglomerations by Tobit model.

Explained variable	Explanatory variable	Coefficient	Standard Error
Overall Technical Efficiency	α_i	0.8382***	0.0538
	X_1	9.5417***	1.1074
	X_2	0.0262	0.2320
	X_3	−0.2102***	0.0206
	X_4	0.00000104	0.000000662
	X_5	−0.0000126**	0.00000507

*p < 0.1, **p < 0.05, ***p < 0.01.

is a positive correlation between government support and the comprehensive technical efficiency, indicating that the government's attention to economic growth can significantly improve its efficiency. Second, there is a negative correlation between labor quality improvement and the comprehensive technical efficiency. As the indicator increases by 1 unit, the comprehensive technical efficiency decreases by 0.2102 unit, showing that the economic growth efficiency of a region with higher labor quality is reduced. This may be explained by the fact that the high-quality labor force fails to give full play to their abilities in the job, thus limiting the improvement of economic efficiency. Thirdly, there is a negative correlation between the improvement of informatization level and the improvement of technical efficiency in regional economic growth, which shows that the informatization level rise is not conducive to the improvement of comprehensive technical efficiency, and instead it is a restraint. The emergence of this phenomenon is closely related to the stage of economic growth. In the early stage of information development, huge capital investment in information equipment and infrastructure is required, which is worthwhile as its role in promoting the improvement of economic efficiency is significant. However, when the informatization level is high, huge capital investment can only lead to small improvement of technical efficiency, which seems that the loss outweighs the gain.

5. Conclusions and Countermeasures

On the basis of developing the technical efficiency indicators for economic development of the three major urban agglomerations in eastern China, and using the input-output data of relevant provinces and cities in 2010-2020, the DEA model and Malmquist index method were employed to make static and dynamic evaluations of the technical efficiency level of the three major urban agglomerations. The Tobit model was used to analyze the influence of five external factors on the technical efficiency of each province and city in the three economic circles, including government support, technical innovation capability, labor quality, employment wage and informationization level. The conclusions are drawn as follows. First, on the whole, the average value of comprehensive technical efficiency of the eight provinces and cities in the three major urban agglomerations decreased slightly amid fluctuation at a high level. The comprehensive technical efficiency of Shanghai and Guangdong Province had been in the optimal state for a long time, and so they should give full play to their leading role in the development of China's urban agglomerations. Second, from the perspective of regional disparities of the urban agglomerations, compared with Yangtze River Delta and Pearl River Delta, the comprehensive technical efficiency of the Beijing-Tianjin-Hebei region was at a low level, mainly due to its relatively low scale efficiency, indicating that the innovation scale of most cities in the Beijing-Tianjin-Hebei region was still far from the optimal scale. In particular, the comprehensive technical efficiency of Tianjin and Hebei Province was signifi-

cantly affected by scale efficiency. Third, government support, labor quality and informatization level were the main factors affecting the comprehensive technical efficiency in the economic development of the three major urban agglomerations. However, government support had a positive role in promoting this indicator, labor quality and informatization level exert some inhibitory effects on it, and technological innovation capability and wage of employees have no significant impact on technical efficiency.

Obviously, the development of urban agglomerations in recent years not only contributes to the transformation of China's economic growth model, but also becomes an increasingly important path to building a new development pattern of "double circulation". To further improve technical efficiency and stimulate the coordinated development of high-quality regional and even national economy, the three major urban agglomerations are advised to take the following measures:

First, the Beijing-Tianjin-Hebei region should focus on narrowing the regional disparities between the province and the cities, achieve complementary advantages through the rational division of labor and cooperation among cities within the urban agglomeration, so that they can effectively promote the coordinated development of this economic circle (Sun & Yuan, 2014). As a region with the most noticeable uncoordinated and unbalanced development among the three major urban agglomerations in eastern China, the large regional disparities make it difficult for Beijing the capital to play a leading role in driving the development of Tianjin and Hebei, and even siphon effect has taken place to some extent, resulting in a wide gap in regional development (Bo & Chen, 2015). In the coordinated development of Beijing, Tianjin and Hebei, Tianjin should make clear its own functional positioning and promote the industrial structure upgrading. Hebei should seize the opportunity of the Beijing-Tianjin-Hebei coordinated development, and take advantage of the establishment of Xiong'an New Area and the Beijing Winter Olympic Games to drive Hebei Province to become an important modern trade logistics base in China, an industrial transformation and upgrading pilot area, a new urbanization and urban-rural overall planning demonstration area, and an ecological support area for Beijing, Tianjin and Hebei.

Second, the Pearl River Delta is one of the regions with the highest degree of marketization and the earliest and largest opening-up in China. In the future, this region should focus on cultivating new drivers of high-quality development and promoting development through innovation (Cai, 2017). With the implementation of the central government's strategic layout of the Guangdong-Hong Kong-Macao Greater Bay Area, the region should rely on government policy support, vigorously develop high-tech manufacturing industry, continuously improve the optimization and upgrading of traditional manufacturing industries, and further improve the efficiency of regional economic growth, so as to make the building of the urban agglomeration of Pearl River Delta an important

driver in the country's high-quality development.

Third, with a good foundation for economic development, the Yangtze River Delta is the most dynamic urban agglomeration in China's economy. As the region was the first to start regional integration, it has the best foundation and the highest degree of regional integration in China (Wang et al., 2022). The technical efficiency of the provinces and cities in the urban agglomeration has reached a high level. From the role of one major city and three provinces in the Yangtze River Delta, Shanghai is known for its development quality, Jiangsu for the total economic volume, Zhejiang for its features, and Anhui for its development potential. In the future, on the one hand, they should actively utilize Shanghai's location advantages and resource conditions to drive the coordinated development of neighboring cities; on the other hand, they should constantly cultivate the independent innovation capability of the regions within the Yangtze River Delta, realize the differentiated development model, and build this urban agglomeration a national demonstration base for high-quality development.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Bo, W. G., & Chen, F. (2015). The Coordinated Development among Beijing, Tianjin and Hebei: Challenges and Predicaments. *Nankai Journal (Philosophy,Literature and Social Science Edition), No. 1,* 110-118.

Cai, C. M. (2017). The Building of a World-Class City Cluster in Guangdong-Hong Kong-Macao Greater Bay Area: Strategic Meanings and Challenges. *Social Sciences in Guangdong, No. 4,* 5-14+254.

Chen, Q. (2016). *Research on the Efficiency of High-Tech Industries Supported by Science-Technology Finance in Jiangsu Province and Its Influencing Factors*. Yangzhou University.

Fan, A. J., & Wang, L. L. (2009). Regional Differences in China's Technical Efficiency and Growth Convergence—A Study based on Provincial Data. *Economist, No. 4,* 83-89.

Li, M. Q. (2018). *Study on the Evolution of Spatial Structure of Three Major Urban Agglomerations in China*. Jilin University.

Lu, D. D. (2015). Function Orientation and Coordinating Development of Subregions within the Jing-Jin-Ji Urban Agglomeration. *Progress in Geography, 34,* 265-270.

Ma, H. L., Huang, D. C., & Yao, H. Z. (2011). Total-factor Energy Efficiency Analysis of Three Major Economic Regions in China: Based on Super-DEA and Malmquist. *China Population, Resources and Environment, 21,* 38-43.

Shi, A. N., & Xu, Q. L. (2015). An Empirical Analysis of Allocation Efficiency of Science & Technology Resources in China Based on Super-efficiency DEA and Malmquist Index Model. *Science and Technology Management Research, 35,* 54-59.

Sun, J. W., & Yuan, Q. S. (2014). Trategic Comparison of Joint Development of Beijing, Tianjin and Hebei. *Comparative Economic & Social Systems, No. 5,* 1-11.

Sun, Z. Q., Li, H. H., & Liu, B. L. (2021). Research on Comprehensive Measurement and

Influencing Factors of Collaborative Innovation Efficiency of China's Four Urban Clusters. *Science & Technology Progress and Policy, 38,* 47-55.

Sun, Z. Y. (2020). *An Empirical Study on the Efficiency and Influencing factors of Regional Science-Technology Finance in China*. Hebei Finance University.

Wang, Q. Y., Zeng, G., Su, C., & Shang, Y. M. (2022). Research Progress of Regional Integration of Yangtze River Delta from the Perspective of Economic Geography. *Economic Geography, 42,* 52-63.

Ye, T. L., Li, L., & Wang, X. Y. (2021). Comparative Research on Innovation Efficiency and Influencing Factors of Three Eastern Urban Agglomerations in China. *Science & Technology Progress and Policy, 38,* 36-45.

Zhang, J., & Zhang, Y. (2003). Recalculating the Capital of China and a Review of Li and Tang's Article. *Economic Research Journal, No. 7,* 35-43+90.