Dynamic Empirical analysis of urban total factor productivity in Hubei Province: Based on DEA-Malmquist index method

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Abstract. High-quality development stage pays more attention to the improvement of supply-side efficiency. TFP can effectively reflect the efficiency of resource allocation and is related to the sustainable and healthy development of economy. Based on the DEA-Malmquist index method, the data of 12 representative cities in Hubei Province from 2010 to 2019 are selected for dynamic empirical analysis of TFP. It is finded that the overall increase trend of TFP in Hubei Province during the selected period is not obvious, mainly due to the impact of technological regression. Technical efficiency has been improved, but it is not enough to make up for the "drag effect" of technological regression. Further analysis of the decomposition terms of technical efficiency shows that the improvement of scale efficiency is greater than that of pure technical efficiency. From the urban distribution characteristics of TFP improvement, the decline of TFP in most cities is the cause of the decline of TFP, and the vast majority of cities show different degrees of technological regression. The results of the empirical analysis attempt to provide policy enlightenment for the recovery of economy and regional coordinated high-quality development after the epidemic in Hubei Province .

1 Introduction

China's remarkable growth miracle over the past 40 years of reform and opening up has generated a great deal of academic attention. What kind of high growth China has achieved and whether it is sustainable have attracted more and more scholars to engage in empirical studies of it. Although the conclusions are different, they basically reflect that the high economic growth that China exhibited in the past was mainly driven by factor input rather than the result of efficiency improvement.

An important index to measure the improvement of economic growth efficiency is total factor productivity (TFP for short, the same below), thus many scholars at home and abroad have studied its measurement methods, mainly from two aspects, one is based on the improvement of measurement model, the other is based on the innovation of research objects. The "growth accounting method" represented by "Solow Residuals" is the most well-known and classical method, but this has many defects ([1]). Later, the improvement of the model evolved from two directions. One is to improve the setting of the model on the basis of the specific production function in order to increase the applicability of the model, which is developed with the maturity of econometrics. Another analysis method, namely data envelopment analysis (DEA for short, the same below), use the difference of data itself to objectively measure TFP, which even abandon the specific function form. This model does not contain parameters and avoids the possible bias caused by the inaccuracy of parameter estimation. Furthermore, it avoids the problem of disconnection from reality brought by strict assumptions.

Due to the particularity of China's national conditions and the nature of the developing countries, Chinese scholars for TFP measurement research mainly focuses on the application of the model, rather than theory. The "application scenarios" of TFP measurement methods are becoming more and more diversified, from large aggregates to small aggregates, from the national level to the provincial level or the city level. Among them, the research on urban TFP is mainly concentrated in the early 21st century, those results vary with the time span and the number of sections of the study. The latest study on urban TFP was conducted by Wang et al ([10]), who adopted the sample data of more cities in China and updated the time. With regard to applicability and selection of the model, some scholars compared 11 representative measurement methods based on the same sample and then concluded that the selection of measurement methods should conform to the characteristics of the data itself ([4]).

To sum up, there are abundant literatures aboutmeasurement of TFP based on the overall level, most pursuing large data samples and long time spans to obtain general conclusions. However, few literatures single out a Province and measure the intra-regional difference of the TFP from a relatively local perspective for targeted analysis. While the assumption of technical homogeneity implied by different methods suggests that

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it is inappropriate to make a general comparison of TFP at various levels across the country, and the production function or production frontier may change at different development stage, so the general conclusions obtained may not be accurate. Considering the heterogeneity of each Province itself, this paper separately selected the urban panel data of Hubei Province from 2010 to 2019 to measure the TFP at the city level, and then combined the DEA model with Malmquist index to explore the dynamic difference of relative efficiency of economic growth of Hubei Province in recent ten years.

2 DEA-Malmquist index

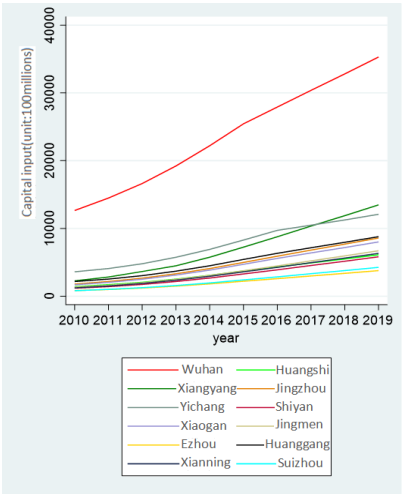

Fig.1 Changes of real GDP of major cities in Hubei Province from 2010 to 2019

Given that the statistical accounting standards for economic data are basically consistent across cities in Hubei Province, as well as the changes in capital and output data over the decade are relatively gentle(as shown in Fig.1, Fig.2), so dose labor mobility (as shown in Fig.3).And DEA using linear optimization boundary estimate production function and distance function, which is more suitable for studies with small samples([5]). Therefore, this paper follows the non-parametric approach, DEA-Malmquist index, used by most scholars who study urban TFP, to measure the change of the relative efficiency of TFP of 12 major cities in Hubei Province from 2010 to 2019.

DEA is the use of mathematical programming method to construct a frontier of possible production, which is set to evaluate the relative effectiveness with multiple input and output of decision making unit (DMU for short, the same below) ([9]). After determining the effective or ideal production frontier, the distance between each DMU and the frontier, i.e. the improvement distance, is used to judge which DMU is DEA-effective. Meanwhile, the projection method can also be used to point out the reasons for non-DEA-effective or weak-DEA-effective and the direction and degree of improvement ([7]). The DEA method can only determine the production frontier for cross-sectional data, rather than the cross-sectional data of different years, whose production frontiers are not the same. It is impossible to compare the changes of the improvement of TFP. Therefore, the DEA method can be combined with Malmquist index to analyze the dynamic changes of TFP or TFP's decomposition terms.

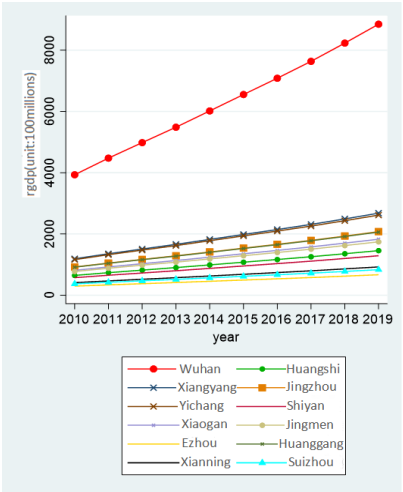

Fig.2 Changes of capital input of major cities in Hubei Province from 2010 to 2019

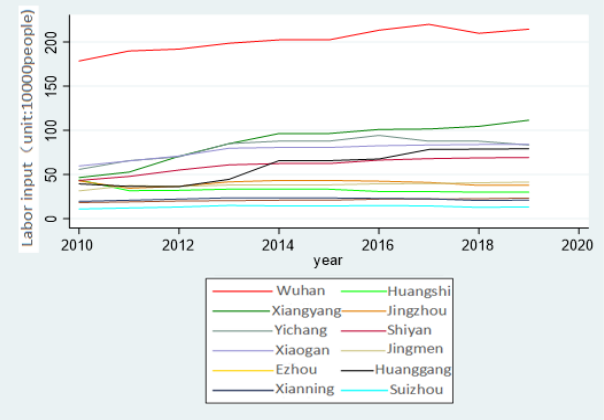

Fig.3 Changes of labor input of major cities in Hubei Province from 2010 to 2019

Malmquist productivity index uses the ratio of distance function to calculate input-output efficiency. Take city *i* as an example, the index can be obtained by the following steps:

First, suppose that there are different technological frontiers in different years, which is indeed in line with the reality, the distance function is defined as $D_t(\cdot)$, to measure the improvement distance from city *i*'s production efficiency and the frontier of year *t*.

Second, the input-output mix of city *i* in year *t* is set as (x_t, y_t), so the production efficiency of city *i* in year *t* can be expressed by $D_t(x_t, y_t)$.

Next, under the assumption of constant returns to scale, and take the frontier of year *t* as reference, the change of TFP (tfpch for the short, the same below) from year *t* to *t*+1 of city *i* is as follows:

$$M_t = \frac{D_t(x_{t+1}, y_{t+1})}{D_t(x_t, y_t)} \quad (1)$$

Also, take the frontier of year t+1 as reference, the tfpch from year t to year t+1 of city i is as follows:

$$M_{t+1} = \frac{D_{t+1}(x_{t+1},y_{t+1})}{D_{t+1}(x_t,y_t)} \quad (2)$$

Base on different frontiers, we cannot for sure that which one will represent the tfpch, so the Malmquist index take the geometric mean of M_t and M_{t+1} to indicates this change:

$$\text{tfpch}=\sqrt{M_t \times M_{t+1}}= \sqrt{\frac{D_t(x_{t+1},y_{t+1})}{D_t(x_t,y_t)} \times \frac{D_{t+1}(x_{t+1},y_{t+1})}{D_{t+1}(x_t,y_t)}} \quad (3)$$

When the index is greater than 1, it indicates that TFP of city i has improved from year t to year t+1, otherwise, it has not. Eq.3 can be further deformed into:

$$\text{tfpch}= \frac{D_{t+1}(x_{t+1},y_{t+1})}{D_t(x_t,y_t)} \sqrt{\frac{D_t(x_t,y_t)}{D_{t+1}(x_t,y_t)} \cdot \frac{D_t(x_{t+1},y_{t+1})}{D_{t+1}(x_{t+1},y_{t+1})}}$$
$$=\text{techch}\times\text{effch} \quad (4)$$

which separates technological change (techch for the short,the same below) from technical efficiency change (effch for the short, the same below). As we can see on the right side of Eq.4, the first term represents the techch, which indicates the change of the frontier from year t to year t+1, a kind of innovation of the technology in a way. Techch is more likely to have a sustainable TFP growth effect. The second term represents the effch, which reveals the efficiency of technology utilization under the same level of input-output set.

Then if we relax the assumption of constant returns to scale, we can decompose the effect of changes in scale from effch, i.e. Eq.4 can be transformed into:

$$\text{tfpch}=\frac{D_{v,\ t+1}(x_{t+1},y_{t+1})}{D_{v,\ t}(x_t,y_t)} \cdot \left[\frac{D_{v,\ t}(x_t,y_t)}{D_{c,\ t}(x_t,y_t)} \div \frac{D_{v,\ t+1}(x_{t+1},y_{t+1})}{D_{c,\ t+1}(x_{t+1},y_{t+1})}\right] \cdot \sqrt{\frac{D_{c,\ t}(x_t,y_t)}{D_{c,\ t+1}(x_t,y_t)} \cdot \frac{D_{c,\ t}(x_{t+1},y_{t+1})}{D_{c,\ t+1}(x_{t+1},y_{t+1})}}$$
$$= \text{pech}\times\text{sech}\times\text{techch} \quad (5)$$

Here effch is decomposed into the pure technical efficiency (pech for the short, the same below) and the scale efficiency (sech for the short, the same below). Footnotes “v” and “c” respectively represent the situations, variable returns to scale and constant returns to scale. Sech is one of the influencing factors for the change in technical efficiency, so decomposing it can further determine the source of effch.

It can be seen that Malmquist index has various advantages. Its divisibility can measure the contribution of pure technical efficiency and scale efficiency to technical efficiency respectively, and help judge if the TFP of a city shows inefficient, what the possible sources of the ineffectiveness is. That is of great significance for guiding practice.

3 Sample, variables and data

3.1 Sample selection

The prerequisite for using DEA-Malmquist method is that the number of DMU should not be too small, or at least twice the number of model variables. If the data is too sparse, it will be impossible to construct an approximate "smooth" technical front surface, resulting in unstable measurement results ([6]). Therefore, this paper selects the city panel data of 12 prefecture-level cities in Hubei Province, and excludes Enshi Autonomous Prefecture, whose data is seriously missing. The number of DMU is greater than twice the number of model variables, which meets the prerequisite set for the model. In addition, these 12 prefecture-level cities contribute more than 95% of the GDP of the whole Hubei Province (as shown in Fig.4), so the improvement of their TFP can largely represent the overall level of Hubei Province .

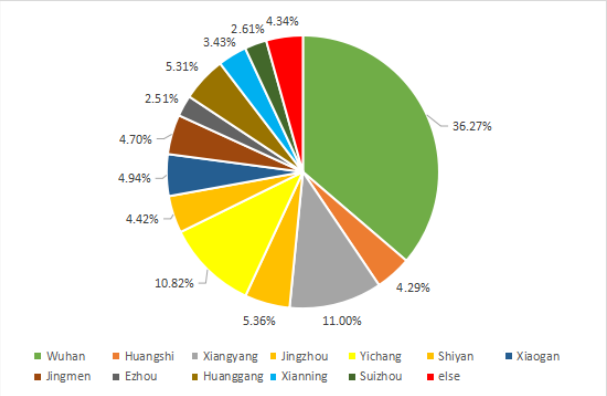

Fig.4. Annual mean of major cities’s contribution to GDP of Hubei Province from 2010 to 2019

The time period chosen is from 2010 to 2019, for which data are of availability and completeness, and China's stage is in the late industrialization and mid-urbanization. The period after 2019 is not taken into account because of the outbreak of the COVID-19 epidemic in early 2020, which made the economy of Hubei Province suffer a heavy blow and the data is more volatile, which will have a greater impact on the measurement results. In the later period of industrialization, China's "demographic dividend" is gradually disappearing. Labor costs have risen significantly, low-end manufacturing is gradually losing its competitiveness, and most industries have excess capacity. The reform focuses on supply-side structure, and the efficiency of production is not high, especially the efficiency of resource utilization is not high.Based on the research results of Liu et al.([2]) on the samples of major cities in China from 1990 to 2006 and Wang et al.([10]) on the samples of major cities from 2000 to 2013, the economic growth in the early stage of urbanization was not only driven by factor input, but also had a small improvement in TFP, and the improvement is not evenly distributed.The improvement of TFP in the eastern region was significantly greater than that in the

central and western. The main source of TFP improvement was techch, and effch had a "drag" effect. When added the samples of the mid-urbanization (about after 2008), the average TFP showed a downward trend, indicating that the "drag" effect of low technical efficiency greatly exceeded technical progress in the mid-urbanization. Therefore, this paper believes that it is necessary to analyze the mid-urbanization separately, and then select the urban samples from 2010 to 2019. In view of the characteristics of Hubei as a large traditional manufacturing Province, the operation efficiency of the real economy is particularly affected by the TFP. From the perspective on the performance of economic development, as the provincial capital, the resource input and economic growth of wuhan are far more than any other places, maybe due to its good foundation or its absorption of population from surrounding cities. But as a pole of economic growth, whether it plays a radiating role or a restraining role needs to be further analyzed.

3.2 Input and output variables

The accurate measurement of input and output variables is controversial, not only due to the non-uniform standard of large base of statistical accounting, but also due to the controversies of accurate measurement of input and output variables is. For example, whether use stock or flow is more appropriate for the measurement of capital input, or whether the measurement of labor input is caused by problems such as labor structure and labor quality, which need to be further improved.. This paper will select relatively accepted by the mainstream indicators for analysis.

3.2.1 Input variable

For the analysis of TFP, the input variables are usually capital and labor. Among them, the labor input is selected from the number of unit employees at the end of the year in *China City Statistical Yearbook*. The accounting scope of this index includes the number of private and individual employees, which can measure the labor input of the economy in the general. There is still no unified standard for the measurement of capital input, and the existing literatures on accounting indicators for capital input have taken the physical capital stock. Since there is no directly and officially available capital stock data, most of them are measured by scholars themselves, and the results measured based on their respective understandings are inconsistent. With the continuous improvement of the national economic accounting system and the continuous updating of data, scholars usually use the internationally accepted perpetual inventory method to estimate the capital stock.

The selection of total fixed asset formation instead of total fixed asset investment is based on the comparative analysis of Shan et al.([4]), who revealed that total fixed asset formation is more consistent with the specific situation of China's development. The base year is set as 2003. The estimation method and economic depreciation rate are both referred to Zhang et al. ([3]). Data on the total fixed assets formation at the city-level are not available, so the provincial-level will be converted into the city-level according to the method of Wang et al. ([10]).

3.2.2 Output variable

The selection of output variable continues with the GDP index. Taking the inflation factor into consideration, the nominal GDP of each year is converted into real GDP by using the GDP deflator on base year of 2003.

In summary, we construct a system of indicators to measure TFP, as shown in Table 1.

Table 1. Indicators' system of TFP' measurement

Input variables		**Output variable**	
variables	indicators	variables	indicators
Labor	Annual number of employees (unit:10,000 people)	Output value	GDP (unit:10,000 RMB)
Capital	Total fixed asset formation (unit:10,000 RMB)		

4 Empirical analysis

DEAP2.1, a professional software for dealing with DEA problems, is used for calculation and analysis. The results obtained by input-oriented or output-oriented are basically consistent (as shown in Table 2), thus the following analysis will be based on the results of the input-oriented method.

4.1 Overall change characteristics of TFP in Hubei Province

Table 2. Mean of Malmquist index in Hubei Province from 2010 to 2019

	effch mean	techch mean	pech mean	sech mean	tfpch mean
input-oriented	1.009	0.963	1.002	1.007	0.971
output-oriented	1.01	0.974	1	1.01	0.984

Table 2 shows the geometric means of Malmquist index in 12 cities of Hubei from 2010 to 2019. The results show that, on the whole, the TFP of Hubei Province declined by 2.9% during 2010-2019, which is close to the 2% decrease in the overall level of urban tfpch calculated by Wang ([10]). This indicates that generally the urban TFP does have a downward trend in the mid-urbanization, and the improvement of TFP in Hubei, as a central Province, is lower than the national level.

According to the decomposition results, the tfpch of Hubei comes from the techch, where the technical efficiency (effch) increases by 0.9%, but the techch

decreases by 3.7%. This result is consistent with the results of scholars such as Liu et al. ([2]) and Wang et al. ([10]) in that whether in the early or middle stage of urbanization, the range of techch is always greater than that of effch, so the main contribution to tfpch is techch. For the slight improvement of techch, the contribution mainly comes from the improvement of sech rather than the improvement of pech, indicating that cities in Hubei have improved their utilization of technology, and that they have improved scale efficiency in response to the task of "cutting overcapacity, reducing excess inventory, deleveraging, lowering costs, and strengthening areas of weakness" proposed by the central government in 2015. The overcapacity problem is particularly prominent in the central region, so the supply-side structural reform of "overcapacity reduction" is obviously the right medicine for the central region. The decline of techch of Hubei, is not match with its science and education Province status. The possible reason is that the integration capacity of its technological resources is still insufficient as well as the loss of high-tech talents, making its good foundation fails to contribute to the economic output as they should. Also the low proportion of hi-tech industry or the immature financial market will lead to the slow progress of technology.

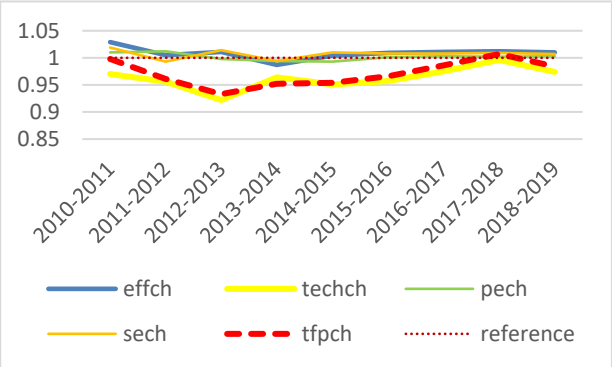

Fig. 5. Maliquist index of annual means in Hubei Province

Fig.5 shows Maliquist index of annual means and its sources in Hubei Province. It can be intuitively seen that techch and tfpch fluctuated significantly and their trends were consistent during the decade, which proves that the tfpch mainly comes from the contribution of techch. Roughly, 2013 is the cut-off point. Before that, both tfpch and techch have been declining year by year. After 2013, both of them began to show significant improvement and reached effective improvement during 2017-2018. At the same time, the variation trend of effch and its decomposition are stable during this period, and the improvement of sech remained in the effective range of greater than 1 after 2015, which also verified the above analysis and showed that the guidance of supply-side structural reform was feasible.

The implications for policies lie in that, on the one hand, the effectiveness of factor input should be improved. From Fig.1 to Fig.3, it can be intuitively seen that the capital input of cities in Hubei has been growing steadily year by year, while the change of labor input is not obvious, indicating that the development of Hubei Province in the past ten years has not attracted enough talents, and the economic growth is mainly driven by capital input, whose driving force is small. Under the current development conditions, Hubei needs to fully tap its economic growth potential, which still needs to be driven by innovation. On the other hand, we should further openning-up to attract high-quality foreign investment, introduce advanced technology, promote technology exchange and diffusion effect, and strengthen the industry-academia-research chain, allowing advanced technology to flow unimpeded into the enterprise thus become truly productive. Also we should strengthen talent policies, increase the proportion of high-quality labor, thus optimize the labor structure. It is worth noting that technological progress and these influencing factors are mutually reinforcing.

4.2 Urban distribution characteristics of total factor productivity change in Hubei Province

Overall result shows that the TFP in Hubei Province from 2010 to 2019 have a trend of decline, therefore, it is necessary to analyze the performance difference of TFP in different regions from the internal components, so as to understand the urban distribution characteristics of the change of TFP in Hubei, and then define the goals of future development. The Maliquist index of cities' means in Hubei Province are shown in Table 3, and the descriptive statistical results are shown in Table 4.

Table 3. Maliquist index of cities' means in Hubei Province from 2010 to 2019.

city	effch	techch	pech	sech	tfpch
Wuhan	1.042	0.983	1	1.042	1.024
Huangshi	1.022	0.982	1.021	1.001	1.003
Xiangyang	0.974	0.925	0.972	1.002	0.901
Jingzhou	1.013	0.99	1.008	1.005	1.003
Yichang	1.024	0.949	1.004	1.02	0.972
Shiyan	1.002	0.915	1.004	0.998	0.917
Xiaogan	1.006	0.915	1.004	1.001	0.92
Jingmen	1	0.947	1	1	0.947
Ezhou	1.007	0.964	1.003	1.004	0.971
Huanggang	1.01	0.941	1.004	1.007	0.951
Xianning	1.005	1.017	1.003	1.003	1.023
Suizhou	1	1.031	1	1	1.031

According to the calculation and statistical results in Table 3 and Table 4, there are five cities with TFP improvement, namely Wuhan, Huangshi, Jingzhou,

Table 4. Descriptive statistical results of cities' means

Index	Mean	Standard deviation	min	max	Number of cities(index > 1)
effch	1.00875	0.0164158	0.974	1.042	9
techch	0.96325	0.0381602	0.915	1.031	2
pech	1.001917	0.0109831	0.972	1.021	8
sech	1.006917	0.0124277	0.998	1.042	9
tfpch	0.9719167	0.0452718	0.901	1.031	5

Xianning and Suizhou, accounting for 41.67% of the total cities in the study, indicating that during 2010-2019, the economic growth of a few cities in Hubei Province was accompanied by the progress of TFP, among which, the maximum improvement is 3.1% in suizhou,and the minimum improvement is 9.9% in Xiangyang. The dispersion degree is large, indicating that the intra-regional tfpch of Hubei is not uniform. In addition, most cities have the improvement of technological efficiency and the regression of technology, indicating that most cities in Hubei lack the driving force of innovation.

The following are further classified statistics to understand the distribution characteristics of the tfpch and its decomposition items in Hubei Province .

Table 5. TFP-improved group (clssified by source)

Total number of tfpch-improved cities (tfpch＞1)	5	Total number of effch-improved cities (effch＞1)	4
effch＞1	4	pech＞1	3
techch＞1	2	sech＞1	4
effch＞1, and techch＞1	1	pech＞1, and sech＞1	3

The results in Table 5 show that, among the TFP-improved cities, technical efficiency has been improved in 4 cities, namely Wuhan, Huangshi, Jingzhou and Xianning, while technological progress has been made in Xianning and Suizhou. Only Xianning has improved its technical efficiency along with technological progress. In most cities with improved effch, the improvement of pech and sech jointly contributed to the improvement of technical efficiency, and only Wuhan had no significant change in pure technical efficiency.

Table 6 . TFP-non-improved group (classified by source)

Total number of tfpch-non-improved cities (tfpch＜1)	7	Total number of Effch-non-improved cities (effch＜1)	1
effch＜1	1	pech＜1	1
techch＜1	7	sech＜1	0
effch＜1, and techch＜1	1	pech＜1, and sech＜1	0

The results in Table 6 show that among the 7 cities with non-improved tfpch, Xiangyang is the only city with non-improved effch, and the decomposition of effch shows that it is mainly the decline in pure technical efficiency (i.e. the non-improved pech) that drags down the decline in technical efficiency.

By the above analysis we can see that the best performance in TFP improvement is Xianning, and the worst is Xiangyang. Wuhan did not show the TFP improvement to match its status. And Hubei Province as a whole, there is an obvious technical regression phenomenon.

Hubei's 14th Five-Year Plan and Long-Range Objectives Through the Year 2035 have laid out a regional development layout of "One main lead, two wings drive, and overall synergy". One of the "main" is to build an upgraded version of Wuhan city circle. The "two wings" are to strengthen the driving role of the two major city clusters - "Xiangshi Suishen" and "Yijing Jingen". Among them, Huangshi is positioned as the regional central city, while Xiangyang and Yichang are the sub-central cities in the province , which means these three cities are entrusted with the task of new economic growth poles after Wuhan.

Table 7. Comparison of the average change of TFP between central and sub-central cities in Hubei Province

city	effch	techch	pech	sech	tfpch
Wuhan	1.042	0.983	1	1.042	1.024
Huangshi	1.022	0.982	1.021	1.001	1.003
Xiangyang	0.974	0.925	0.972	1.002	0.901
Yichang	1.024	0.949	1.004	1.02	0.972

Among the four cities, as Table 7 presents, the tfpch and effch of Wuhan are both the highest, and the main source of the improvement of TFP is the improvement of technical efficiency, while the improvement of technical efficiency is entirely from the improvement of scale efficiency. As the old industrial city of wuhan, the supply-side structural issues are the most serious. In recent years, the industrial structure has been gradually transformed and upgraded through reform and adjustment, so that the scale efficiency has been significantly improved, thus the TFP has been improved. Appeared at the same time, the four cities have different levels of technology, it is one of the salient features of the economic development of Hubei Province found in this study. The common technological regression accompanied by a small improvement of technological efficiency is actually quite contradictory. In the process of urbanization in China, most cities showed technological progress accompanied by a decline in technological efficiency.

As one of the key supporting cities of Wuhan City Circle, Huangshi is to be built into the regional central city of Middle Reach of Yangtze River as well as a demonstration area for industrial transformation and upgrading. Its pure technical efficiency is the highest among the 12 cities, while its scale efficiency is at a lower level in the improvement group. It can be seen that It can be seen that it needs further promotion on industrial transformation and upgrading from the improvement of scale efficiency to drive economic growth potential.

As the "bellwether"of the two major city clusters, Xiangyang and Yichang both have poor performance, especially the indexes of Xiangyang all show different degrees of decline, and its economic dynamism has yet to be unleashed with great room for improvement. Economic centers need to play a radiative driving role, but at present in Hubei Province, they fail to play a corresponding role at all levels, which may lead to the decline of TFP in Hubei Province.

5 Conclusions

Based on the DEA-Malquist index method, this paper selects the panel data of 12 cities that can represent the economic development of Hubei Province to analyze the changes of TFP and the contribution of its decomposition items from 2010 to 2019, which draws the following conclusions:

First, the dynamic average change of TFP in Hubei Province during 2010-2019 shows a downward trend, which indicates the TFP of most cities declined.

Second, the decrease of TFP in Hubei Province is mainly due to the impact of technology regression. There is a small improvement in technical efficiency but it is not enough to make up for the impact of technology regression.

Third, the improvement of technical efficiency mainly comes from the improvement of scale efficiency, while the improvement of pure technical efficiency makes little contribution.

Finally, among the 12 cities, Xianning is the best performer in TFP improvement, and it is the only city with all indexes greater than 1. Xiangyang is the worst performer, and it has the most declining indexes. From the perspective of the 14th Five-Year Plan, the performances of central cities or sub-central cities are not good, for failing to play the corresponding role of economic radiation.

Since the development of Hubei Province was relatively stable in the past ten years before the epidemic, as well as the phenomenon of technological regression is common, the assumption of technological homogeneity among cities within the province is consistent with the actual situation, and the change of relative efficiency measured by DEA-Malmquist was also accurate.

Above all, this paper puts forward the following policy recommendations:

First, in view of Hubei's universal phenomenon of technology retrogression, it is supposed to continue to strengthen innovation-driven strategy, focus on industrial structure of rationalization and upgrading, pay attention to the introduction of advanced technology and high-quality scientific and technological personnel, create environment of barrier-free flow of innovation resources, and use the technology spillover to drive the coordinated development of overall region of Hubei.

Second, for the differences in the improvement of TFP shown by different cities, it's ought to adapt to local conditions and make up for the weakness, especially strengthen the integration ability of innovative resources of regional central cities, and form new growth poles of leading economy substantially, so as to drive the development of surrounding cities.

Third, for purely technical efficiency improvements that are not significant, it is necessary to reinforce the special functional positioning of different cities, develop industries in line with their factor endowment advantages, attach importance to the transformation and upgrading of traditional industries, and explore the path of integrated development with industries in the technological frontier fields. At the same time, we should improve the operation of the capital market, in order to improve the efficiency of capital allocation and contribute to the high-quality development of the industry.

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