ISSN: 1813-4890

Digital development status and evaluation research of iron and steel enterprises

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Abstract

Based on the analysis of the digital development status of iron and steel enterprises, from the digital basis, digital management, digital effect of building steel enterprises digital development level evaluation index system, using the entropy method of 26 listed steel enterprises digital development level index weight, to evaluate the 26 steel enterprises digital development degree. The study found that from the perspective of individual enterprises, Baosteel, Valin Steel and TiSCO ranked the top three stainless steel, indicating that their digital development level is high. From the perspective of regional distribution, China's iron and steel enterprises are widely distributed, and the digital transformation level of iron and steel enterprises in different regions is also different. The digital development level of the steel enterprises in eastern China is high, the steel enterprises in central China are the second, and the steel enterprises in the western region are in a state of gradually catching up.

Keywords

Iron and steel enterprises; digital development status; digital development level evaluation.

1. Introduction

With the continuous emergence and rapid iteration of emerging digital technologies such as cloud computing, big data, Internet of Things, and artificial intelligence, the era of digital economy, a new economic form driven by digital technology and a key production factor with data as the key factor of production, has arrived. With the rapid promotion of the digital economy, the Party and the Central Committee attach great importance to the development of the digital economy and gradually upgrade the digital economy to a national strategy. In the "Proposal of the Central Committee of the Communist Party of China on Formulating the 14th Five-Year Plan for National Economic and Social Development and the Long-term Goals for 2035", it is pointed out that to meet the digital era, tap the potential of data, give full play to the advantages of massive data and rich application scenarios, and promote the integrated development of the digital economy and the real economy. As a traditional pillar industry, steel enterprises are the foundation of the country, the instrument of national rejuvenation, and the foundation of strengthening the country, and their digital development is the top priority for further developing and expanding the integration and development of the digital economy and the real economy.

As an important bearer of the development of the manufacturing industry, steel enterprises urgently need to cope with the adjustment brought about by external uncertainties through digital development in the environment of rapid development of digital economy, increasingly diverse customer needs and blurred organizational boundaries. However, the current research on the digitalization of steel enterprises mainly focuses on digital human resource transformation [1], digital information construction[2], bottlenecks and challenges in digital development[3], intelligent manufacturing[4], sustainable development[5], etc., while the

ISSN: 1813-4890

research on the digital development of steel enterprises is relatively weak. Under the macro background of the rapid development of digital economy, it is of great significance to evaluate and analyze the digital development of steel enterprises, explore the digital development degree of steel enterprises, and promote the digital transformation and development of steel enterprises.

Based on the above research limitations, this study analyzes the digital development status of steel enterprises on the basis of the current research, and evaluates the digital development level of steel enterprises by constructing the evaluation index of digital development level of steel enterprises and using the entropy value method.

2. The current situation of digital development of steel enterprises

Digital technology is widely used. With the development of emerging digital technologies and the fourth industrial revolution, digital technologies are widely used in the digital transformation process of steel enterprises. The application of digital technology in steel enterprises has promoted enterprises in reducing costs, improving production efficiency, improving product quality, and promoting green production. For example, Baosteel uses the Internet, Internet of Things technology, cloud computing, big data and robotics to effectively shorten product development cycle, reduce operating costs, improve production efficiency, improve product quality and reduce resource consumption. Nangang Co., Ltd. has developed a refining furnace robot, a converter continuous casting machine crystallizer and a protective slag robot, and the developed robot is applied to production, which greatly reduces the labor cost of the enterprise, improves the accuracy of steel production, and improves work efficiency. For the first time, Shougang applied image intelligent recognition technology to particulate matter emission control, strengthening enterprise emission management and promoting the green development of enterprises.

Digital platform construction and use. The application of digital platforms makes full use of the vast amount of data in the production process of steel companies. The construction of digital platform enables steel enterprises to form six application modes of platform design, intelligent manufacturing, personalized customization, service-oriented extension, digital management and network collaboration, covering 29 application scenarios and initially forming 89 specific applications: including engineering digital design and delivery, ironmaking process collaborative application, energy management application, user collaborative development, digital customized steel, warehouse management application, industrial chain collaborative application, 5G energy and environmental protection management and 5G production site monitoring. The construction and use of digital platforms have further promoted the digital development of steel enterprises.

The pace of smart manufacturing is accelerating. With the deepening of digital transformation, realizing smart manufacturing, building a smart manufacturing system integrating intelligent equipment, smart factories and smart operations, and improving the company's cost, quality and service competitiveness have gradually become the goals of digital transformation of domestic steel enterprises. For example, Baosteel 1580 intelligent workshop transformation, Angang intelligent mine, Tanggang intelligent factory, etc., are all leaders in the development of China's steel intelligent manufacturing; Take Baoshan Iron and Steel as an example, focusing on industrial Internet and industrial robots, build intelligent workshops; Bayi Steel leads the digitalization of enterprises with informatization, intelligent transformation and upgrading, actively builds a smart manufacturing system integrating intelligent equipment, intelligent factories and intelligent operations, and establishes an evaluation mechanism for smart manufacturing projects. Shougang Qianshun Base promotes the application of big data, explores the construction of 21 business decision-making models such as POC intelligent

ISSN: 1813-4890

control and performance risk control, and realizes one-click statistical analysis of business management and control.

3. Evaluation of the digital development level of China's steel enterprises

3.1. Indicator selection

Drawing on the "Digital Level Assessment Form for Manufacturing SMEs (2022 Edition)" distributed by the Ministry of Industry and Information Technology, the digital level of steel enterprises is evaluated based on three aspects: digital foundation, digital management and digital effectiveness, including six subdivision indicators of digital economic foundation, digital equipment system, digital talent reserve, digital capital investment, digital technology application, and digital economic benefits, as shown in Table 1.

Based on the "Evaluation Form for the Digital Level of Manufacturing SMEs (2022 Edition)" distributed by the Ministry of Industry and Information Technology, the digital economic foundation and digital equipment system are used to measure the digital foundation. Among them, the foundation of digital economy draws on Li Xiaoqing et al [6] to study and use a comprehensive index of four indicators: return on net assets, return on total investment, net profit growth rate, and total asset growth rate. The digital equipment system draws on the research software equipment of Tang Xiaowen et al [7], and the measurement is increased in this issue. Use digital talent reserve and digital capital investment to measure digital management, and draw on the research of Yang Haochang et al [8] to use the number of R&D personnel and R&D investment amount to measure digital talent reserve and digital capital investment. Measure digital effectiveness with the application of digital technologies and the economic benefits of digitalization. Among them, the application of digital technology draws on the research of Wu Fei et al [9], and uses text analysis method to extract keywords and capture data from the text of annual reports of listed steel enterprises. The benefits of digital economy are constructed by drawing on the indicators of Cheng Cuifeng[10], and measured by a comprehensive index of three indicators: cost and expense profit margin, main business profit margin, and asset-liability ratio.

Table 1 Iron and steel enterprises digital development level evaluation index

Level 1 indicators	Secondary indicators	Description of secondary indicators	Metric properties
Digital foundations	The foundation of the digital economy X_1	A comprehensive index of four indicators: return on net assets, return on total investment, growth rate of net profit, and growth rate of total assets	Positive
	Digital device systems X_2	Software appliances were added during the period	Positive
Digital management	Digital talent pool X_3	The number of R&D personnel in the enterprise	Positive
	Digital funding X_4	The amount of R&D investment of the enterprise	Positive
Digital effectiveness	Application of digital technology X_5	The text analysis method was used to extract "artificial intelligence", "blockchain", "cloud computing",	Positive

ISSN: 1813-4890

		"big data", "Internet", "AI", "Internet of Things", "informatization" and "digitalization" as keywords to capture data from the annual reports of listed steel enterprises	
	Digital economic benefits X_6	A comprehensive index of three indicators: cost and expense profit margin, main business profit margin, and asset-liability ratio	Positive

3.2. Model building

In order to measure the level of digitalization of steel companies, the following model is constructed:

$$DL = \partial_1 DF + \partial_2 DM + \partial_3 DE \tag{1}$$

In Formula (1), it represents the level of digital development, represents the digital foundation, represents the digital management, represents the digital effectiveness, and represents the entropy weight of the digital foundation, digital management and digital effectiveness, respectively.

3.3. Sample selection and data sources

Based on the availability of data, this study selects the panel data of listed steel companies for the analysis of digital development level, and through the preliminary screening of 44 listed steel companies, considering the integrity of the data and the absence of words such as "digital", "intelligent" and "big data" in the annual reports of steel companies, 26 listed steel companies were finally determined to be used as research samples. The data comes from Guotai'an database, Juchao.com and the annual reports of various steel companies. Selection time basis China issued "Made in China 2025" in 2015, marking the beginning of China's entry into the fourth industrial revolution based on digital technology to 2020, so the final limit of data selection is 2015-2020.

3.4. The entropy method calculates the metric weights

In order to comprehensively reflect the level of digital development of steel enterprises, this paper uses the improved entropy value method to determine the weight of the above indicators, as follows:

The range transformation method is used to process the data dimensionlessly. The formula is as follows:

$$X'_{i,j} = \frac{x_{i,j} - x_{j\min}}{x_{j\max} - x_{j\min}} \text{ (Positive indicators)} \tag{2}$$

$$X'_{i,j} = \frac{x_{j\max} - x_{i,j}}{x_{j\max} - x_{j\min}} \text{ (Inverse indicators)} \tag{3}$$

In formula (2) and formula (3), "i" representative evaluation sample, "j" representative evaluation indicators, "x" represents the evaluation index value, "X'" represents the dimensionless index value.

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(2)After dimensionless processing of the data using the range variation method, 0 appears in the data. Add 0.0001 to each data and shift 0.0001 units to the right. It is then normalized. The formula is as follows:

$$Y_{i,j} = \frac{x'_{i,j}}{\sum_{i=1}^{n} X'_{i,j}} \tag{4}$$

In formula (4), "Y "the value of the indicator after normalization is depresented; "n "represents the total number of samples.

(3)The proportion of each sample on each index is obtained, and the entropy value and difference coefficient of each index are further calculated.

$$e_j = -K * \sum_{i=1}^{n} Y_{i,j} * \ln Y_{i,j} \tag{5}$$

In formula (5), $K = \frac{1}{\ln n}$, "e "represents the information entropy value.

Coefficient of variation of the j index :

$$d_j = 1 - e_j \tag{6}$$

In formula (6), "d_j " representative coefficient of variation.

(4)Use the following formula to calculate the weight of each indicator.

$$w_j = \frac{d_j}{\sum_{i=1}^{m} d_i} \tag{7}$$

In formula (7), "w " representative index weight.

(5)Empower each indicator to get a composite index. The formula is as follows:

$$y_i = \sum_{j=1}^{m} X'_{i,j} * w_j \tag{8}$$

In formula (8), "y "represents the iron and steel enterprises digital development level index.

According to formula (5), formula (6) and formula (7), the information entropy, difference coefficient and the weight of each index of the digital development level evaluation index of iron and steel enterprises are calculated, as shown in Table 2.

Table 2 Iron and steel enterprises digital development level index weight

Level 1 indicators	Secondary indicators	Information entropy	Coefficient of variation	Weight
Digital foundations (Entropy rights：0.3656)	The foundation of the digital economy X_1	0.6508	0.3492	0.1775
	Digital device systems X_2	0.6298	0.3702	0.1881
Digital management	Digital talent pool X_3	0.7031	0.2969	0.1509
	Digital funding X_4	0.6528	0.3472	0.1765

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(Entropy rights：0.3274)				
Digital effectiveness (Entropy rights：0.3071)	Application of digital technology X_5	0.6892	0.3108	0.1580
	Digital economic benefits X_6	0.7066	0.2934	0.1491

3.5. Evaluation results of digital development level

According to the constructed index system and combined with the index weights calculated by the entropy method, the results of 26 steel companies on digital foundation, digital management, digital effectiveness and digital development level were obtained and ranked, and the results were shown in Table 3.

Table 3 Sample digital development level comparison of steel enterprises compared

Business name	Digital foundations	Digital management	Digital effectiveness	The level of digital development
Baosteel shares	0.7065(3)	0.4477(1)	0.5123(1)	0.5110 (1)
Hunan Valin Steel	0.5992(14)	0.4183(2)	0.2366(5)	0.4144 (2)
Too steel stainless steel	0.7052(4)	0.3211(5)	0.2428(4)	0.4134 (3)
XinyuIron&SteelCo.,Ltd	0.5734(18)	0.3823(3)	0.1840(11)	0.3760 (4)
Maanshan Iron & Steel Company Limited	0.5740(17)	0.3446(4)	0.2252(6)	0.3760 (5)
Angang Steel Company Limited	0.6490(8)	0.2131(7)	0.2449(3)	0.3573 (6)
GansuJiuSteelGroupHongxing Iron&SteelCo.,Ltd.	0.6976(6)	0.1354(13)	0.1999(8)	0.3292 (7)
Sansteel MinGuang Co.,Ltd.,Fujian	0.7099(1)	0.1471(11)	0.1690(16)	0.3271 (8)
Hbis Company Limited	0.5393(20)	0.1574(9)	0.2897(2)	0.3180 (9)
Bengang Steel Plates Co.,Ltd.	0.5275(23)	0.2555(6)	0.1771(12)	0.3133 (10)
Beijing Shougang Co.,Ltd	0.6372(10)	0.1635(8)	0.1677(17)	0.3103 (11)
SGIS Songshan Co.,Ltd.	0.7027(5)	0.0965(17)	0.1752(14)	0.3084 (12)
Shandong Steel	0.5848(16)	0.0381(21)	0.2034(7)	0.2974 (13)
CITIC Pacific Special Steel Group Co., Ltd	0.6508(7)	0.1310(14)	0.1418(19)	0.2942 (14)
Nanjing Iron & Steel Co., Ltd.	0.5923(15)	0.1444(12)	0.1709(15)	0.2906 (15)

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Xinxing Pipes	0.5699(19)	0.1284(15)	0.1929(9)	0.2851 (16)
XinJiang Ba Yi Iron & Steel Co.,Ltd.	0.7075(2)	0.0340(22)	0.1221(23)	0.2696 (17)
InnerMongoliaBaoTou SteelUnionCo.,Ltd	0.4893(26)	0.1532(10)	0.1890(10)	0.2681 (18)
Liuzhou Iron&Steel Co., Ltd	0.6400(9)	0.0310(23)	0.1762(13)	0.2655 (19)
LingyuanIron&SteelCo.,Ltd.	0.6225(11)	0.0557(19)	0.1345(21)	0.2555 (20)
Jiangsu Shagang Co., Ltd.	0.6082(13)	0.0490(20)	0.1250(22)	0.2456 (21)
Chongqing Iron & Steel Company Limited	0.5331(21)	0.0987(16)	0.1203(24)	0.2391 (22)
Anyang Iron and Steel Co., Ltd.	0.5316(22)	0.0738(18)	0.1482(18)	0.2387 (23)
Fangda Special Steel Technology Co.,Ltd	0.6108(12)	0.0074(26)	0.1348(20)	0.2344 (24)
Zhejiang JIULI Hi-tech Metals Co.， Ltd	0.5107(24)	0.0303(24)	0.1131(25)	0.2049 (25)
Jiangsu Changbao Steeltube Co.,Ltd	0.5077(25)	0.0270(25)	0.1102(26)	0.2018 (26)

From the perspective of digital foundation, the overall score of 26 sample steel enterprises is high, and 25 of the 26 sample steel enterprises have digital foundation scores above 0.5, indicating that most steel enterprises have a certain ability to carry out digital transformation, have sufficient economic foundation and digital development of equipment systems, which provide a guarantee for the digital transformation of steel enterprises, thereby ensuring the smooth implementation of digital development of steel enterprises.

From the perspective of digital management, the overall score of 26 sample steel companies is low, 19 of the 26 sample steel companies scored below 0.2, and only two steel companies scored more than 0.4, indicating that most steel companies in digital management talent reserve and capital investment is still relatively insufficient, steel enterprises need to continue to strengthen digital talent reserve and digital capital investment, for the digital transformation of enterprises to improve the guarantee of talents and funds, and then promote the digital development of steel enterprises.

From the perspective of digital effectiveness, the overall score of the 26 sample steel companies was relatively low, only Baosteel scored more than 0.5, and other steel companies scored below 0.3, indicating that the digital performance of most steel companies is not satisfactory at present, digital development is still in its infancy, and it is necessary to continue to explore to complete digital transformation.

From the analysis of the digital development level of steel enterprises, Baosteel Co., Ltd., Valin Steel Co., Ltd. and TISCO Stainless Steel ranked in the top three, among which, Baosteel Co., Ltd. ranked in the top three, indicating that Baosteel's digital development level is better. Ranked fourth and fifth were Xingang and Masteel. In recent years, Xingang and Masteel have increased their technological innovation, and the establishment of R&D centers by Masteel has had a great impact on their digital development. From the enterprise level, half of the enterprises scored below 0.3, indicating that the digital development level of China's steel enterprises is still in its infancy, and the digital level needs to be improved. At the same time, China's steel enterprises

ISSN: 1813-4890

are widely distributed, and the digital development level of steel enterprises in different regions is also different. From the perspective of regional distribution, the digital development level of steel enterprises in the eastern region is relatively high, followed by steel enterprises in the central region, and the steel enterprises in the western region are in a state of catching up.

4. Conclusion

Steel enterprises are an important part of the market economy system, and digital transformation is a long-term and gradual comprehensive project. In the era of digital economy, with the integration and development of digital technology and traditional industries, emerging digital technologies continue to penetrate into steel enterprises, and actively use digital technology to accelerate the digital transformation of steel enterprises. In the future, steel enterprises should accelerate the pace of digital transformation, strive to explore the key factors affecting the digital transformation of steel enterprises, and explore a digital transformation path suitable for their development.

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