Construction and Empirical Analysis of the Index System of High-quality Development of Manufacturing in China

Huiai Yuan [1] and Lihong Zhao [2]

[1]Northwest University, Xi'an, Shaanxi, China
[2]Tibet University, Lhasa, Tibet, China

Abstract. Promoting high-quality development of manufacturing is not only an important part of promoting high-quality economic development, but also an inevitable requirement for deepening supply-side structural reform, as well as an objective requirement for comprehensively building a great modern socialist country. Based on the basic requirement of manufacturing high-quality development, this paper builds evaluation index system from two dimensions of “source” and “fruit”, containing six secondary indicators: innovation-driven, intellectualization-driven, service-driven, high added-value, high productivity, high efficiency. Then, we measure the high-quality development level of 30 provinces and 27 manufacturing sub-industries in China from 2011 to 2019 by using the ″Vertical-Horizontal″ Wide Range. We find that the overall high-quality development level of manufacturing industry is on the rise; By region, the high-quality development level of manufacturing industry is normally distributed, showing obvious regional heterogeneity of "strong east and weak west". By industry, the sub-industries of the manufacturing industry have improved their high-quality development level to varying degrees, showing a good development trend. However, most of the molecular industries in China's manufacturing industry are at a lower level, and only a small part is at a higher level. Based on this, the path of high-quality development of manufacturing industry lies in encouraging enterprise innovation, promoting supply-side structural reform, highlighting the integrated development of industries and driving intelligent manufacturing.

Keywords: Manufacturing; High-quality development; ‘Vertical-Horizontal’ Wide Range.

1. Introduction

Promoting high-quality development of manufacturing is the prerequisite and foundation for accelerating the development of the real economy, building a modern economic system, and achieving high-quality economic development. It is of great significance to scientifically understand and accurately grasp the connotation, foundation and direction of high-quality development of manufacturing industry.

The concept of high quality in manufacturing industry has not been put forward abroad. Scholars mainly focus on conceptual framework, development model (Frank et al., 2019), contribution of industrial performance (Dalenogare et al., 2018), short-term supply chain scheduling (Ivanov et al., 2016), supply chain risk (Dmitry et al.,2018), industrial convergence (Hofmann, 2017), comparison of manufacturing development strategies in different countries (Li,2018) and how to support the development of circular economy (Desousajabbour, et al., 2018). Some scholars also studied the impact of the subsector of manufacturing (additive manufacturing) on economic development (Weller, et al., 2015), the deindustrialization phenomenon in different countries from the political and economic perspectives (Rodrik, 2016), the impact of energy conservation policy on green productivity from the perspective of green development (Li, et al, 2016), the moderating effect of green operation and supplier environmental management ability on manufacturing enterprise performance (Wong et al., 2012) and The driving factors of green and non-green innovation in low-technology small and medium-sized manufacturing enterprises ([Maria C. Cuerva, Ángela Triguero-Cano, D Córcoles],2014). High quality development of manufacturing industry is the extension of high-quality development of economy. Domestic scholars believe that the high-quality development of manufacturing supports the development speed of other industries, improves the utilization rate of energy and resources, and protects the ecological environment, which is conducive to economic development (Shi & Li,2019). It mainly evaluates China's high-quality development from two theoretical perspectives of economic growth quality and new development concept (2020; Zhang, 2020).

Accordingly, how to accurately grasp the connotation of high-quality development of China's manufacturing

industry? On this basis, how to construct a measurement system? What is the status quo of the development of high-quality manufacturing in various regions and industries in China? Clarifying these problems is helpful to scientifically grasp the high-quality development of China's manufacturing industry. Therefore, this paper aims to analyze the theoretical connotation of high-quality development of manufacturing industry in China, construct regional and industry measurement system, and provide policy suggestions based on empirical analysis results.

2. The theoretical basis of high-quality development of Chinese manufacturing industry

The 2019 Central Economic Work Conference proposed that "quality reform, efficiency reform and power reform" are the fundamental requirements for high-quality development of manufacturing industry. Based on the fundamental requirements of "quality change, efficiency change and power change" for the high-quality development of manufacturing industry, this paper summarizes the connotation into the following two points: (1)The first level is the development source level, which mainly focuses on "power change", high-quality development of the manufacturing industry is guided by a new development concept and innovation-driven at the core, fostering new drivers of industrial development by integrating various factors with advanced technologies of the new era. (2) The second level is development results, centering on "quality reform and efficiency reform", adhering to the principle of "quality first, efficiency first", the high-quality development of manufacturing industry is to improve product quality and environmental quality, gradually shift to high-end production products, high value-added production products, green production process, and further improve the efficiency and benefit of sustainable development.

2.1 Sources of development.

Innovation-driven. Innovation is the primary driving force for economic development and industrial upgrading. Dynamic mechanism of economic growth in China has gradually from the factors of production and investment structure to scientific and technological innovation, and thus the dynamic mechanism based on technology and human resources of science and technology innovation in China is formed, which is the fundamental reason to promote the high-quality, steady and sustainable development of China's manufacturing industry. **Intellectualization-driven.** The new round of scientific and technological revolution, mainly marked by data-driven technology, promotes the integration of digital technology and manufacturing technology, enables flexible, refined, personalized and intelligent innovative design and production, and meets the diversified and customized needs of consumers (Huang, 2020). Relying on new-generation information technologies such as artificial intelligence, big data and the Internet of Things, intelligent technology will expand "intelligent +" and "5G+ cloud manufacturing" and constantly promote new business models featuring personalized, customized and intelligent, which can promote manufacturing productivity (Liu, 2020), global value chain climbing (Zhang, 2020) and manufacturing transformation and upgrading (Li et al., 2020), and lead high-quality development of manufacturing (Ren, 2020). **Service-driven.** Manufacturing servitization is the integration of innovation to form a new industrial form. It is a process in which manufacturing enterprises change from providing goods to providing services (Liu et al., 2007), not only improving the competitiveness of enterprises and bring direct economic benefits to enterprises, but also reducing environmental pollution and bring indirect environmental benefits to society. (Guo, 2019) points out that the integration of advanced manufacturing and producer services can effectively improve the quality of supply, realize differentiated competition and improve the production efficiency and economic benefits of the manufacturing industry. It can be seen that the servitization of manufacturing industry is an important approach to the transformation and upgrading of manufacturing industry and the high-quality development.

2.2 Fruits of development.

High added-value. The high-quality development of the manufacturing industry not only requires comprehensively improving the quality and efficiency of the manufacturing supply system, but also needs to reduce costs and burdens, improve the profitability of manufacturing enterprises, resolutely eliminate "zombie enterprises", and strengthen and standardize industry management. High added value is the micro basis for strengthening high-quality development of manufacturing industry (Yu, 2020). Added value is the new value added to the original value of the product created by effective labor in the production process. Therefore, high value-added products refer to those with a higher "input-output ratio", whose technological content and corporate culture are far higher than ordinary products, with a large market appreciation and high profits. High Productivity. To promote efficiency reform is to fill up all kinds of low efficiency depression and lay a solid foundation for high-quality development of manufacturing industry, it is necessary to promote the organic combination of new production factors and traditional production factors, and improve the quality, allocation efficiency and use efficiency of production factors. Improving manufacturing efficiency development needs to speed up the integration of social and public data resources, establish a sharing framework of public information resources, improve resource utilization and development of data market, increase the ascension information infrastructure level, speed up the construction of ultra-high speed, large capacity, a new generation of intelligent information infrastructure, and effectively promote the development of manufacturing high quality. High efficiency. High efficiency is the ecological bottom line that the high-quality development of manufacturing industry must adhere to. It is high-quality green

manufacturing based on low carbon cycle, and it is to promote the transformation of manufacturing industry from traditional extensive and inefficient development mode to modern intensive and efficient development mode (Wang, 2020). High efficiency under high-quality development emphasizes environmental benefits and advocates an inclusive growth coordinated between people, industry and nature (Yu, 2020). It is to promote all links of existing social production to adapt to human health and ecological health through certain technological level and management means, and at the same time obtain ecological economic benefits, and finally realize an inclusive growth coordinated between human, industry and nature (Yu Donghua, 2020).

3. Measurement of high-quality development of China's manufacturing industry

3.1 Index system framework

As the connotation of high-quality development of manufacturing industry is rich and diverse, it is necessary to adopt composite indicators for evaluation (Zhang, 2020).Based on the connotation and characteristics of high-quality development of manufacturing industry, on the basis of referring to the existing relevant research, adhering to the principle of systematization, comparability and quantification, this paper takes "development sources" and "development fruits" as the primary index, and constructs the evaluation index system of high-quality development of manufacturing industry in China from the regional and industrial levels. See Table 1 and Table 2.

Table 1. Index system of manufacturing high-quality development based on regional level

First-Level	Second-Level	Third-Level	Third-Level Index Explanation
sources	Innovation-driven	R&D investment	Proportion of r&d investment in operating revenue of enterprises above designated size
		Technological innovation output level	Number of effective invention patents/R&D expenditure
		Contribution of innovation	Technology market turnover
		Creativity of innovation	Number of patent applications for manufacturing inventions /R&D expenditure
	Intellectualization-driven	Digital practitioners	Number of people employed in software and information technology services
		Digital software revenue	Software revenue
		Digital equipment input	Investment in fixed assets of software and information technology services
		Smart benefit	Profits of electronics and communication equipment manufacturing
		Number of intelligent patents	Number of patent applications for electronic and communication equipment manufacturing
	Service-driven	Servitization input	Co-agglomeration index of producer services and manufacturing
fruits	High added-value	Patent density	Number of effective invention patents in manufacturing/gross output value
		New product sales revenue	Sales revenue of industrial new products above designated size
		Industrial Labor productivity	Gross industrial product/average number of industrial employees
		Profit ratio of sales	Manufacturing operating profit/manufacturing main business income
		Proportion of high technology (manufacturing)	Income from main business of high-tech manufacturing/income from main business of manufacturing
	High Productivity	Gross profit margin	Proportion of total profits of industrial enterprises above designated size in regional GDP
		Growth rate of gross profit	Growth rate of total profits of industrial enterprises above designated size
		Profit margin on total assets	Profit rate of total assets of industrial enterprises above designated size
	High efficiency	Water supply volume	Water consumption per 10000 of GDP
		Consumption of electric power	Electricity consumption per 10000 of GDP

		Hazardous waste production	Hazardous waste production per 10000 of GDP
		Production of general industrial solid waste	The output of general industrial solid waste per 10000 of GDP

Table 2. Index system of manufacturing high-quality development based on industry level

First-Level	Second-Level	Third-Level	Third-Level Index Explanation
sources	Innovation-driven	R&D investment	R&D capital stock calculated by perpetual inventory method
		Enterprise	Number of enterprises with R&D activities/number of enterprises above designated size
		R&D investment intensity	R&D internal expenditure /prime operating revenue
		Ratio of r&d personnel	Full-time equivalent of R&D personnel above designated size/average number of employments in the industry
	Intellectualization-driven	Information service input	Information service input/total input
		Proportion of enterprises using the Internet to carry out transactions	The number of enterprises using the Internet to carry out transactions/the total number of enterprises above designated size
		Proportion of e-commerce enterprises	Number of enterprises with e-commerce transaction activities/total number of enterprises above designated size
		Number of computers per 100 people	Number of computers owned by enterprises/average number of employed persons
		Advanced equipment input	Capital stock of instruments and equipment input of industrial enterprises above designated size
	Service-driven	servitization input	Producer services' intermediate inputs to manufacturing/total inputs to manufacturing
fruits	High added-value	Patent density	Number of effective invention patents in manufacturing/gross output value
		Proportion of new product sales revenue	Manufacturing new product sales revenue/manufacturing prime operating revenue
		Output servitization	Manufacturing output consumed by services/total manufacturing output
		Profit ratio of sales	Total operating profit/prime operating revenue
		Sales growth rate	MBRG
	High Productivity	Growth rate of labor	Value added/industry average number of workers
		Growth rate of capital	Added value/original price of fixed capital
		TFP	According to C-D function
	High efficiency	Energy consumption per unit output value	End energy consumption per unit of output
		Wastewater discharge intensity	Industrial waste water discharge per unit output value
		Exhaust emission intensity	Industrial exhaust emissions per unit of output value
		Waste discharge intensity	General industrial fixed waste emissions per unit of output value

3.2 Data sources and processing

The sample data mainly come from “China Statistical Yearbook”, “China Statistical Yearbook of Science and Technology”, “China Environmental Statistics Yearbook”, “China Industrial Statistics Yearbook”, “China Economic Census Yearbook”, and “China Input-Output Table”. Firstly, this study covers 30 provincial-level administrative regions in Mainland China from 2011 to 2019, the data of Hong Kong, Macao, Taiwan, and Tibet of China were excluded. There are 31 sub-ind manufacturing in GB/T 4754-2017. In this paper, C41, C42 and C43 are no longer discussed by referring to the processing principle of industry merging proposed by Chen (2011). C37 is incorporated into C36 due to the change of statistical data. Therefore, the research in this paper covers 27 sub-industries of the manufacturing industry. Secondly, for missing data, interpolation method or analogy method is used to estimate. Thirdly, the

original data are used for proportion calculation or price adjustment for some index data.

3.3 Calculation method

"Vertical-Horizontal" Wide Range is mainly used to solve the weight of multiple indicators in panel data, which maximizes the overall difference of evaluation objects from the horizontal and horizontal directions. this paper chooses this method to calculate. For a 3d sequential stereo table of raw data, the specific steps of this method are as follows:

Dimensionless processing of data

Standardize the raw indicator data to eliminate dimensionality and incomparability between indicators

Calculate the expected evaluation score

Expected score:

$$y_{it}=\sum_{j=1}^{m}x_{ijt}w_j,t=1,2,\cdots,k;i=1,2,\cdots,n \quad (1)$$

In equation (1): x_j represents evaluation indicator, j=1,2,⋯,m; y_{it} represents the comprehensive evaluation score of the research object S_i at time t; w is the weight of j indicator; x_{ijt} is the dimensionless data of the j indicator of the i at time t.

Compute the square of the maximum total deviation

The basic idea of the scaling method is to maximize the differences between the evaluated objects in the sequential stereoscopic data table. The overall difference of evaluation objects in panel data can be described by the total deviation square σ^2 of y_{it}.

$$\sigma^2=\sum_{t=1}^{T}\sum_{i}^{n}(y_{it}-\bar{y})^2 \quad (2)$$

$$\bar{y}=\frac{1}{T}\sum_{t=1}^{T}(\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{m}x_{ijt}w_j) \quad (3)$$

$$\sigma^2=\sum_{t=1}^{T}\sum_{i}^{n}(y_{it}-\bar{y})^2=\sum_{t=1}^{T}[w'H_tw]=w'\sum_{t=1}^{T}H_tw=w'Hw \quad (4)$$

In equation (2), (3) and (4): $w=(w_1,w_2,\cdots,w_1)'$; $H=\sum_{t=1}^{T}H_t$, H is an m × m symmetric matric, $H_t=X_t'X_t(t=1,2,\cdots,k)$;$X_t$ is the dimensionless data matrix of j indicators in i industries in the t year.

σ^2 is maximized when w is equal to the eigenvector w^* corresponding to the maximum eigenvalue $\lambda_{max}(H)$ of the matrix H, that is, $\max_{|w|} w'Hw=\lambda_{max}(H)$.

Calculate the weights of the coefficients

When $w_i^*>0$, the weight coefficient w^s is obtained after normalization;

When $w_i^*<0$, the following nonlinear programming needs to be solved first, and then the weight coefficient w^s can be normalized;

$$\max w^THw,\ s.t.\begin{cases}w^Tw=1\\ w>0\end{cases} \quad (5)$$

Calculate the final comprehensive score of each evaluation object

$$y_{it}=\sum_{j=1}^{m}x_{ijt}w_j^*,t=1,2,\cdots,k;i=1,2,\cdots,n \quad (6)$$

4. Empirical analysis of the high-quality development of China's manufacturing industry

4.1 Measurement results of high-quality manufacturing development at regional level

As can be seen from Table 3, the high-quality development level of China's regional manufacturing industry is steadily improving. The high-quality development of the manufacturing sector has all achieved positive growth in the eastern region, the central region, the western region and the northeast region, and the average value of the index increasing from 0.277, 0.191, 0.153 and 0.185 in 2011 to 0.410, 0.276, 0.248 and 0.217 in 2019 respectively. Furthermore, there are great differences in the development level of high-quality manufacturing in different regions, and the average value of the eastern region is much higher than the other three regions.

Table 3. Comprehensive level of high-quality development of China's regional manufacturing industry from 2009 to 20

Region	Code	2011	2013	2015	2017	2019
Eastern	BJ	0.362 (3)	0.379 (3)	0.379 (3)	0.444 (3)	0.488 (3)
	GD	0.380 (2)	0.423 (2)	0.530 (1)	0.649 (1)	0.751 (1)
	ZJ	0.267 (6)	0.286 (6)	0.328 (5)	0.378 (4)	0.416 (4)
	SH	0.297 (4)	0.306 (4)	0.341 (4)	0.342 (5)	0.365 (6)
	JS	0.401 (1)	0.427 (1)	0.514 (2)	0.542 (2)	0.607 (2)
	SD	0.277 (5)	0.292 (5)	0.311 (6)	0.341 (6)	0.390 (5)
	FJ	0.220 (10)	0.234 (10)	0.256 (11)	0.322 (7)	0.327 (9)
	TJ	0.239 (8)	0.246 (8)	0.278 (7)	0.297 (9)	0.309 (11)
	HE	0.114 (28)	0.130 (28)	0.184 (22)	0.234 (18)	0.241 (19)
	HI	0.216 (11)	0.215 (13)	0.224 (14)	0.218 (22)	0.208 (25)
MEAN		0.277	0.294	0.335	0.377	0.410
Central	HB	0.184 (16)	0.205 (14)	0.229 (12)	0.264 (12)	0.363 (7)
	JX	0.165 (19)	0.174 (19)	0.170 (24)	0.198 (24)	0.235 (20)
	AH	0.203 (13)	0.221 (12)	0.271 (9)	0.294 (10)	0.349 (8)
	HN	0.248 (7)	0.254 (7)	0.227 (13)	0.261 (13)	0.282 (16)

	HA	0.185 (15)	0.193 (16)	0.202 (19)	0.238 (17)	0.246 (18)
	SX	0.160 (21)	0.163 (24)	0.164 (26)	0.176 (29)	0.178 (29)
MEAN		0.191	0.202	0.211	0.239	0.276
Western	CQ	0.226 (9)	0.238 (9)	0.260 (10)	0.307 (8)	0.314 (10)
	GX	0.153 (25)	0.161 (25)	0.190 (21)	0.231 (20)	0.211 (23)
	SC	0.157 (23)	0.174 (20)	0.224 (15)	0.257 (14)	0.299 (12)
	SN	0.150 (26)	0.167 (22)	0.203 (18)	0.233 (19)	0.284 (14)
	NM	0.180 (18)	0.190 (17)	0.150 (30)	0.199 (23)	0.196 (27)
	YN	0.160 (22)	0.167 (23)	0.169 (25)	0.186 (27)	0.209 (24)
	NX	0.161 (20)	0.173 (21)	0.273 (8)	0.221 (21)	0.235 (21)
	GZ	0.194 (14)	0.203 (15)	0.205 (16)	0.254 (15)	0.262 (17)
	GS	0.094 (29)	0.107 (30)	0.157 (28)	0.176 (30)	0.198 (26)
	QH	0.091 (30)	0.112 (29)	0.172 (23)	0.191 (26)	0.295 (13)
	XJ	0.118 (27)	0.133 (27)	0.191 (20)	0.248 (16)	0.226 (22)
MEAN		0.153	0.166	0.199	0.228	0.248
Northeast	LN	0.214 (12)	0.224 (11)	0.204 (17)	0.270 (11)	0.283 (15)
	HL	0.183 (17)	0.188 (18)	0.155 (29)	0.185 (28)	0.189 (28)
	JL	0.157 (24)	0.157 (26)	0.159 (27)	0.192 (25)	0.178 (30)
MEAN		0.185	0.190	0.173	0.216	0.217

The high-quality development level of manufacturing industry has significant regional heterogeneity. In the eastern region, except HB, HI and TJ, the other 7 provinces ranked in the top 10, with GD leading the way with a comprehensive score of 0.751 in 2019, followed by JS and BJ with a comprehensive score of 0.607 and 0.488 respectively. The central region has taken over the relatively backward and inefficient production capacity of the eastern region, among which AH and HB have a higher level of high-quality manufacturing development. In the western region, the high-quality development level of manufacturing industry in CQ exceeded 0.3 in 2019, showing a good momentum of development, while the high-quality development level of manufacturing industry in other provinces is in a state of fluctuation, ranking relatively backward. In northeast China, LN has a high level of high-quality manufacturing development, ranking among the top 50%.

According to the comprehensive scores of provinces in 2019, 30 provinces in China are divided into four categories using cluster analysis method, with scores above 0.4, 0.3 ~ 0.4, 0.2 ~ 0.3 and 0.2 below, respectively, as shown in Table 4.

Table 4. Classification of high-quality development level in manufacturing industry

Category	Criterion	Eastern	Central	Western	Northeast	Level
I	≥0.4	BJ, GD, ZJ, JS				Highest
II	≥0.3~ < 0.4	SH, SD, FJ, TJ	HB, AH	CQ		Higher
III	≥0.2~ < 0.3	HE, HI	JX, HN, HA	GX, SC, SN, YN, NX, GZ, QH, XJ	LN	Lower
IV	< 0.2		SX	NM, GS	HL, JL	Lowest

As can be seen from Table 4, the high-quality development level of manufacturing industry in the eastern, central and western provinces is mainly in II and III, while the I and IV are less, showing a normal distribution as a whole. The 11 provinces at the higher level and above include the I and II: the I category includes BJ, GD, ZJ, and JS. Although the manufacturing industry started early and developed fast, it is constantly exploring new ways to develop the manufacturing industry by relying on advanced information and digital technology and strong scientific and technological capabilities. The II category includes SH, SD, FJ and TJ in the east, HB and AH in the central region, and CQ in the west, with a comprehensive score between 0.3 and 0.4, which is significantly different from provinces of the I category, but has a lot of room for improvement. 19 provinces in the III and IV are at or below the lower level: The III category includes HE and HI in the east, JX, HN and HA in the central region, GX, SC, SN, YN, NX, GZ, QH, and XJ in the west, and LN in the northeast, indicating that most provinces in the central and western regions of China have a lower level of high-quality manufacturing development. The IV category includes SX, NM, GS, HL and JL, which are limited by different conditions such as geography, resources, policies and technology, resulting in slow development and the lowest quality of manufacturing.

4.2 Measurement results of high-quality manufacturing development at industrial level

As can be seen from Table 5, the high-quality development level of China's manufacturing sub-industries is steadily improving. The comprehensive scores of high, middle and low technology industries have increased from 0.18, -0.60 and -0.64 in 2011 to 1.18, 0.07 and -0.16 in 2019 respectively.

Table 5. Comprehensive level of high-quality development of China's manufacturing sub-industries from 2011 to 2019

Indus	Code	2011	2013	2015	2017	2019
	C26	-0.32(10)	-0.09(8)	0.10(8)	0.39(8)	0.45(8)
	C27	0.46(2)	0.75(2)	0.95(3)	1.27(4)	1.51(4)
	C28	-0.59(18)	-0.51(18)	-0.38(18)	-0.14(17)	0.08(16)
	C34	0.19(6)	0.37(6)	0.55(7)	0.81(6)	1.03(6)
HT	C35	0.45(3)	0.49(5)	0.65(5)	1.03(5)	1.35(5)
	C36	-0.01(7)	0.25(7)	0.56(6)	0.71(7)	0.88(7)
	C38	0.41(4)	0.69(4)	0.94(4)	1.31(3)	1.52(3)
	C39	0.72(1)	1.07(1)	1.44(1)	1.9(1)	2.22(1)
	C40	0.33(5)	0.72(3)	0.97(2)	1.31(2)	1.62(2)
MEAN		0.18	0.42	0.64	0.95	1.18
	C14	-0.44(11)	-0.27(12)	-0.14(12)	0.01(13)	0.12(15)
	C15	-0.61(19)	-0.56(19)	-0.58(22)	-0.39(24)	-0.21(22)
	C22	-0.91(25)	-0.73(25)	-0.61(23)	-0.34(20)	-0.24(24)
	C23	-0.51(14)	-0.34(14)	-0.21(15)	-0.04(14)	0.15(13)
MT	C29	-0.55(17)	-0.34(15)	-0.20(14)	0.04(12)	0.21(12)
	C30	-0.94(27)	-0.78(26)	-0.68(27)	-0.4(25)	-0.17(20)
	C31	-0.73(21)	-0.62(21)	-0.66(25)	-0.22(19)	0.15(14)
	C32	-0.28(9)	-0.14(9)	-0.03(11)	0.18(9)	0.38(9)
	C33	-0.46(13)	-0.24(11)	-0.01(10)	0.07(11)	0.27(11)
MEAN		-0.60	-0.45	-0.35	-0.12	0.07
	C13	-0.44(12)	-0.3(13)	-0.19(13)	-0.08(15)	-0.03(18)
LT	C16	-0.81(23)	-0.66(23)	-0.67(26)	-0.41(26)	-0.22(23)
	C17	-0.79(22)	-0.63(22)	-0.48(20)	-0.35(22)	-0.32(25)
	C18	-0.54(16)	-0.42(16)	-0.32(16)	-0.2(18)	-0.12(19)
	C19	-0.62(20)	-0.57(20)	-0.46(19)	-0.34(21)	-0.19(21)
	C20	-0.85(24)	-0.71(24)	-0.63(24)	-0.5(27)	-0.45(27)
	C21	-0.52(15)	-0.47(17)	-0.37(17)	-0.12(16)	0.03(17)
	C24	-0.27(8)	-0.16(10)	0.02(9)	0.17(10)	0.29(10)
	C25	-0.93(26)	-0.79(27)	-0.51(21)	-0.38(23)	-0.43(26)
MEAN		-0.64	-0.52	-0.40	-0.25	-0.16

The comprehensive score of high quality of most of China's manufacturing sub-industries is relatively stable. From 2011 to 2019, the overall score of the electronics industry (C39) remained at the top, followed by C40, C38, C27, C35, while that of the C19, C17, C25 remained at the bottom. Among the 27 sub-industries of manufacturing industry, the ranking of the comprehensive score of high-quality development of four industries changed greatly, C30(27→20), C31(21→14) and C40(5→2) increased significantly, and the ranking of the comprehensive score of high-quality development of C13(12→18) decreased significantly. In addition, from the mean value of each category, the comprehensive score of high-quality development of the three categories is HT>MT>LT, in which category HT has high technology intensity and cleaner production process, and has the highest comprehensive score. Category LT industries are mainly labor-intensive traditional manufacturing industries, and the production process is generally not green enough, with the lowest overall score.

5. Conclusion and policy implications

This paper firstly systematically combs the connotation of high-quality development and extracts two dimensions of "source" and "fruit" according to the fundamental requirements of "quality change, efficiency change and power change". Secondly, based on the principles of systematicness, scientificness, availability and simplicity, an evaluation system of 6 factor layers and 23 index layers is constructed. Finally, combining the ″Vertical-Horizontal″ Wide Range, the high-quality development level of manufacturing industry in China is measured. The findings are as follows: First, the high-quality development level of manufacturing industry has been steadily improved, and the regional level is the highest in the east, the lowest in the west. Among the 30 provinces, BJ, GD, ZJ, and JS have the highest level of manufacturing development, while SX, NM, GS, HL and

JL have the lowest level. Second, from 2011 to 2019, 27 sub-industries of the manufacturing industry have seen their high-quality development levels improved to varying degrees, showing a good development trend. However, most sub-industries in China's manufacturing industry are at a lower level, and only a small part of sub-industries are at a higher level. Overall, HT>MT>LT on average. Specifically, C39 had the highest level of development in 2019, and C20 had the lowest level.

Based on the above analysis, the following suggestions are put forward. (1) We should establish cooperation mechanisms between large, medium and small enterprises, increase the scale and profits of enterprises, build an innovation-driven and coordinated development ecosystem, and form a comprehensive innovation system with enterprises as the main body and the market as the guide. (2) Integrating advanced manufacturing with modern service industries, and promoting manufacturing enterprises to engage in more service activities in value-added links of the value chain, such as R&D, design, marketing, after-sales service, brand management, can help China's manufacturing industry to get rid of the situation of being in the middle and low end of the value chain for a long time and improve its position in the division of labor in the international industrial chain. (3) We should focus on breakthroughs in the key areas, key technology, speed up the manufacturing supply-side structural reform, promote technology innovation and accelerate the application of human-computer intelligent interaction, additive manufacturing, industrial robots, intelligent logistics management and other technologies and equipment in manufacturing process.

C13: Processing of food from agric. products; C14: Manufacture of foods; C15: Manufacture of alcohol, beverages, and refined tea; C16: Manufacture of tobacco; C17: Manufacture of textiles; C18: Manufacture of textiles, clothing; apparel industry; C19: Manufacture of leather, fur, feather and related products; footwear industry; C20: Processing of timber, manufacture of wood, bamboo, rattan, palm, and straw products; C21: Manufacture of furniture; C22: Manufacture of paper and paper prod; C23: Printing and recorded media; C24: Manufacture of articles for culture, education, art, sports, and entertainment; C25: Processing of petroleum, coal and other fuel ; C26: Manufacture of chemical raw materials and chemical products; C27: Manufacture of medicines; C28: Manufacture of chemical fibers; C29: Manufacture of rubber and plastics; C30: Manuf. of non-metallic mineral products; C31: Smelting and processing of ferrous metals; C32: Smelting and processing of non-ferrous metals; C33: Manufacture of metal products; C34: Manufacture of general purpose machinery; C35: Manufacture of special purpose machinery; C36: Manufacture of automobiles; C37: Manufacture of railway, ships, aerospace and other transportation equipment; C38: Manufacture of electrical machinery and equipment; C39: Manufacture of computers, communication and other electronic equipment; C40: Manufacture of measuring instruments; C41: Other manufacturing; C42: Comprehensive use of waste resources; C43: Repair of metal products, machinery and equipment.

References

1. Dalenogare L S, Benitez G B, Ayala N F, et al.: The expected contribution of Industry 4.0 technologies for industrial performance. International Journal of Production Economics 204(OCT.):383-394 (2018).
2. Desousajabbour A B L, Jabbour C, Filho M G, et al.: Industry 4.0 and the circular economy: a proposed research agenda and original roadmap for sustainable operations. Annals of Operations Research 270(1-2):273-286 (2018).
3. Dmitry I, Alexandre D, Boris S.: The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics. International Journal of Production Research, 1-18 (2018).
4. Frank A G, Dalenogare L S, Ayala N F.: Industry 4.0 technologies: Implementation patterns in manufacturing companies. International Journal of Production Economics 210(APR.):15-26 (2019).
5. Guo C X.: Integration of advanced manufacturing industry and modern service industry to promote high quality development of manufacturing industry. Journal of Beijing University of Technology (Social Sciences Edition) 19(4): 49-60 (2019).
6. Hofmann E, M Rüsch.: Industry 4.0 and the current status as well as future prospects on logistics. Computers in Industry 89:23-34 (2017).
7. Huang S H, LIU F R.: Research on the development of electronic information industry in Jiangxi: based on the perspective of digital economy. Price Monthly 523(12): 82-88(2020).
8. Ivanov D, Dolgui A, Sokolov B, et al.: A dynamic model and an algorithm for short-term supply chain scheduling in the smart factory industry 4.0. International Journal of Production Research 54(1-2):386–402 (2016).
9. Li C F, Li D D, Zhou C.: The mechanism of digital economy driving transformation and upgrading of manufacturing: based on the perspective of industrial chain restructuring. Commercial Research 514(2): 73-82 (2020).
10. Li K, Lin B.: Impact of energy conservation policies on the green productivity in China's manufacturing sector: Evidence from a three-stage DEA model. Applied Energy 168:351-363 (2016).
11. Li, Ling.: China's manufacturing locus in 2025: With a comparison of "Made-in-China 2025" and "Industry 4.0". Technological Forecasting and Social Change, 66-74 (2018).
12. Liu F.: How does digital transformation improve manufacturing productivity—Based on the triple impact mechanism of digital transformation. Finance & Economics 391(10): 93-107 (2020).

13. Liu J G, Li J F.: A review of foreign research on servitization of Manufacturing Industry. Economist 111(3): 119-126 (2007).
14. [Maria C. Cuerva, Ángela Triguero-Cano, D Córcoles].: Drivers of green and non-green innovation: empirical evidence in Low-Tech SMEs. Journal of Cleaner Production, 2014.
15. Ren B P.: The logic, mechanism and path of digital economy leading high-quality development. Journal of Xi'an University of Finance and Economics 33(2): 5-9 (2020).
16. Rodrik D.: Premature deindustrialization. Journal of Economic Growth 21(1) (2016).
17. Shi D, Li P.: Quality evolution and assessment of China's industry over the past seven decades. China Industrial Economics 378(9): 5-23(2019).
18. Su Y W.: The influence of establishment FTA on economic convergence : analysis of intermediary effect based on industrial structure upgrading. On Economic Problems 493(9): 85-91, 117(2020).
19. Wang H T, Lu M.: Supply-demand balance, kinetic energy conversion and high-quality development of manufacturing industry. Jiangsu Social Sciences 311(4): 128-136(2020).
20. Weller C, Kleer R, Piller F T.: Economic implications of 3D printing: Market structure models in light of additive manufacturing revisited. International Journal of Production Economics 164:43-56(2015).
21. Wong C W Y, Lai K H, Shang K C, et al.: Green operations and the moderating role of environmental management capability of suppliers on manufacturing firm performance. International Journal of Production Economics 140(1):283-294 (2012).
22. Yu D H.: Research on the Connotation, path and dynamic mechanism of high quality development of manufacturing industry. Review of Industrial Economics 36(1): 13-32(2020).
23. Zhang Q, Yu J P.: Input digitization and climbing global value chain: micro evidence from Chinese manufacturing enterprises. Economic Review 226(6): 72-89 (2020).
24. Yu D H.: Research on the connotation, path and dynamic mechanism of high quality development of manufacturing industry. Review of Industrial Economics 36(1): 13-32 (2020).
25. Zhang T.: Theoretical interpretation and measurement methods of high-quality development in China. The Journal of Quantitative & Technical Economics 37(5): 23-43(2020).
26. Zhao A Y, Niu X X, Shen Z L.: Difficulties and paths of high-quality development of China's manufacturing industry. Journal of Xi'an University of Finance and Economics 33(6): 49-57 (2020).