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Measurement of High-Quality Development Efficiency and Analysis Study on Regional Differences in 31 Provinces in China

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Abstract. With the economic development entering a new era, promoting high-quality development has become an inevitable requirement for the sustainable and healthy development of China's economy. Based on the relevant data from 2010 to 2020, DEA-BCC model, Malmquist index and Dagum Gini coefficient are used to calculate the high-quality development efficiency of 31 provinces and analyze the differences between the eastern, central and western regions. The results show that: (1) Static efficiency. From the temporal dimension, the national high-quality development efficiency has shown a "U" trend, and the changes in most provinces are relatively stable, a few fluctuate greatly. From the regional dimension, the efficiency mean in each province within 11 years is significantly different, which is not proportional to the degree of regional economic development. (2) Dynamic efficiency. The national efficiency has been improved in only a few periods and most of them benefit from technological efficiency progress. Although the eastern and central regions lag behind in technological progress, the overall is better. But the western region has deteriorated, and technology needs to be improved. (3) Regional differences. National coordination in high-quality development is weak and mainly affected by Inter-regional differences. Among them, the eastern and central regions differ the largest, while the central and western regions differ the smallest. The level of coordinated economic development in western region is the lowest and the central region is the highest. Finally, some suggestions are put forward to promote the high-quality development efficiency.

Keywords: high-quality development · efficiency measurement · DEA-BCC · Malmquist index · Dagum Gini coefficient

1 Introduction

In 2021, at the time of the historical intersection of the goal of "wo one hundred years", Xi Jinping emphasized the significance of "high-quality development" in two sessions. Promoting high-quality development is not only the inevitable requirement of maintaining sustained and healthy economic development, but also the only way to build a modern

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economic system. We can promote the process of high-quality economic development in our country by realizing it in 31 provinces. However, there are various problems in the development of these provinces, such as the low efficiency of high-quality development in most provinces, the poor development coordination within provinces and the unbalanced development among provinces. Therefore, measuring the high-quality development efficiency of each province can help us understand the current situation of them, find the differences and existing problems and put forward corresponding countermeasures and suggestions.

The current academic research on high-quality development is divided into qualitative research and quantitative research. Qualitative research takes the connotation or internal mechanism of high-quality development as the research theme. Some scholars believe that developing countries urgently need high-quality economic growth, which refers to the environment-friendly type with high efficiency and low cost [1, 2]. Some scholars believe that high-quality development can meet people's growing needs for a better life, and its theoretical connotation will be continuously enriched with the improvement of productivity level and economic and social development level [3]. It makes China choose a new era of economic development model with higher quality, more efficiency, more stability and more openness [4].

The quantitative research on high-quality development mainly measures and evaluates the efficiency or level. Many scholars use different methods to build an index system to measure the efficiency of cities or the whole and analyze the differences in time and space between efficiency. There are mainly two methods to measure it. The first is to measure it by using a representative single index, such as total factor productivity, which ignores the green development and other aspects in the process of development [5, 6]. The second is to construct a comprehensive index evaluation system, which comprehensively considers the development of innovation, coordination and other aspects, so most scholars choose the latter. [4, 7–9]. At the same time, indicators should be selected from different dimensions according to the specific situation to construct an index system, such as from the economic development power, the quality of urban development, three dimensions of urban ecological quality and urban life quality, fundamentals and social achievements, and five dimensions of "efficiency, people's livelihood, coordination, green and openness" [10–13]. After the construction, scholars used entropy weight method, SBM model, DEA method, Malmquist index, subjective and objective empowerment method and cluster analysis method to measure the efficiency and Theil index, coefficient of variation, gini coefficient to analyze spatial differences [14–16].

To sum up, the existing literature adopts different methods to measure, but their research subjects focus on the whole country or cities, and 31 provinces are rarely studied. Based on this, the purpose of this study is to evaluate the high-quality development efficiency of 31 provinces and use Dagum gini coefficient to analyze the differences between the eastern, central and western regions. The main contributions lie in three aspects. Firstly, this study constructs the index system from the angle of input and output based on the connotation of high-quality economic development and the five development concepts of "innovation, coordination, green, openness and sharing" in our country. Secondly, this study combines DEA static and dynamic analysis methods to dynamically evaluate and compare the efficiency of 31 provinces. Thirdly, unlike the existing literature, this study enriches the research on provinces and clarifies the differences between the eastern, central and western regions.

2 Material and Methods

2.1 DEA-BCC Model

The traditional DEA model (CCR model) was first proposed by Charnes et al. (1978), which assumed that the scale reward was unchanged. However, the actual development situation of economy and society can not guarantee the constant scale reward, so the BCC model was built by Banke et al. (1984) which assumed variable scale reward. This model divides the technical efficiency in CCR mode into scale efficiency and pure technical efficiency, that is, technical efficiency = Scale efficiency × pure technical efficiency, in this way, the two reasons (not in the best scale and low efficiency in production technology) causing technical invalidity are separated, the pure technical efficiency obtained under the condition of excluding the restriction of scale factors is more accurate than the technical efficiency under the CCR mode, which reflects the operation and management level of the investigated object. Therefore, this study selects the BCC model to calculate the high-quality development efficiency.

2.2 Malmquist Index Model

Malmquist index was proposed by Malmquist (1953) and färe et al. (1992) combined it with DEA method to calculate and decompose Malmquist index, which is often used to study the change of dynamic efficiency. The most commonly used is Malmquist total factor productivity (TFP) index analysis. Malmquist exponential decomposition into changes in technical efficiency (EFC) and changes in technical progress (TEC). On the premise of variable scale reward, EFC can be further decomposed into pure technical efficiency change (PEC) and scale efficiency change (SEC). The exponential decomposition formula can be expressed:

$$TFP = TEC \times EFC = TEC \times PEC \times SEC \tag{1}$$

Among them, when the TFP is greater than 1, it means that the comprehensive productivity of the unit increases and the situation is improved; Conversely, it means that the efficiency decreases and the situation deteriorates.

2.3 Dagum Gini Coefficient

The methods to analyze the unbalanced development of regional space include coefficient of variation, Gini coefficient, Theil index, etc. Based on Theil index, Dagum decomposes Gini coefficient into contribution G_w of regional gap, contribution G_{nb} of regional super variable net value gap and contribution G_t of regional super variable density, the overlapping problem between samples is solved. This study uses Dagum Gini coefficient to decompose the differences of high-quality development efficiency of 31 provinces. When decomposing, the high-quality development efficiency of each province in the region must be sorted. The larger the Gini coefficient is, the greater the degree of regional differentiation is. The main calculation formula is as follows:

$$G = \sum_{j=1}^{\mathrm{k}} \sum_{h=1}^{k} \sum_{i=1}^{n_j} \sum_{r=1}^{n_h} |y_{ji} - y_{hr}| / 2n^2 \cdot \bar{\mathrm{y}} \tag{2}$$

$$G = G_{\mathrm{w}} + G_{nb} + G_{\mathrm{t}} \tag{3}$$

$$\bar{y}_h \leq \bar{y}_j \leq \ldots \leq \bar{y}_k \tag{4}$$

$$G_{\mathrm{jj}} = \frac{1}{2\overline{Y}_j} \sum_{i=1}^{n_j} \sum_{r=1}^{n_{\mathrm{j}}} |y_{ji} - y_{jr}| / n_j^2 \tag{5}$$

$$G_w = \sum_{j=1}^{k} G_{jj} P_j S_j \tag{6}$$

$$G_{jh} = \sum_{i=1}^{n_j} \sum_{r=1}^{n_{\mathrm{h}}} |y_{ji} - y_{hr}| / n_j n_h (\overline{Y}_{\mathrm{j}} + \overline{Y}_{\mathrm{h}}) \tag{7}$$

$$G_{nb} = \sum_{j=2}^{k} \sum_{h=1}^{j-1} G_{jh} (p_j s_h + p_h s_j) D_{jh} \tag{8}$$

$$G_t = \sum_{j=2}^{k} \sum_{h=1}^{j-1} G_{jh} (p_j s_h + p_h s_j)(1 - D_{jh}) \tag{9}$$

$$D_{\mathrm{j}h} = \frac{d_{jh} - p_{jh}}{d_{jh} + p_{jh}} \tag{10}$$

Among them, y_{ji} (y_{hr}) is the high-quality development efficiency of any province in the j (h) region; $\bar{y}$ is the average of high-quality development efficiency of each province; n is the number of provinces; k is the number of regions. n_j(n_h) is the number of provinces j(h). Formulas (5) and (6) represent the Gini coefficient of region j and the contribution of regional differences; (7) and (8) represent the contribution of Gini coefficient between region j and region h and the difference between regions; $p_j = n_j/n$, $s_j = n_j\ \bar{y}_j/n\bar{y}$; D_{ij} represents the relative influence of energy consumption between Region i and region j. In formula (9), 1-D_{ij} is defined as super variable density; G_t is the contribution of super variable density in the subgroup.

$$\mathrm{d}_{jh} = \int_0^\infty dF_{\mathrm{j}}(y) \int_0^y (y - x) dF_{\mathrm{h}}(y) \tag{11}$$

$$\mathrm{p}_{jh} = \int_0^\infty dF_{\mathrm{h}}(y) \int_0^y (y - x) dF_{\mathrm{j}}(y) \tag{12}$$

$F_j(F_h)$ represents the cumulative distribution function of region j(h). d_{jh} is defined as the difference of energy consumption between region j and region h, that is, the sample value of $y_{ji} - y_{hr} > 0$ in region j and region h plus the total mathematical expectation. Similarly, p_{jh} is the sample value of all $y_{hr} - y_{ji} > 0$ in region j and region h plus the total mathematical expectation.

2.4 Indicator Selection and Data Sources

On the basis of comprehensive sorting and summary of domestic and foreign literature, we draw on the research results of scholars of Zhang Z, Liu XM, Xiao D, Yu F, Wu XF. [6, 9, 11], taking into account the principles of operability and comparability of index system setting. This study constructs an index system from the perspective of input and output, including labor, land, capital, technology and data inputs, which are respectively expressed by the employment personnel of urban units, built-up area, fixed assets investment, scientific and technological research and development and education investment costs, and the number of Internet broadband access ports. At the same time, in order to respond to the national call, to promote the development of high-quality so as to conform to the trend of the world development, on the basis of the five development concept from innovation, coordination, green, open and sharing five aspects choose output index, respectively with patent application authorization, tire index, proper green coverage and sulfur dioxide emissions, total import and export volume of foreign-invested enterprises and per ten thousand health institutions beds to say. The data are all from the National Bureau of Statistics and the Regional Statistical Yearbook, in which the Tyre index is calculated, that is, the Thiel index = per capita disposable income of urban residents/per capita disposable income of rural residents. The specific indicators are selected in Table 1.

Limited to the availability of the data, this study selects the data of 31 provinces from 2010 to 2020 and divide them into the eastern, central and western regions for research according to the relevant national regulations. The eastern region includes 11 provinces, Beijing, Tianjin, Hebei, Liaoning, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Hainan; the central region includes 8 provinces, Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan; the remaining provinces belong to the western region. All data are from the National Bureau of Statistics and provincial statistical yearbooks.

3 Results

3.1 Static Efficiency of High-Quality Development in 31 Provinces Based on the DEA-BBC Model

Using DEA2.1 software, select the BCC model of output orientation and variable scale reward, and calculate the efficiency of high-quality development of 31 provinces from 2010 to 2020. The results are shown in Table 2.

According to the calculation principle of DEA, the highest measurement value is 1, which indicates the highest level of high-quality development; 0.8–1 indicates the

Table 1. Indicator selection

Indicator	Secondary indicator	Third-level indicator
Input	Labor input	Employment personnel in urban units (10000 people)
	Land investment	Built-up area (Km^2)
	Capital input	Fixed investments (100 million yuan)
	Technology investment	Investment in scientific research and education (100 million yuan)
	Data input	Number of Internet broadband access ports (10 thousand)
Output	Innovative development	Number of patent application granted (Number)
	Harmonious development	Thiel index (None)
	Green development	Green coverage rate of the built-up area (None)
		Sulfur dioxide emissions (100 million m^3)
	Open development	Total import and export volume of foreign-invested enterprises (1000 dollars)
	Shared development	Number of beds in medical and health institutions per 10,000 people (Number)

relatively high level; 0.6–0.8 indicates the general level; lower than 0.6 indicates a low level. From the analysis of Table 2 and Fig. 1, we can see: (1) from the perspective of time, the average of high-quality development efficiency in 31 provinces showed a "U" trend as a whole during the 11 years. Most provinces have relatively stable changes in their own efficiency, but some provinces have relatively large fluctuations. Liaoning has the largest fluctuation range, with a range of 0.498. (2) from a regional perspective, the temporal evolution trend of the high-quality development efficiency in the eastern, central and western regions is generally similar, both of them showed a trend of decline first and then rising (except for the decline in the western region between 2019 and 2020), but the average efficiency in the research period were quite different, 0.831, 0.481, 0.567, respectively, the range is 0.35. (3) judging from the average efficiency in 11 years, the average efficiency range among provinces reached 0.69, with significant difference. Among them, the average efficiency of Shanghai, Zhejiang, Hainan, Tibet, Qinghai and Ningxia is 1, and the overall level is the highest; The average efficiency of Beijing, Tianjin, Jiangsu and Guangdong is between 0.8 and 1, the overall level is relatively high; the average efficiency of Fujian and Chongqing is between 0.6 and 0.8, and the level is general; other provinces' level is relatively low. It can be seen that the degree of economic development of provinces is not proportional to their high-quality development efficiency.

Table 2. Static efficiency values of high-quality development based on DEA-BBC model

Province	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average
Beijing	0.834	0.852	0.896	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.962
Tianjin	1.000	0.943	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.995
Hebei	0.303	0.307	0.275	0.311	0.325	0.346	0.349	0.409	0.420	0.435	0.505	0.362
Liaoning	0.461	0.421	0.359	0.400	0.473	0.570	0.716	0.765	0.759	0.778	0.857	0.596
Shanghai	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Jiangsu	1.000	1.000	1.000	1.000	0.982	1.000	1.000	1.000	1.000	1.000	1.000	0.998
Zhejiang	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Fujian	0.667	0.673	0.633	0.712	0.672	0.735	0.788	0.804	0.867	0.870	0.882	0.755
Shandong	0.485	0.415	0.411	0.421	0.435	0.480	0.467	0.480	0.484	0.526	0.594	0.473
Guangdong	1.000	1.000	1.000	1.000	1.000	1.000	0.957	1.000	1.000	1.000	1.000	0.996
Hainan	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Shanxi	0.399	0.351	0.323	0.333	0.365	0.374	0.394	0.566	0.562	0.478	0.515	0.424
Jilin	0.617	0.617	0.502	0.542	0.577	0.556	0.574	0.578	0.602	0.636	0.659	0.587
Heilongjiang	0.511	0.604	0.517	0.533	0.561	0.588	0.608	0.618	0.632	0.633	0.692	0.591
Henan	0.296	0.284	0.288	0.298	0.324	0.388	0.403	0.398	0.416	0.425	0.427	0.359
Hubei	0.540	0.495	0.403	0.431	0.421	0.428	0.408	0.446	0.477	0.523	0.565	0.467
Hunan	0.425	0.363	0.320	0.333	0.371	0.412	0.395	0.440	0.424	0.449	0.451	0.398
Inner Mongolia	0.284	0.294	0.315	0.298	0.329	0.341	0.344	0.364	0.406	0.423	0.460	0.351
Guangxi	0.263	0.294	0.254	0.291	0.289	0.305	0.316	0.334	0.349	0.355	0.369	0.311
Guizhou	0.324	0.338	0.340	0.399	0.392	0.415	0.362	0.371	0.404	0.453	0.445	0.386
Chongqing	0.598	0.605	0.510	0.643	0.669	0.758	0.795	0.726	0.713	0.714	0.651	0.671
Sichuan	0.519	0.392	0.394	0.371	0.413	0.444	0.448	0.478	0.502	0.490	0.463	0.447
Yunnan	0.282	0.295	0.259	0.304	0.278	0.292	0.293	0.326	0.328	0.358	0.350	0.306
Xizang	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Shaanxi	0.407	0.405	0.365	0.462	0.461	0.499	0.656	0.540	0.520	0.545	0.538	0.491
Gansu	0.335	0.349	0.420	0.389	0.389	0.361	0.379	0.552	0.614	0.615	0.613	0.456
Qinghai	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Ningxia	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Xinjiang	0.488	0.396	0.410	0.346	0.370	0.372	0.385	0.366	0.414	0.394	0.353	0.390
East	0.795	0.783	0.779	0.804	0.808	0.830	0.843	0.860	0.866	0.874	0.894	0.831
Centre	0.459	0.454	0.402	0.427	0.450	0.473	0.486	0.520	0.526	0.535	0.561	0.481
West	0.542	0.531	0.522	0.542	0.549	0.566	0.582	0.588	0.604	0.612	0.604	0.567
Country	0.610	0.600	0.582	0.605	0.615	0.636	0.650	0.667	0.677	0.685	0.696	0.639

3.2 Dynamic Efficiency of High-Quality Development in 31 Provinces Based on Malmquist Index

Based on the input-output panel data of 31 provinces, the index decomposition model of Malmquist is further constructed to dynamically measure the change trend of the whole country and the high-quality development efficiency decomposition of 31 provinces, the empirical results are shown in Table 3 (only the empirical results from 2016 to 2020 are given due to limited space).

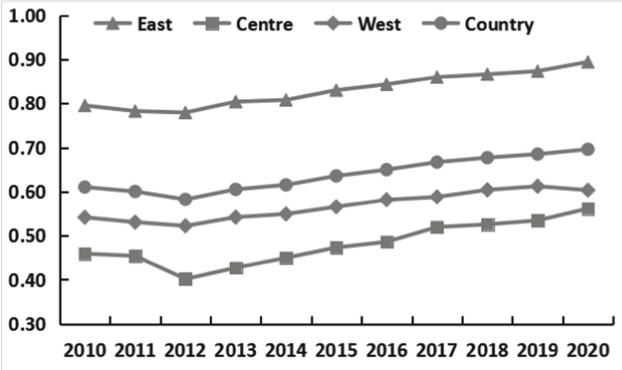

Fig. 1. The evolution trend of the static efficiency time series of high-quality development

From the perspective of national TFP (total factor productivity), the year when TFP is greater than 1 has only four time periods: 2013–2014, 2016–2017, 2017–2018, 2019–2020, so the high-quality development efficiency has been improved in only a few time periods. From the perspective of national TEC (changes in technological progress) and EFC (changes in technological efficiency), there are only two periods where TEC and EFC are greater than 1 at the same time, 2017–2018 and 2019–2020 respectively; there are two time periods of TEC and EFC being less than 1 at the same time, which are 2010–2011 and 2011–2012 respectively, which indicates that both production technology and technical efficiency have deteriorated in these two time periods; in the remaining 6 periods, TEC is less than 1 but EFC is greater than 1, indicating that the improvement of dynamic efficiency of national high-quality development mostly benefits from the improvement of technical efficiency. The time series Evolution Trend of TFP in China and eastern, central and western regions is shown in Fig. 2.

It can be seen from Fig. 2 that during the research period, the dynamic efficiency of high-quality development of the whole country, the eastern and central regions all showed a wave trend, the specific fluctuation situation is decline-up-down-up-down-down-up-up-up, and the overall situation is up; The western region also shows a wave-type trend, but the fluctuation direction is different, the specific fluctuation is up-down-up-down-down-up, and the overall fluctuation is also up. This shows that the dynamic efficiency in various regions is unstable over time. From the perspective of provinces and eastern and western regions, the comprehensive dynamic efficiency of 31 provinces from 2010 to 2020 is shown in Table 4 (due to limited space, only the empirical results of Beijing, Tianjin, Hebei, eastern, central and western regions and the whole country are listed).

It can be seen from Table 4 that the comprehensive TFP of 16 provinces is greater than 1 during the 11 years, which means that the high-quality development efficiency of most provinces has been improved; The improvement of efficiency in Hebei province is the most significant, among them, TEC and EFC are 1.018 and 1.053 respectively, indicating that Hebei province responds to the national policy and continuously improves technology and technology efficiency in order to realize high-quality development to the greatest extent; TFP in eastern and central regions is greater than 1, however, TEC is less than 1, indicating that the high-quality development in the eastern and central regions

Table 3. Dynamic efficiency decomposition of high-quality development in 31 provinces.

Province	2016–2017			2017–2018			2018–2019			2019–2020		
	TFP	TEC	EFC	TFP	TEC	EFC	TFP	TEC	EFC	TFP	TEC	EFC
Beijing	0.990	0.990	1.000	1.111	1.111	1.000	1.039	1.039	1.000	1.185	1.185	1.000
Tianjin	1.044	1.044	1.000	1.079	1.079	1.000	0.914	0.914	1.000	1.117	1.117	1.000
Hebei	1.152	0.980	1.175	1.281	1.247	1.027	1.041	1.005	1.036	1.462	1.260	1.161
Liaoning	1.044	0.976	1.069	1.129	1.138	0.992	1.035	1.010	1.025	1.221	1.109	1.102
Shanghai	1.041	1.041	1.000	0.996	0.996	1.000	0.953	0.953	1.000	1.099	1.099	1.000
Jiangsu	0.972	0.972	1.000	1.176	1.176	1.000	0.970	0.970	1.000	1.325	1.325	1.000
Zhejiang	0.916	0.916	1.000	1.253	1.253	1.000	0.940	0.940	1.000	1.305	1.305	1.000
Fujian	0.948	0.930	1.020	1.194	1.107	1.078	0.926	0.922	1.004	1.242	1.225	1.014
Shandong	0.987	0.960	1.027	1.217	1.207	1.008	1.046	0.963	1.086	1.465	1.297	1.129
Guangdong	1.106	1.058	1.045	1.237	1.237	1.000	0.985	0.985	1.000	1.275	1.275	1.000
Hainan	0.963	0.963	1.000	0.980	0.980	1.000	0.998	0.998	1.000	1.019	1.019	1.000
Shanxi	1.347	0.929	1.450	1.034	1.052	0.982	0.950	1.114	0.852	1.147	1.065	1.077
Jilin	0.996	0.986	1.011	1.042	1.004	1.038	1.052	0.984	1.069	1.054	1.028	1.025
Heilongjiang	0.978	0.959	1.020	1.106	1.082	1.022	1.001	0.994	1.007	1.153	1.059	1.088
Anhui	0.963	0.984	0.978	1.137	1.307	0.870	1.024	0.989	1.035	1.418	1.279	1.109
Jiangxi	0.970	0.932	1.041	1.320	1.171	1.127	1.021	0.986	1.035	1.240	1.261	0.984
Henan	0.963	0.973	0.990	1.173	1.122	1.045	0.948	0.927	1.023	1.242	1.235	1.006
Hubei	1.035	0.949	1.091	1.241	1.159	1.071	1.039	0.948	1.095	1.359	1.259	1.080
Hunan	1.014	0.908	1.117	1.123	1.166	0.963	1.027	0.969	1.060	1.236	1.231	1.005
Inner Mongolia	1.015	0.961	1.056	1.147	1.028	1.115	1.000	0.958	1.044	1.149	1.060	1.085
Guangxi	0.997	0.943	1.058	1.118	1.066	1.049	0.980	0.967	1.013	1.195	1.143	1.045
Guizhou	1.004	0.980	1.025	1.171	1.077	1.088	1.085	0.967	1.122	1.190	1.211	0.983
Chongqing	0.871	0.953	0.914	1.086	1.106	0.982	0.941	0.940	1.001	1.071	1.176	0.911
Sichuan	1.034	0.968	1.068	1.239	1.182	1.049	0.926	0.948	0.977	1.167	1.234	0.945
Yunnan	1.011	0.908	1.113	1.101	1.095	1.005	1.031	0.944	1.093	1.148	1.177	0.975
Tibet	0.873	0.873	1.000	0.911	0.911	1.000	0.959	0.959	1.000	1.063	1.063	1.000
Shaanxi	0.764	0.929	0.823	1.049	1.089	0.964	0.980	0.935	1.048	1.177	1.192	0.987
Gansu	1.313	0.901	1.458	1.190	1.069	1.113	1.057	1.057	1.000	1.018	1.021	0.997
Qinghai	0.987	0.987	1.000	0.989	0.989	1.000	0.974	0.974	1.000	1.033	1.033	1.000
Ningxia	0.937	0.937	1.000	1.046	1.046	1.000	1.041	1.041	1.000	1.027	1.027	1.000
Xinjiang	0.943	0.991	0.951	1.198	1.059	1.131	0.999	1.051	0.951	0.907	1.011	0.897
East	1.015	0.985	1.031	1.150	1.139	1.010	0.986	0.973	1.014	1.247	1.201	1.037
Centre	1.033	0.953	1.087	1.147	1.133	1.015	1.008	0.989	1.022	1.231	1.177	1.047
West	0.979	0.944	1.039	1.104	1.060	1.041	0.998	0.978	1.021	1.095	1.112	0.985
Country	1.006	0.961	1.048	1.131	1.107	1.023	0.996	0.979	1.019	1.184	1.161	1.020

is relatively good. Although it lags behind in terms of technological progress, it does not affect the overall development. TFP and TEC in the western regions are both less than 1, it shows that the high-quality development in the western region is deteriorating,

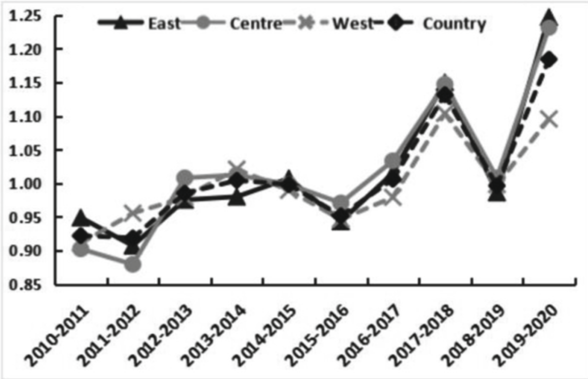

Fig. 2. Time series evolution trends of TFP in the country and East and western region

Table 4. Comprehensive dynamic efficiency of high-quality development in 31 provinces from 2010 to 2020

Province	TFP	TEC	EFC
Beijing	1.054	1.035	1.018
Tianjin	0.972	0.972	1.000
Hebei	1.072	1.018	1.053
East	1.007	0.991	1.017
Centre	1.012	0.991	1.021
West	0.992	0.976	1.016
Country	1.003	0.985	1.018

mainly because the technology needs to be further improved, and also shows that there are regional differences in high-quality development.

3.3 Comparative Analysis of Regional Differences in High-Quality Development Based on the Dagum Gini Coefficient

No matter from the perspective of static efficiency or dynamic efficiency, the high-quality development efficiency in the eastern, central and western regions shows great differences. Therefore, this study uses Dagum Gini coefficient to calculate the overall Gini coefficient of the whole country from 2010 to 2020 respectively, the Gini coefficient of high-quality development level within and between eastern, central and western regions is decomposed. The calculation results are shown in Table 5.

Table 5. Gini coefficients and their decomposition results of high-quality development efficiency in each region

Year	Ensemble coefficient	Regional internal gini coefficient			Gini coefficient between regions			Contribution rate%		
		East	Centre	West	East and Centre	East and West	Centre and West	Within the area	Between the area	Supervariable density
2010	0.2490	0.1666	0.1092	0.2767	0.2996	0.2802	0.2366	27.95%	48.58%	23.48%
2011	0.2562	0.1762	0.1476	0.2691	0.3095	0.2864	0.2427	28.10%	47.02%	24.88%
2012	0.2696	0.1865	0.1220	0.2753	0.3546	0.2967	0.2438	27.45%	52.21%	20.34%
2013	0.2588	0.1677	0.1392	0.2660	0.3406	0.2823	0.2429	27.16%	52.35%	20.49%
2014	0.2486	0.1614	0.1296	0.2626	0.3167	0.2749	0.2337	27.40%	51.14%	21.46%
2015	0.2354	0.1428	0.1021	0.2585	0.2980	0.2643	0.2248	26.77%	52.27%	20.96%
2016	0.2311	0.1314	0.1068	0.2578	0.2947	0.2551	0.2298	26.55%	52.08%	21.37%
2017	0.2138	0.1179	0.0877	0.2393	0.2692	0.2469	0.2043	25.86%	52.82%	21.32%
2018	0.2043	0.1136	0.0795	0.2250	0.2663	0.2349	0.1894	25.70%	54.27%	20.03%
2019	0.1974	0.1069	0.0795	0.2168	0.2586	0.2280	0.1819	25.50%	55.26%	19.24%
2020	0.1928	0.0880	0.0893	0.2181	0.2408	0.2331	0.1814	24.58%	55.65%	19.77%

3.3.1 Overall Differences in Development Level and Intra-regional Differences in High-Quality Development

It can be seen from Table 5 and Fig. 3, that the overall Gini coefficient in the study period decreased from 0.2490 in 2010 to 0.1928 in 2020, with a large fluctuation range. Specifically, it showed an upward trend from 2010 to 2012, peaked at 0.2696 in 2012, and continued to decline from 2012 to 2020. It can be seen that in the 11 years from 2010 to 2020, the overall difference change trend of all provinces in China is not strictly decreasing, that is, the overall synergy is relatively weak. Therefore, to alleviate the overall differences in all provinces, it is necessary to actively formulate policies to promote the coordinated development of relevant regions and put them into practice, and strive to narrow the overall differences in high-quality development efficiency among 31 provinces in the country.

The Gini coefficient in the eastern, central and western regions differs greatly, among which the Gini coefficient in the western region is the largest (higher than the overall), indicating that the level of coordinated economic development of each province in the western region is relatively low and the economic development is unbalanced. The Gini coefficient in the central region is the smallest, while that in the eastern region is between the two. During the study period, the Gini coefficient of the eastern, central and western regions showed a downward trend as a whole. The Gini coefficient in the eastern region rises first and then declines, from 0.1666 in 2010 to 0.0880 in 2020, reaching the peak of 0.1865 in 2012; The Gini coefficient fluctuates frequently in the central region, from 0.1092 in 2010 to 0.0893 in 2020, it reached its peak of 0.1476 in 2011; The Gini coefficient in the western region showed a downward-upward-downward trend, from 0.2767 in 2010 to 0.2181 in 2020, the year 2010 was the peak.

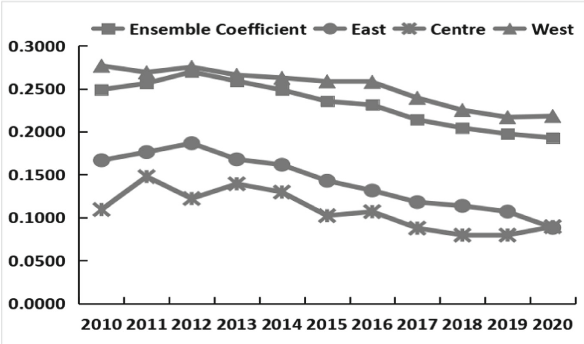

Fig. 3. Trends of overall Gini coefficient and gini coefficient in the eastern, central and western regions

3.3.2 Inter-regional Differences of High-Quality Development Level

It can be seen from Fig. 4 that the variation of regional differences between eastern and central regions and eastern and western regions all show an inverted "V" trend of rising first and then falling, the difference between the central and western regions presents an "M" trend, that is, rising first, then falling, then rising and finally falling, but the fluctuation range is not large, and the trend is relatively gentle. Among them, the high-quality development efficiency level difference between eastern and central areas is relatively large, the Gini coefficient is as high as 0.3546, exceeding the overall difference; The difference between eastern and western areas takes second place, and the Gini coefficient is as high as 0.2967; the difference between the middle and the West is the smallest, and the Gini coefficient is the highest of 0.2438. Therefore, efforts should be made to improve the high-quality development efficiency of the central region and narrow the gap between the central and eastern regions.

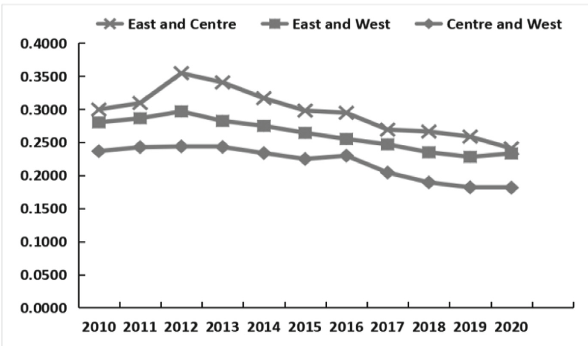

Fig. 4. Trend of Gini coefficient between the eastern, central and western regions

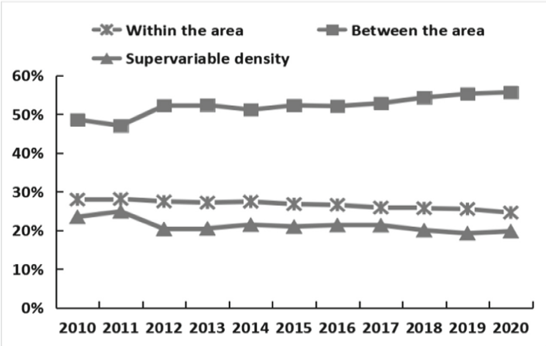

Fig. 5. Trend of contribution rate of high-quality development level Conclusions

3.3.3 Source of Difference and Contribution of High-Quality Development Level

According to Fig. 5, from the perspective of contribution rate of difference sources, the contribution rate of regional differences is the largest in the study period, and the contribution rate is distributed between 47.02% and 55.65%, which is higher than the rate of regional differences and hypervariable density from beginning to end; the fluctuation of the rise and fall of the contribution rate within the region and the contribution rate of hypervariable density is relatively frequent, but the overall trend shows a downward trend, which is distributed between 24.58% - 28.10% and 19.24% - 24.88% respectively; From 2012 to 2020, the contribution rate of regional differences is higher than the sum of the regional differences and the hypervariable density, which indicates that regional differences are the main factors affecting the overall regional differences. High-quality development requires the overall vitality, benefits and quality, but there are great differences in many aspects such as geographical environment, industrial structure, degree of opening to the outside world and ecological environment in the eastern, central and western regions of our country, however, the numerous differences among the three regions have intensified the differences in the overall high-quality development of the country.

4 Conclusions

This study constructs an evaluation index system of regional high-quality development and use the DEA-BCC model and Malmquist index to calculate efficiency of high-quality development in 31 provinces, and use the Dagum Gini coefficient to measure the regional differences. The basic conclusions are as follows:

4.1 In Terms of Static Efficiency

From the perspective of time, the change of national high-quality development efficiency in the research period generally presents a "U" trend, most provinces have stable changes in their own efficiency values, but some provinces fluctuate greatly.

From the perspective of region, the average difference of efficiency in each province is very significant, and the efficiency is not proportional to its economic development degree. The temporal evolution trend of the efficiency level in the eastern, central and western regions is generally similar, showing a "U" trend, but the average of efficiency differs greatly.

4.2 In Terms of Dynamic Efficiency

From the perspective of national TFP, high-quality development efficiency has been improved in only a few time periods, and most of the improvement in efficiency benefits from the improvement of technical efficiency.

From the perspective of TFP in the east, middle and west, the efficiency of most provinces has been improved, and the dynamic efficiency in various regions is unstable with the evolution of time. The development of high-quality in the eastern and central regions is relatively good. Although it lags behind in the aspect of technological progress, it does not affect the overall development situation; The development of high-quality in the western regions deteriorates, the main reason is that the technology needs to be further improved, and it also shows that there are regional differences in high-quality development.

4.3 In Terms of Regional Differences

The change trend of overall differences in all provinces is not strictly decreasing, that is, the overall synergy is relatively weak.

The Gini coefficient in the eastern, central and western regions differs greatly, among which the Gini coefficient in the western region is the largest (higher than the overall), which indicates that the level of coordinated economic development of each province in the western region is relatively low and the economic development is unbalanced, the Gini coefficient in the central region is the smallest, while that in the eastern region is between the two.

The high-quality development efficiency difference between eastern and central regions is larger, exceeding the overall difference, the difference between eastern and western regions takes the second place, and the difference between central and western regions is the smallest; and the contribution rate of regional differences in the study period is higher than that of regional differences and the contribution rate of hypervariable density, which indicates that regional differences are the main factors affecting the overall regional differences.

Based on the above conclusions, this study puts forward some suggestions. First, overall consideration of economic, innovation, green and other aspects of development, improve the high-quality development efficiency of each province by providing advanced equipment, paying attention to environmental pollution, developing new energy and improving the open pattern. Second, promote the integration development of all regions and provinces, narrow the difference in eastern, central and western regions. Play the engine role of leading cities and core provinces, and use their positive spillover effect to form a complementary and mutual development model to drive the development of marginal provinces; promote the integrated development of provinces within the region, enhance their connection, use the effect of economies of scale to promote the development of industrial specialization, promote knowledge spillover among industries, reduce transaction costs, and optimize the allocation of factor resources. Third, formulate differentiation policies to fill in the shortcomings and realize high-quality coordinated economic development between three regions. Continue to maintain the high efficiency of central region and adopt appropriate preferential policies to raise other two regions' level. Each region should formulate differentiated development policies according to its own advantages and disadvantages in terms of geographical environment, resource endowment and industrial structure.

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