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Measurement of Fiscal Expenditure, Scientific and Technological Innovation and High-quality Economic Development in China

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Abstract: This paper measures the provincial high-quality economic development index, financial expenditure level and scientific and technological innovation level from 2011 to 2020. Firstly, measure the level of fiscal expenditure from two aspects: scale and structure; Secondly, Malmquist index is used to measure the input-output efficiency of scientific and technological innovation, and to measure the level of scientific and technological innovation; Finally, based on the principal component analysis, under the guidance of the new development concept, this paper constructs a comprehensive index system, and measures the comprehensive index of high-quality economic development

Keywords: Financial expenditure, Scientific and technological innovation, High quality economic development, Malmquist index.

1. Measurement of Fiscal Expenditure Scale and Structure

1.1. Selection of Financial Expenditure Scale and Structure Indicators

The measurement of fiscal expenditure in the existing literature is mainly based on two perspectives: scale and structure. In order to fully analyze the impact of fiscal expenditure on high-quality economic development driven by scientific and technological innovation, this paper comprehensively uses the scale and structure of fiscal expenditure to measure the level of government fiscal expenditure.

The scale of fiscal expenditure can be measured from the perspective of absolute and relative scale, but the absolute scale is difficult to reflect the proportion of resources. At the same time, the level of inflation and economic development in various regions are uneven, and the absolute number has great restrictions when comparing the basic situation of different time points and regions. Therefore, based on the method of Wang Liyong et al. (2018), this paper selects the relative scale, that is, the general budget expenditure / GDP to measure the scale of fiscal expenditure [1].

Fiscal expenditure structure refers to the horizontal allocation between expenditure items. China mainly divides the structure of fiscal expenditure according to the purpose of expenditure, functional nature and economic nature. The classification of fiscal revenue and expenditure was reformed in 2007, and the research range of this paper is 2011-2020. Therefore, using the reformed method, the fiscal expenditure is divided into five categories according to the expenditure function (Science, education, culture and health expenditure, economic construction expenditure, general public service expenditure, social security and employment expenditure and environmental protection expenditure). The fiscal expenditure structure is measured by the proportion of each item in the general fiscal expenditure.

1.2. Measurement of Fiscal Expenditure Scale and Structure Level

1.2.1. Scale of Fiscal Expenditure

This part measures the scale of fiscal expenditure from 2011 to 2020 with general fiscal budget expenditure / GDP. See Table 1 for specific data results.

According to table 1, on the whole, the scale of fiscal expenditure in various regions of the country showed an overall upward trend during the study period, and a few regions showed a downward trend. Among them, the growth rate of Heilongjiang Province is the largest, above 0.1, and the growth rate of expenditure scale in other regions is below 0.1. The scale of fiscal expenditure in Inner Mongolia, Anhui, Fujian, Chongqing, Guizhou, Yunnan, Shaanxi and Qinghai shows a downward trend on the whole. Among them, Chongqing, Guizhou and Qinghai have a large decline of more than 0.05, and the scale of fiscal expenditure varies greatly among regions.

Taking 2020 as an example, the scale of fiscal expenditure in Inner Mongolia, Jilin, Heilongjiang, Hainan, Guizhou, Gansu, Qinghai, Ningxia and Xinjiang remained above 0.3, of which Qinghai Province was the highest, reaching 0.6430, the scale of fiscal expenditure in other regions was below 0.3, and Fujian Province was the lowest, 0.1188. Generally speaking, the scale of fiscal expenditure in the northeast and western regions is at a high level, thanks to the regional coordinated development strategy implemented by the state in recent years, and the northeast and western regions have received a high level of resource support.

Table 1. Scale of fiscal expenditure in various regions from 2011 to 2020

Region	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Whole country	0.2482	0.2596	0.2592	0.2588	0.2794	0.2769	0.2674	0.2630	0.2651	0.2660
Beijing	0.1888	0.1937	0.1975	0.1974	0.2316	0.2369	0.2284	0.2257	0.2090	0.1971
Tianjin	0.2214	0.2370	0.2563	0.2711	0.2971	0.3223	0.2636	0.2322	0.2530	0.2238
Hebei	0.1654	0.1768	0.1818	0.1855	0.2134	0.2125	0.2167	0.2378	0.2375	0.2492
Shanxi	0.2170	0.2362	0.2528	0.2551	0.2892	0.2870	0.2593	0.2684	0.2777	0.2895
Inner Mongolia	0.3160	0.3272	0.3236	0.3191	0.3284	0.3273	0.3041	0.2993	0.2963	0.3036
Liaoning	0.2388	0.2554	0.2706	0.2537	0.2217	0.2245	0.2249	0.2270	0.2311	0.2395
Jilin	0.2847	0.2848	0.2911	0.2923	0.3211	0.3439	0.3411	0.3367	0.3354	0.3352
Heilongjiang	0.2812	0.2879	0.2843	0.2822	0.3439	0.3554	0.3769	0.3640	0.3700	0.3978
Shanghai	0.1956	0.1964	0.1952	0.1948	0.2303	0.2315	0.2292	0.2319	0.2153	0.2094
Jiangsu	0.1274	0.1309	0.1314	0.1307	0.1360	0.1290	0.1237	0.1251	0.1274	0.1332
Zhejiang	0.1206	0.1210	0.1267	0.1289	0.1528	0.1476	0.1437	0.1488	0.1609	0.1560
Anhui	0.2028	0.2160	0.2113	0.2071	0.2198	0.2099	0.2090	0.1932	0.2006	0.1932
Fujian	0.1227	0.1291	0.1364	0.1326	0.1492	0.1444	0.1384	0.1249	0.1200	0.1188
Jiangxi	0.2188	0.2357	0.2427	0.2478	0.2630	0.2511	0.2529	0.2495	0.2589	0.2598
Shandong	0.1280	0.1375	0.1413	0.1414	0.1492	0.1490	0.1469	0.1516	0.1522	0.1536
Henan	0.1614	0.1729	0.1765	0.1744	0.1833	0.1852	0.1833	0.1846	0.1892	0.1886
Hubei	0.1612	0.1664	0.1723	0.1747	0.2021	0.1926	0.1827	0.1727	0.1754	0.1943
Hunan	0.1861	0.1942	0.1992	0.1939	0.2007	0.2055	0.2031	0.2059	0.2014	0.2011
Guangdong	0.1265	0.1296	0.1346	0.1343	0.1716	0.1637	0.1641	0.1574	0.1602	0.1574
Guangxi	0.2471	0.2641	0.2578	0.2561	0.2747	0.2756	0.2759	0.2706	0.2755	0.2789
Hainan	0.3161	0.3268	0.3245	0.3189	0.3319	0.3365	0.3211	0.3444	0.3487	0.3565
Chongqing	0.2529	0.2627	0.2351	0.2260	0.2364	0.2220	0.2161	0.2103	0.2054	0.1957
Sichuan	0.2221	0.2279	0.2346	0.2352	0.2471	0.2417	0.2294	0.2263	0.2232	0.2304
Guizhou	0.4006	0.4087	0.3866	0.3862	0.3737	0.3615	0.3390	0.3276	0.3547	0.3220
Yunnan	0.3076	0.3219	0.3194	0.3161	0.3150	0.3066	0.3090	0.2909	0.2915	0.2844
Shanxi	0.2407	0.2350	0.2304	0.2277	0.2445	0.2305	0.2251	0.2215	0.2217	0.2265
Gansu	0.3719	0.3819	0.3840	0.3899	0.4512	0.4560	0.4504	0.4655	0.4533	0.4617
Qinghai	0.7060	0.7583	0.7168	0.7292	0.7534	0.6752	0.6208	0.5995	0.6337	0.6430
Ningxia	0.3654	0.4056	0.3963	0.4044	0.4414	0.4510	0.4290	0.4043	0.3837	0.3776
Xinjiang	0.3497	0.3670	0.3655	0.3581	0.4088	0.4297	0.4155	0.3913	0.3909	0.4010

Table 2. Proportion of various expenditures in general fiscal expenditure in 2020

Region	Science, education, culture and health	Economic construction	General public services	Social security and employment	Environmental protection
Beijing	0.334	0.239	0.074	0.148	0.033
Tianjin	0.245	0.255	0.070	0.165	0.019
Hebei	0.297	0.261	0.087	0.157	0.056
Shanxi	0.263	0.287	0.083	0.159	0.051
Inner Mongolia	0.223	0.321	0.075	0.162	0.028
Liaoning	0.219	0.208	0.075	0.276	0.016
Jilin	0.227	0.295	0.078	0.198	0.032
Heilongjiang	0.195	0.295	0.059	0.248	0.040
Shanghai	0.261	0.277	0.046	0.121	0.022
Jiangsu	0.315	0.253	0.090	0.130	0.025
Zhejiang	0.339	0.224	0.104	0.112	0.022
Anhui	0.333	0.283	0.069	0.157	0.026
Fujian	0.348	0.212	0.090	0.110	0.030
Jiangxi	0.327	0.259	0.084	0.130	0.033
Shandong	0.338	0.222	0.100	0.148	0.026
Henan	0.324	0.255	0.102	0.152	0.026
Hubei	0.313	0.251	0.091	0.168	0.026
Hunan	0.288	0.255	0.102	0.155	0.029
Guangdong	0.382	0.192	0.108	0.104	0.030
Guangxi	0.301	0.282	0.084	0.149	0.016
Hainan	0.307	0.292	0.081	0.128	0.029
Chongqing	0.273	0.252	0.067	0.194	0.037
Sichuan	0.279	0.254	0.085	0.178	0.024
Guizhou	0.318	0.275	0.087	0.118	0.025
Yunnan	0.291	0.300	0.087	0.140	0.024
Shanxi	0.287	0.259	0.089	0.168	0.032
Gansu	0.277	0.314	0.092	0.140	0.027
Qinghai	0.231	0.334	0.073	0.165	0.038
Ningxia	0.260	0.314	0.066	0.139	0.033
Xinjiang	0.272	0.312	0.086	0.117	0.015

1.2.2. Financial Expenditure Structure level

This part divides the fiscal expenditure structure into five parts according to the expenditure function, and measures the fiscal expenditure structure by the proportion of the five items in the general fiscal expenditure. Since the proportion of various fiscal expenditures in general fiscal expenditure in each region during the study period needs to be presented in multiple tables, considering space constraints, only the proportion of various expenditures in general fiscal expenditure in 2020 is listed here. See Table 2 for specific data results.

Table 3. Proportion of science, education, culture and health expenditure in general fiscal expenditure in all regions from 2011 to 2020

Region	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Beijing	0.313	0.333	0.323	0.334	0.297	0.276	0.288	0.293	0.322	0.334
Tianjin	0.269	0.279	0.285	0.290	0.271	0.240	0.241	0.258	0.231	0.245
Hebei	0.294	0.317	0.304	0.310	0.304	0.305	0.309	0.294	0.299	0.297
Shanxi	0.278	0.301	0.288	0.282	0.293	0.296	0.283	0.275	0.262	0.263
Inner Mongolia	0.218	0.214	0.210	0.214	0.218	0.213	0.229	0.213	0.212	0.223
Liaoning	0.226	0.243	0.214	0.212	0.234	0.238	0.231	0.216	0.214	0.219
Jilin	0.240	0.277	0.254	0.244	0.260	0.247	0.243	0.239	0.227	0.227
Heilongjiang	0.223	0.253	0.232	0.241	0.229	0.222	0.209	0.199	0.193	0.195
Shanghai	0.262	0.278	0.274	0.266	0.234	0.243	0.247	0.240	0.252	0.261
Jiangsu	0.285	0.310	0.306	0.305	0.306	0.314	0.319	0.309	0.315	0.315
Zhejiang	0.328	0.347	0.338	0.347	0.326	0.326	0.329	0.319	0.320	0.339
Anhui	0.297	0.304	0.296	0.296	0.301	0.314	0.315	0.322	0.321	0.333
Fujian	0.292	0.323	0.299	0.320	0.317	0.311	0.309	0.324	0.330	0.348
Jiangxi	0.289	0.303	0.296	0.301	0.303	0.312	0.318	0.329	0.321	0.327
Shandong	0.322	0.334	0.323	0.326	0.326	0.334	0.330	0.325	0.332	0.338
Henan	0.314	0.334	0.327	0.328	0.320	0.311	0.312	0.309	0.309	0.324
Hubei	0.257	0.297	0.266	0.281	0.272	0.299	0.301	0.279	0.278	0.313
Hunan	0.251	0.292	0.272	0.278	0.279	0.282	0.283	0.278	0.280	0.288
Guangdong	0.303	0.324	0.333	0.331	0.290	0.328	0.332	0.353	0.365	0.382
Guangxi	0.297	0.312	0.312	0.329	0.328	0.324	0.317	0.303	0.295	0.301
Hainan	0.262	0.275	0.277	0.274	0.279	0.270	0.270	0.270	0.285	0.307
Chongqing	0.202	0.230	0.232	0.239	0.249	0.251	0.251	0.258	0.257	0.273
Sichuan	0.255	0.293	0.279	0.273	0.290	0.290	0.284	0.273	0.281	0.279
Guizhou	0.270	0.283	0.283	0.293	0.318	0.322	0.323	0.324	0.300	0.318
Yunnan	0.271	0.290	0.266	0.254	0.276	0.291	0.292	0.293	0.268	0.291
Shanxi	0.279	0.317	0.302	0.289	0.294	0.307	0.300	0.290	0.283	0.287
Gansu	0.265	0.283	0.269	0.266	0.284	0.290	0.287	0.266	0.272	0.277
Qinghai	0.202	0.223	0.183	0.209	0.203	0.209	0.237	0.236	0.227	0.231
Ningxia	0.235	0.204	0.210	0.216	0.224	0.222	0.231	0.235	0.238	0.260
Xinjiang	0.265	0.265	0.263	0.266	0.266	0.252	0.240	0.242	0.244	0.272

According to table 2, in general, the proportion of economic construction expenditure, science, education, culture and health expenditure in 2020 is relatively high. Except that the proportion of economic construction expenditure in Guangdong is 19.2%, the proportion of economic construction expenditure and science, education, culture and health expenditure in other regions is more than 20%, and the sum of the two accounts for more than 50%; The proportion of social security and employment expenditure is slightly lower. Except that the proportion of social security and employment expenditure in Liaoning and Heilongjiang is higher than 20%, the proportion of other regions is lower than 20%; The proportion of general public service expenditure is relatively low. Except that the proportion of general public service expenditure in Zhejiang, Shandong, Henan, Hunan and Guangdong is higher than 10%, all other regions are lower than 10%; The proportion of environmental protection expenditure is the lowest. Except Hebei and Shanxi, the proportion of environmental protection expenditure in other areas is less than 5%. It can be seen that at present, the key areas of China's fiscal expenditure are concentrated in the fields of economic construction, science, education, culture and health, and the coordinated development of environmental protection, public services, social security and employment.

In order to further analyze the change trend of fiscal expenditure structure and consider space constraints, this part lists the proportion of science, education, culture and health expenditure in general fiscal expenditure in various regions from 2011 to 2020. See Table 3 for specific data results.

Overall, from 2011 to 2020, the proportion of science, education, culture and health expenditure in general fiscal expenditure in all regions of the country showed an overall upward trend. Among them, Fujian, Hubei, Guangdong and Chongqing increased significantly, more than 0.05, and the increase in other regions was less than 0.05. The proportion of science, education, culture and health expenditure in general fiscal expenditure in Tianjin, Shanxi, Liaoning, Jilin, Heilongjiang and Shanghai shows a downward trend. Among them, Tianjin and Heilongjiang provinces have a large decline, more than 0.02.

Taking 2020 as an example, the proportion of science, education, culture and health expenditure in general fiscal expenditure in Beijing, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Guangdong, Guangxi, Hainan and Guizhou remained above 0.3, which was at a high level in the country. The proportion of science, education, culture and health expenditure in general fiscal expenditure in most other regions was between 0.2 and 0.3, and that in Heilongjiang Province was the lowest, accounting for 0.195. On the whole, the proportion of science, education, culture and health expenditure shows a trend of low in the West and high in the East. This is because the eastern region has a large population and is prone to agglomeration effect, so the level of fiscal expenditure is relatively high, while the western region has a small population. At the same time, location factors also greatly affect the distribution of local financial resources. At present, the government actively introduces relevant policies and measures, such as the development of the Yangtze River economic belt and the coordinated development of Beijing, Tianjin and Hebei, Adjust the regional economic level and resource differences.

2. Indicators and Measurement of Scientific and Technological Innovation

2.1. Selection of Scientific and Technological Innovation Indicators

At present, there is no corresponding direct data statistical caliber for scientific and technological innovation indicators. In the past, many scholars used indicators such as patent application authorization and technology market turnover to directly measure the output level of scientific and technological innovation, but the corresponding input cannot be ignored when considering the output. The input-output indicators should be included in the comprehensive index of scientific and technological innovation. Therefore, at present, scholars prefer to use the input-output efficiency of scientific and technological innovation to measure the level of scientific and technological innovation. This paper also uses this method to use the input-output efficiency of scientific and technological innovation to measure the development of scientific and technological innovation. The input index is R & D funds and R & D personnel, and the output index is the number of scientific and technological papers and patents. This part of data comes from China Science and technology database.

2.2. Measurement of Scientific and Technological Innovation Level

On the measurement of scientific and technological innovation level, the traditional research methods mainly include data envelopment analysis and DEA. DEA method measures the level of scientific and technological innovation under given conditions, which belongs to static measurement, while Malmquist index can realize dynamic measurement, which can measure the impact of technological progress and operation management on scientific and technological innovation in the whole process, and eliminate the limitation that the improvement of innovation efficiency caused by the change of production factors is difficult to be identified and measured [2].

Based on the dynamic panel data from 2011 to 2020, this part measures the level of scientific and technological innovation and deeply discusses the dynamic changes of the input-output efficiency of scientific and technological innovation. Therefore, the Malmquist index method is used to measure the input-output efficiency of scientific and technological innovation in 30 provinces (except Tibet, Hong Kong, Macao and Taiwan) from 2011 to 2020, so as to make up for the deficiency of DEA simple static measurement.

The Malmquist composite index based on the reference technology of phase t and phase t+1 is:

$$M(X^t, y^t, X^{t+1}, y^{t+1}) = (M_t * M_{t+1})^{\frac{1}{2}} = \left[\frac{D_c^t(X^{t+1}, y^{t+1})}{D_c^t(X^t, y^t)} \frac{D_c^{t+1}(X^{t+1}, y^{t+1})}{D_c^{t+1}(X^t, y^t)} \right]^{\frac{1}{2}} \quad (1)$$

Where, (X^t, y^t) and (X^{t+1}, y^{t+1}) represent the input and output vectors of T period and T+1 period respectively; $D_c^t(X^t, y^t)$ and $D_c^{t+1}(X^{t+1}, y^{t+1})$ represent the distance function. After exponential decomposition, the following formula is obtained:

$$M(x^t, y^t, x^{t+1}, y^{t+1}) = Effch * Tech = Tech * (Pech * Sech) \quad (2)$$

According to the above formula, the change of input-output efficiency of scientific and technological innovation is decomposed into technological change (Tech) and technological efficiency change (effch), and the change of technological efficiency can be further divided into pure technological efficiency change (pech) and scale efficiency change (sech). Based on Malmquist comprehensive production index method, we measure the comprehensive efficiency of scientific and technological innovation input-output of 30 provinces in China from 2011 to 2020. See Table 4 for specific calculation results.

According to table 4, during the study period, the overall input-output comprehensive efficiency of scientific and technological innovation in most regions showed an upward trend, and the comprehensive efficiency of scientific and technological innovation input-output in Qinghai, Tianjin and Shandong was at a high level; The overall efficiency of scientific and technological innovation input-output in Shanxi, Liaoning, Heilongjiang, Zhejiang, Sichuan and Guizhou showed a downward trend. Before 2014, there were very limited areas where the input and output of scientific and technological innovation reached effective comprehensive efficiency. Since 2015, the situation has improved significantly, and all regions have basically achieved effective comprehensive efficiency. In recent years, with the continuous progress of science and technology, all regions have gradually increased investment in science and technology, paid attention to the transformation of scientific and technological achievements, effectively improved the level of scientific and technological output, actively expanded the scale of R & D and improved the utilization efficiency of scientific and technological innovation resources.

In order to further analyze the changes of input-output comprehensive efficiency of scientific and technological innovation and explore the reasons for the changes of input-output efficiency of scientific and technological innovation, the comprehensive efficiency of input-output of scientific and technological innovation in various regions in 2020 is deeply decomposed. See Table 5 for specific decomposition indicators.

Table 4. Comprehensive efficiency of input and output of scientific and technological innovation in various regions

Region	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average ranking
Beijing	0.985	0.978	1.069	1.022	1.128	1.078	0.988	1.168	1.105	1.052	7
Tianjin	0.931	0.84	1.322	0.898	1.168	1.342	1.185	1.086	1.149	1.083	2
Hebei	0.732	0.885	0.848	0.842	1.096	1.137	0.968	1.309	1.053	1.115	19
Shanxi	1.044	1.118	0.971	0.881	1.316	1.242	0.912	1.081	1.05	0.974	5
Inner Mongolia	0.844	0.847	0.823	0.954	0.996	1.069	1.163	1.435	1.038	0.931	17
Liaoning	1.097	0.966	0.936	0.901	1.386	1.058	0.956	0.991	1.018	0.921	11
Jilin	0.707	0.740	0.973	0.849	1.151	1.044	1.063	1.658	0.95	1.030	13
Heilongjiang	1.118	0.997	0.950	1.073	1.087	0.955	1.079	1.625	0.94	1.005	4
Shanghai	0.959	0.991	0.935	0.964	1.077	1.048	1.180	1.134	1.26	1.034	6
Jiangsu	1.028	1.130	0.930	0.753	0.928	1.087	0.907	1.057	0.908	1.121	21
Zhejiang	1.073	1.148	1.014	0.792	1.058	1.167	0.871	1.085	0.862	1.062	15
Anhui	0.64	1.201	1.052	0.924	1.138	1.173	0.867	1.034	0.694	1.093	23
Fujian	0.906	1.080	1.071	0.957	1.301	1.401	0.850	1.112	0.806	1.025	8
Jiangxi	0.969	0.912	0.820	1.024	1.056	1.413	0.927	1.009	0.889	1.110	16
Shandong	0.973	1.038	1.084	1.007	1.165	1.100	0.973	1.143	1.347	1.096	3
Henan	0.815	1.024	0.994	0.978	1.089	1.117	1.093	1.156	0.811	1.101	12
Hubei	0.710	0.831	0.838	0.922	0.953	0.955	1.036	0.991	0.980	1.074	27
Hunan	0.731	0.796	0.907	0.918	0.932	0.962	0.976	1.052	0.962	1.009	28
Guangdong	0.830	0.976	1.003	0.948	1.157	1.289	1.116	1.119	0.926	1.109	9
Guangxi	0.640	0.891	0.991	1.069	1.490	1.261	0.976	0.770	0.808	1.056	20
Hainan	0.692	0.755	0.908	0.880	1.102	1.216	1.241	0.966	1.202	1.178	14
Chongqing	0.993	1.024	1.087	0.941	1.306	0.619	0.919	1.044	0.831	1.053	22
Sichuan	1.046	0.979	1.047	0.953	1.064	1.120	1.004	0.803	0.759	1.031	24
Guizhou	0.976	1.013	1.231	1.064	0.819	0.963	1.152	1.094	0.834	0.942	18
Yunnan	0.683	0.783	0.999	0.979	0.905	0.882	0.777	1.018	0.834	1.017	30
Shanxi	0.825	0.866	0.992	0.869	1.103	0.979	1.177	0.936	0.989	0.903	26
Gansu	0.868	0.754	0.924	0.918	0.926	1.022	1.208	1.172	0.941	1.026	25
Qinghai	1.018	0.947	0.860	0.862	1.750	0.895	0.900	1.743	0.819	1.287	1
Ningxia	0.797	0.789	0.796	0.977	0.755	0.953	1.077	0.869	0.860	1.118	29
Xinjiang	0.931	1.055	0.938	1.096	0.988	0.969	1.128	1.036	1.123	1.114	10

It can be seen from table 5 that the total factor productivity of scientific and technological innovation in most regions is greater than 1, the highest is Qinghai, and the tfpch value is 1.287, indicating that the input-output efficiency of scientific and technological innovation in these regions has been improved in 2020. The total factor productivity of scientific and technological innovation in Shanxi, Inner Mongolia, Liaoning, Guizhou and Shaanxi provinces is less than 1, the lowest is Shaanxi, and the tfpch value is 0.903, indicating that the input-output efficiency of scientific and technological innovation in these regions will decline in 2020. It can be seen that the input-output efficiency of scientific and technological innovation varies greatly among regions.

The total factor productivity of scientific and technological innovation in most regions is greater than 1 because these regions have not only achieved technological progress and scientific and technological development, but also made efficient use of resources, so as to improve the input-output efficiency of scientific and technological innovation. The technological change (techch) of the five provinces with the total factor productivity of scientific and technological innovation less than 1 is greater than 1, indicating that the region has achieved technological progress and scientific and technological development, but the pure technological efficiency change (pech) and scale efficiency change (sech) are relatively low, indicating that the utilization rate of regional scientific and technological resources is relatively low, and the scale of scientific and technological input has not been effectively improved, resulting in the decline of the input-output efficiency of scientific and technological innovation.

Generally speaking, the total factor productivity level of scientific and technological innovation in all regions of the country was high in 2020. Most regions have achieved technological progress and scientific and technological innovation, but pech and sech are relatively low, indicating that there is still much room for progress in the management level and scientific and technological investment scale of scientific and technological innovation in China.

3. Indicators and Measures of High-quality Economic Development

3.1. Construction of High Quality Economic Development Index System

The new development concept describes the characteristics of high-quality development, which is not only the core essence of high-quality development, but also an important theoretical basis for evaluating high-quality economic development. In recent years, scholars have constructed a new economic development system with high quality as the guidance. Based on the methods of Cheng Jingjing, Cheng Jingjing et al. (2021), Zhou Chao et al. (2021), Zhang Caicai et al. (2022), and guided by the new development concept, this paper constructs an economic high-quality development index evaluation system covering five first-class indicators: innovation, coordination, green, openness and sharing [3-5]. See Table 6 for specific indicators.

Table 5. Changes in input-output efficiency of scientific and technological innovation measured by Malmquist index in 2020

Region	effch	techch	pech	sech	tfpch
Beijing	1.023	1.028	1	1.023	1.052
Tianjin	0.759	1.427	0.986	0.77	1.083
Hebei	0.785	1.42	1.024	0.767	1.115
Shanxi	0.94	1.036	0.956	0.984	0.974
Inner Mongolia	0.901	1.033	0.879	1.026	0.931
Liaoning	0.9	1.024	0.929	0.969	0.921
Jilin	0.985	1.046	0.962	1.024	1.030
Heilongjiang	1	1.005	1	1	1.005
Shanghai	0.935	1.106	1.029	0.908	1.034
Jiangsu	0.786	1.427	1	0.786	1.121
Zhejiang	0.744	1.427	0.968	0.769	1.062
Anhui	0.766	1.427	1.011	0.758	1.093
Fujian	0.718	1.427	0.944	0.76	1.025
Jiangxi	0.778	1.427	1.01	0.77	1.110
Shandong	0.792	1.383	1.153	0.687	1.096
Henan	0.772	1.427	1.016	0.76	1.101
Hubei	0.945	1.136	1.023	0.924	1.074
Hunan	0.875	1.154	0.989	0.884	1.009
Guangdong	0.777	1.427	1	0.777	1.109
Guangxi	0.928	1.138	0.984	0.942	1.056
Hainan	1.000	1.178	1	1	1.178
Chongqing	0.899	1.172	1.012	0.888	1.053
Sichuan	0.891	1.156	1.015	0.878	1.031
Guizhou	0.707	1.333	0.834	0.848	0.942
Yunnan	0.964	1.055	0.982	0.981	1.017
Shanxi	0.880	1.026	0.911	0.966	0.903
Gansu	1.035	0.992	0.977	1.059	1.026
Qinghai	1.197	1.075	1	1.197	1.287
Ningxia	1.037	1.077	1.086	0.956	1.118
Xinjiang	1.112	1.002	1.101	1.01	1.114

Table 6. Index system of high-quality economic development

Primary index	Secondary index	Index attribute
Innovation-driven development	Technology market turnover / regional GDP (X1)	+
	R & D investment intensity (X2)	+
	Number of patent applications (X3)	+
Coordinated development	GDP per capita (X4)	+
	Ratio of per capita disposable income of urban and rural residents (X5)	-
Green development	Energy saving and environmental protection expenditure (X6)	+
	Proportion of coal consumption in total energy consumption (X7)	-
	Harmless treatment rate of domestic waste (X8)	+
Development for global progress	Number of foreign-invested enterprises (X9)	+
	Overseas project contracting personnel (X10)	+
Development for the benefit of all	Number of health technicians per 1000 people (X11)	+
	Per capita disposable wage income of residents (X12)	+
	Residents' food consumption expenditure (X13)	+

3.2. Measurement of High-quality Economic Development Level

In the past, most scholars used the relative index method, entropy method and principal component analysis method to measure the high-quality economic development level, but the first two methods used artificial weighting, which is highly subjective. Therefore, in order to minimize the error caused by subjective measurement, this paper introduced the principal component analysis method for measurement. The main measurement process is as follows:

(1) Standardize the data. Suppose there are m indicators and n evaluation objects, and the value of the j indicator of the

j evaluation object is xij, then the standardized value of each indicator is $\widetilde{x}_{ij}$.

$$\widetilde{x}_{ij} = \frac{x_{ij} - \overline{x}_j}{s_j}, (i = 1,2,\cdots,n; j = 1,2,\cdots,m) \quad (3)$$

Where, $\overline{x}_j = \frac{1}{n}\sum_{i=1}^{n} x_{ij}$, $s_j = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_{ij} - \overline{x}_j)^2}, (j = 1,2,\cdots,m)$, $\overline{x}_j$ and s_j are the mean and standard deviation of the j-th sample respectively.

(2) The correlation coefficient matrix R is calculated.

$$R = (r_{ij})_{m\times m}, \quad r_{ij} = \frac{\sum_{k=1}^{n}\widetilde{x}_{ki}\cdot\widetilde{x}_{kj}}{n-1}, (i,j = 1,2,\cdots m) \quad (4)$$

Where, $r_{ii} = 1$, $r_{ij} = r_{ji}$, r_{ij} is the correlation coefficient between index i and index j..

(3) The eigenvalues and eigenvectors are calculated.

Eigenvalues $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_m \geq 0$, eigenvectors $u_1, u_2, \cdots u_m$, and $u_j = (u_{1j}, u_{2j}, \cdots u_{nj})^T$. The m new index variables composed of eigenvectors are as follows:

$$\begin{cases} y_1 = u_{11}\widetilde{x}_1 + u_{21}\widetilde{x}_2 + \cdots + u_{n1}\widetilde{x}_n \\ y_2 = u_{12}\widetilde{x}_1 + u_{22}\widetilde{x}_2 + \cdots + u_{n2}\widetilde{x}_n \\ \cdots\cdots\cdots\cdots\cdots\cdots \\ y_m = u_{1m}\widetilde{x}_1 + u_{2m}\widetilde{x}_2 + \cdots + u_{nm}\widetilde{x}_n \end{cases} \quad (5)$$

Where, ya is the principal component a.(a=1, 2, 3… m).

(4) The cumulative contribution rate is calculated. Select $p(p \leq m)$ principal components to calculate the comprehensive evaluation value. The cumulative contribution rate is as follows:

$$\alpha_p = \frac{\sum_{k=1}^{p}\lambda_k}{\sum_{k=1}^{m}\lambda_k} \quad (6)$$

When α_p is close to 1, we select the first p index variables as the principal component and conduct comprehensive analysis. The formula for calculating the comprehensive score of high-quality economic development index is as follows:

$$Z = \sum_{j=1}^{p} b_j y_j \quad (7)$$

Table 7. Comprehensive score of regional high-quality economic development index from 2011 to 2020

Region	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	平均得分
Beijing	1.402	-1.121	1.362	1.432	0.965	1.076	-0.241	1.204	1.615	1.617	0.931
Tianjin	0.481	1.076	1.02	0.494	1.566	1.479	-0.249	1.285	0.967	1.022	0.914
Hebei	-0.189	0.553	-0.036	-0.197	0.198	0.176	-0.21	0.06	0.437	0.408	0.120
Shanxi	-0.287	-0.185	-0.238	-0.338	-0.276	-0.279	-0.162	-0.212	-0.007	0.005	-0.198
Inner Mongolia	-0.178	-0.26	-0.186	-0.188	-0.247	-0.288	-0.251	-0.301	-0.204	-0.186	-0.229
Liaoning	0.128	-0.06	-0.22	0.034	-0.178	-0.156	-0.24	-0.225	0.173	0.174	-0.057
Jilin	-0.229	0.092	-0.028	-0.297	-0.093	-0.159	0.712	0.14	0.582	0.49	0.121
Heilongjiang	-0.206	-0.263	-0.174	-0.287	-0.337	-0.333	0.629	-0.332	-0.172	-0.114	-0.159
Shanghai	1.137	-0.219	-0.129	1.096	-0.244	-0.274	0.548	0.322	-0.218	0.192	0.221
Jiangsu	0.727	1.093	0.498	0.668	0.758	0.725	-0.22	0.76	0.861	0.861	0.673
Zhejiang	0.598	0.802	0.853	0.55	0.675	0.668	-0.096	0.537	0.627	0.604	0.582
Anhui	-0.24	0.65	0.42	-0.205	0.512	0.503	-0.397	0.462	0.603	0.587	0.289
Fujian	0.035	-0.093	-0.198	0.153	-0.249	-0.238	0.21	-0.229	0.029	0.172	-0.041
Jiangxi	-0.297	0.208	-0.199	-0.306	-0.066	-0.057	-0.173	-0.113	0.198	0.194	-0.061
Shandong	0.131	-0.193	-0.421	0.118	-0.435	-0.409	0.068	0.396	0.105	0.076	-0.056
Henan	-0.218	0.18	0.282	-0.219	0.203	0.207	-0.2	0.234	0.185	0.194	0.085
Hubei	-0.061	-0.111	-0.139	-0.07	-0.222	-0.215	0.738	-0.171	-0.033	-0.059	-0.034
Hunan	-0.221	-0.06	-0.047	-0.164	-0.049	-0.011	-0.362	-0.044	0.086	0.022	-0.085
Guangdong	0.068	-0.071	-0.215	0.654	-0.251	-0.21	-0.453	0.199	0.058	0.332	0.011
Guangxi	-0.279	0.689	0.71	-0.227	0.602	0.589	-0.162	0.862	0.824	0.769	0.438
Hainan	-0.134	-0.197	-0.325	-0.114	-0.341	-0.366	-0.139	-0.389	-0.185	-0.153	-0.234
Chongqing	-0.147	-0.131	-0.516	-0.151	-0.426	-0.457	-0.323	0.039	0.152	0.16	-0.180
Sichuan	-0.102	0.008	-0.261	-0.061	-0.224	-0.206	-0.3	-0.191	-0.032	-0.031	-0.140
Guizhou	-0.595	-0.027	-0.077	-0.566	-0.142	-0.135	0.093	-0.123	0.001	0.013	-0.156
Yunnan	-0.416	-0.467	-0.422	-0.391	-0.398	-0.309	-0.355	-0.3	-0.302	-0.334	-0.369
Shanxi	-0.189	-0.328	-0.283	-0.127	-0.38	-0.334	-0.333	-0.311	-0.266	-0.275	-0.283
Gansu	-0.445	-0.164	0.004	-0.422	0.03	0.061	-0.318	0.103	-0.086	-0.082	-0.132
Qinghai	-0.244	-0.525	-0.139	-0.232	-0.194	-0.211	-0.255	-0.331	-0.358	-0.342	-0.283
Ningxia	-0.381	-0.313	-0.301	-0.362	-0.253	-0.303	-0.193	-0.265	-0.278	-0.246	-0.289
Xinjiang	-0.263	-0.326	-0.363	-0.275	-0.302	-0.343	-0.124	-0.23	-0.222	-0.252	-0.270

Through SPSS software and principal component analysis, the dimension of high-quality economic development index system is reduced, the multicollinearity between indexes is eliminated, and most of the information in the variables is extracted. The calculated comprehensive score represents the high-quality economic development level of each region from 2011 to 2020. The specific score results are shown in Table 7.

According to table 7: Overall, from 2011 to 2020, the high-quality economic development level in most regions of China has been continuously improved, and the growth rate is stable. Only a few regions have seen a decline in the high-quality economic development level.

The high-quality economic development index of Tianjin, Hebei, Jilin, Anhui, Guangxi and Guizhou has increased significantly, and the comprehensive score of the high-quality economic development index has increased by more than 0.5, indicating that the high-quality economic development in this region has achieved remarkable results and people's living standards have improved significantly. The high-quality economic development index of Beijing, Shanxi, Liaoning, Heilongjiang, Jiangsu, Zhejiang, Fujian, Jiangxi, Henan, Hubei, Hunan, Guangdong, Chongqing, Sichuan, Yunnan, Gansu, Ningxia and Xinjiang has improved, but the growth rate is relatively small and remains within 0.5, indicating that from 2011 to 2020, the high-quality economic development in most regions of China has been stable and sustainable, and people's quality of life has been effectively improved.

The comprehensive score of high-quality economic development index in Inner Mongolia, Shanghai, Shandong, Hainan, Shaanxi and Qinghai showed an overall downward trend. Among them, the downward trend of comprehensive score of high-quality economic development index in Shanghai was the most obvious, and the decline was the largest. Moreover, by 2020, the comprehensive score of economic high-quality development index of Inner Mongolia, Heilongjiang, Hubei, Hainan, Sichuan, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang is still negative. At the same time, the overall average comprehensive score of high-quality economic development indicators in the western region, the southwest region and the northeast region is at a low level.

During the research period, the high-quality economic development in most regions of China has achieved remarkable results. This is due to the fact that the Party led the people throughout the country to adhere to the new development concept as the guiding principle, requiring innovation to become the first driving force, coordination to become an endogenous feature, green to become a universal form, opening to the outside world to become the only way, and sharing to become the fundamental purpose, thus further improving the quality of economic development. The high-quality economic development level of a few regions is difficult to improve or even decline. This is because, on the one hand, the innovation development level of some regions has always been in the forefront of the country, but in recent years, it is difficult to significantly improve the innovation efficiency, the growth of innovation level tends to be slow, and the rising space is relatively small compared with other regions. At the same time, there is a large gap between urban and rural development in the region, which fails to achieve coordinated development and achievement sharing; On the other hand, China has a vast territory, obvious differences in initial resource endowments, and the problem of uncoordinated urban-rural and regional development still exists. There is a large gap between the economic development level of the western and northeast regions and the eastern coastal regions, and the innovation and development capacity of each region needs to be improved. In addition, the opening and shared development of the western and northeast regions are also hindered to some extent due to geographical location and other factors, Although the government gives support through certain policy preferences, there is still a large development gap with the eastern coastal areas, and the high-quality economic development level has not been significantly improved.

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