Exploring the Pathway to Transformation and Upgrading of Sichuan Province's Manufacturing Industry Amidst the Dual-Carbon Target Imperative

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Abstract. As industrialization accelerates, global warming poses a dire threat to humanity and nature. China's ambitious 2060 "dual carbon" target underscores the urgency. Sichuan, a manufacturing hub, faces a paradox: lagging tech intensity vs. abundant clean energy resources. Leveraging these strengths, Sichuan's manufacturing must transform for high-quality development, crucial to China's carbon goals. This study (2008-2022) assesses Sichuan's manufacturing upgrade across five dimensions. It shows a "two rises, one fall" trend peaking in 2020, with network informatization leading, followed by innovation, intelligent manufacturing, economic, and green development. It advocates targeted strategies to strengthen weaknesses while maintaining strengths. The paper offers strategic recommendations for Sichuan's enterprises and government to facilitate a seamless industry transition, aiding China's "dual carbon" targets and securing Sichuan's manufacturing sector's sustainable prosperity.

Keywords: Manufacturing industry transformation and upgrading; Dual carbon; Sichuan province; High-quality development.

1 Introduction

In recent years, extreme weather events such as typhoons and hailstorms have become increasingly frequent globally, while the intensity of natural disasters like floods has continued to escalate. These phenomena underscore the accelerating pace of global warming, a pressing environmental challenge confronting all humanity. One of the primary culprits behind this issue is the massive emission of greenhouse gases, including carbon dioxide, stemming from human activities. This, in turn, triggers the greenhouse effect, leading to a relentless rise in global temperatures [1-2]. As a responsible major country, China, during the 75th Session of the United Nations General Assembly on September 22, 2020, unveiled its ambitious "3060 Dual Carbon" target for the first time. Simultaneously, it emphasized the significance and fundamental pathways for optimizing and upgrading industrial structures under the "Dual Carbon" framework. Multiple policies, including the "Action Plan for Peaking

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Carbon Dioxide Emissions Before 2030," have been enacted to ensure the achievement of these targets [3].

At the 9th Meeting of the Central Commission for Finance and Economics held in March 2021, the clean and low-carbon transformation of energy was prioritized, and the improvement of the "dual control" system for energy was proposed. It is evident that the optimization and adjustment of industrial and energy structures serve as catalysts for advancing the "Dual Carbon" work, guiding China's industries towards high-quality development. Furthermore, the 20th National Congress of the Communist Party of China (CPC) provided clear directives for the "Dual Carbon" efforts, emphasizing the modern industrial system. The CPC and the state have always attached great importance to the development of the real economy, particularly manufacturing. The report of the 20th CPC National Congress advocates "promoting the high-end, intelligent, and green development of manufacturing" and solidly advancing the green and low-carbon transformation of the manufacturing sector [4].

Sichuan Province, known as the "Land of Abundance" with its crisscrossing rivers, is a major producer of clean energy and serves as the largest clean energy production base and a national demonstration province for clean energy in China. To a certain extent, it contributes to the advancement of the "Dual Carbon" work[5-6]. However, Sichuan is also a populous, manufacturing-intensive, and consumption-driven province, facing numerous challenges in meeting the high standards and requirements of achieving the "Dual Carbon" targets[7]. Therefore, by deeply analyzing the carbon emissions and development status of Sichuan's manufacturing sector and selecting relevant data indicators to comprehensively evaluate the level of its transformation and upgrading, we can identify issues, analyze causes, and ultimately propose corresponding solutions. These efforts aim to provide valuable insights for southwestern China and other provinces nationwide, thereby facilitating the progress of China's "Dual Carbon" work.

2 Literature Review

Most domestic scholars primarily focus on the influencing factors, pathways, factor-driven mechanisms, and measurements of the transformation and upgrading of the manufacturing industry. Shipper, utilizing the Adaptive Weight Approach (AWA), discovered that energy structure and energy intensity are crucial factors influencing carbon emissions[5]. Arif Ullah et al., through panel data unit root testing, conducted a study on factors affecting carbon dioxide emissions in the BRICS countries, revealing that technological innovation has a significantly positive impact on carbon emissions, both in the long and short term[6]. Li Chunlin, and Li Jingyi conducted empirical research on the dynamic relationships among the influencing factors of manufacturing upgrading using both qualitative and quantitative analysis methods, along with the VAR model[7]. They ultimately discovered that technological innovation has a more enduring and significant impact, with ample room for future growth in its influence. Qu Xiaoyi and Lu Ping employed the SFA method to conclude that investment in research and development personnel, funding, and expenditure are crucial factors influencing the transformation and upgrading of the manufacturing industry[8]. Liu Shuping and Liao Anyong, focusing on the path of the current era of big information under the Internet, both constructed GMM econometric models to explore the relationship between informatization and the transformation and upgrading of the manufacturing industry[9-10]. They ultimately found that informatization enhances manufacturing productivity, thereby reducing costs to a certain extent and achieving cost-effectiveness.

In terms of measurement analysis, Zhang Yujun employed the coupling coordination degree to study the carbon economic system and the manufacturing system, and further utilized a comprehensive indicator system to measure these two systems[11]. The research revealed that green technology is the key to the transformation and upgrading of the manufacturing industry. Ma Mingyu, by establishing an evaluation index system for the level of manufacturing transformation and upgrading, applied the entropy weight method to determine the weight of indicators for measurement analysis[12]. The study found that factors such as economy, innovation, greenness, intelligence, and networking all exert varying degrees of influence on the transformation and upgrading of the manufacturing industry. Regarding pathway research, Xu Hong[13] argues that technological innovation serves as the primary driving force, resource efficiency forms the basic impetus, and industrial policies act as the guiding force.

The literature on manufacturing transformation covers factors, pathways, mechanisms, and measurements. Yet, research under "dual carbon" goals is scarce, focusing mainly on heavy industrial regions, limiting findings. This paper studies Sichuan, a "Clean Energy Province," to enrich "dual carbon"-integrated manufacturing transformation research.

3 Construction of an Indicator System for the Transformation and Upgrading of the Manufacturing Industry Model Construction

3.1 Selection and Interpretation of Evaluation Indicators

This paper selects data from Sichuan Province spanning nearly fifteen years, from 2008 to 2022, to construct an evaluation index system for the level of manufacturing transformation and upgrading in Sichuan Province. This system comprises five primary indicators: economic development, green development, innovation drive, intelligent manufacturing, and cyber-informatization. Under each primary indicator, three secondary indicators are set, totaling 15 secondary indicators.The specific indicators are shown in Table 1.

Table 1. Comprehensive evaluation index system for the transformation and upgrading level of manufacturing industry in Sichuan Province

Target Level	Primary Indicator	Code	Secondary Indicator Indicator	Explanation Indicator	Unit	Indicator Attribute

Construction of Evaluation Index System for the Level of Manufacturing Transformation and Upgrading Development in Sichuan Province	A1 Economic Development	B1	Production Status	Total Output Value of Manufacturing	million yuan	Positive Indicator
		B2	Operating Conditions	Total Profit of Manufacturing/Total Output Value of Manufacturing	%	Positive Indicator
		B3	Labor Productivity	Total Output Value of Manufacturing / Number of Employees in Manufacturing	10,000 yuan/person	Positive Indicator
	A2 Green Development	B4	Carbon Emission Intensity of Manufacturing Value	Total CO2 Emissions of Manufacturing / Gross Production	tons/10,000 yuan	Negative Indicator
		B5	Coal Consumption per Unit of Manufacturing	Output Value Coal Consumption of Manufacturing / Total Output Value of Manufacturing	tons/10,000 yuan	Negative Indicator
		B6	Electricity Consumption per Unit of Manufacturing	Output Value Terminal Electricity Consumption of Manufacturing / Total Output Value of Manufacturing	100 million kWh/100 million yuan	Negative Indicator
	A3 Innovation Drive	B7	Number of Authorized Invention Patents	Number of Valid Authorized Invention Patents in High-tech Industries	10,000 pieces	Positive Indicator
		B8	Investment in Scientific and Technological Manpower	Full-time Equivalent of R&D Personnel in Industrial Enterprises above Designated Size	person-years	Positive Indicator
		B9	Intensity of R&D Expenditure	R&D Expenditure of Manufacturing / Gross Production Value	%	Positive Indicator
	A4 Intelligent Manufacturing	B10	Employment of Intelligent Technology and Skilled Talents Average	Number of Employees in Computer, Communications, and Other Electronic Equipment Manufacturing / Number of Employees in Manufacturing	%	Positive Indicator
		B11	Output Value of Intelligent Manufacturing	Output Value of Computer, Communications, and Other Electronic Equipment Manufacturing / Output Value of Manufacturing	%	Positive Indicator

	B12	ntelligent Manufacturing B12 Revenue Generation from Intelligent Manufacturing	Total Profit of Computer, Communications, and Other Electronic Equipment Manufacturing / Total Profit of Manufacturing	%	Positive Indicator
A5 Network Informatization	B13	Internet Plus	Internet Broadband Access Ports	10,000 units	Positive Indicator
	B14	Number of Internet Users	Mobile Internet Users	10,000 households	Positive Indicator
	B15	Revenue of Communications Equipment	Total Volume of Telecommunications Business	100 million yuan	Positive Indicator

3.2 Model Construction

This paper chooses the entropy weight method as the research method to evaluate the level of transformation and upgrading of the manufacturing industry.

$$Z_i = \sum_{j=1}^{n} W_j \times P_{ij} \tag{1}$$

$$W_{\mathrm{j}} = \frac{1-e_j}{\sum_{j=1}^{n} 1-e_j} \tag{2}$$

In formula (2)

$$\mathrm{d}_j = 1-e_j \tag{3}$$

$$e_j = -\frac{1}{Lnm}\left(\sum_{i=1}^{m} P_{ij} \times LnP_{ij}\right) \tag{4}$$

$$P_{\mathrm{ij}} = \frac{Y_{ij}^{'}}{\sum_{i=1}^{m} Y_{ij}^{'}} \tag{5}$$

Formula (5) represents the proportion of the j-th indicator of the i-th evaluation object to the sum of all values of the j-th indicator;

$$Y_{ij}^{'} = Y_{ij} + 0.0001 \tag{6}$$

Positive Indicator:

$$Y_{ij} = \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})} \tag{7}$$

Negative Indicator:

$$Y_{ij} = \frac{\max(X_{ij}) - X_{ij}}{\max(X_{ij}) - \min(X_{ij})} \tag{8}$$

In formulas (7) and (8), the value of the i-th evaluation object in the j-th indicator is represented by (i=1, 2,...), m; j=1,2,……,n); Represents the maximum value of the i-th evaluation object in the jth indicator, and represents the minimum value of the i-th evaluation object in the jth indicator.

4 Empirical Analysis

Standardize the data, determine the weights of each indicator, and calculate the comprehensive score for each year and the mean of each primary indicator. The results are shown in the table 2.

Table 2. Score Table of Manufacturing Industry Transformation and Upgrading in Sichuan Province

Year	Economic Development	Green Development	Innovation Drive	Intelligent Manufacturing	Network Informatization	Comprehensive score
2008	0.0026	0.0021	0.0034	0.0029	0.0029	0.0139
2009	0.0040	0.0014	0.0035	0.0025	0.0053	0.0167
2010	0.0064	0.0031	0.0031	0.0023	0.0096	0.0245
2011	0.0083	0.0056	0.0017	0.0060	0.0029	0.0245
2012	0.0091	0.0049	0.0070	0.0114	0.0047	0.0371
2013	0.0089	0.0061	0.0085	0.0140	0.0065	0.0440
2014	0.0082	0.0071	0.0102	0.0162	0.0098	0.0515
2015	0.0077	0.0084	0.0127	0.0093	0.0139	0.0520
2016	0.0101	0.0095	0.0147	0.0109	0.0203	0.0655
2017	0.0135	0.0107	0.0191	0.0143	0.0200	0.0776
2018	0.0150	0.0120	0.0202	0.0137	0.0384	0.0993
2019	0.0152	0.0122	0.0227	0.0137	0.0551	0.1189
2020	0.0164	0.0124	0.0270	0.0182	0.0787	0.1527
2021	0.0212	0.0125	0.0314	0.0174	0.0274	0.1099
2022	0.0208	0.0127	0.0412	0.0167	0.0214	0.1128
Mean Value	0.0112	0.0080	0.0151	0.0113	0.0211	0.0667

From Table 2, the average scores of each primary indicator from 2008 to 2022 can be obtained. The ranking from high to low is network informatization, innovation driven, intelligent manufacturing, economic development, and green development. Among them, the score of economic development showed an initial increase and then a decrease before 2015, and after 2015, it basically showed a linear upward trend. In summary, this article can draw a development trend chart of the transformation and upgrading level of manufacturing industry in Sichuan Province from 2008 to 2022 (as shown in Figure 1).

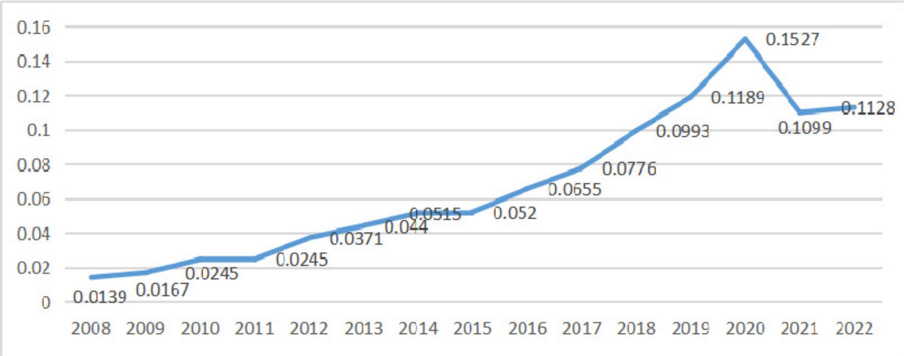

Fig. 1. Development Trend of Manufacturing Industry Transformation and Upgrading in Sichuan Province from 2008 to 2022

As depicted in Figure 1, the development trend of the manufacturing industry's transformation and upgrading in Sichuan Province generally exhibits a pattern of "two rises and one fall." From 2008 to 2015, there was a modest upward trend in the transformation and upgrading of Sichuan's manufacturing industry. This was attributed to the global financial crisis, which prompted enterprises to place greater emphasis on the domestic demand market, thereby accelerating the transformation of the manufacturing sector towards high quality and high value-added production. Concurrently, Sichuan Province increased investment in technological innovation during this period, leveraging both imported and independently developed new technologies to gradually shift its manufacturing sector from traditional manufacturing towards smart manufacturing, green manufacturing, and other innovative manufacturing modalities. Between 2016 and 2020, the transformation and upgrading of Sichuan's manufacturing industry experienced a significant surge, culminating in a peak in 2020.

5 Conclusion

This paper establishes an evaluation index system for the transformation and upgrading of Sichuan's manufacturing industry, encompassing economic development, green development, innovation drive, smart manufacturing, and cyber-informatization. Based on 2008-2022 data, the entropy weight method quantifies the transformation and upgrading process. Key findings indicate that cyber-informatization is the primary driver, followed by innovation drive, smart manufacturing, economic development, and green development.

With cyber-informatization accelerating, data security emerges as a challenge, necessitating investments in high-quality talent. Innovation drive remains crucial, while smart manufacturing is central. Economic stability across sectors is essential. Green development, though least impactful, is a vital focus under "dual carbon" goals, urging strategies for energy, industrial structures, and green technologies.

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References

1. Song Aifeng, Liang Huihui, Pan Langxuan. "Research on the Path of Green and Low-Carbon Transformation of Henan Province's Manufacturing Industry Driven by the 'Dual Carbon' Strategy" [J]. Journal of Zhongzhou University, 2023, 40(02).
2. Ji Li. Research on the Measurement and Influencing Factors of China's Manufacturing Industry Transformation and Upgrading under the Background of Low Carbon [D]. Harbin University of Commerce, 2023.
3. Xu Hong. "Research on the Path of Green Transformation of China's Manufacturing Industry under the Goal of 'Dual Carbon'" [J]. Enterprise Science and Technology & Development, 2023(08): 10-12+32.
4. Na Dandan, Li Ying. "Research on Influencing Factors of Manufacturing Industry Transformation and Upgrading" [J]. Study & Exploration, 2020(12): 130-135.
5. SchiPPer L,Murtishaw S,Khrushch M.Carbon emissions from manufacturing ergyusein13 IEA eountries: Long-term trends through 1995[J].Energy Poliey,2001,(29):667-688.
6. Ullah, A., Raza, K. & Mehmood, U. The impact of economic growth, tourism, natural resources, technological innovation on carbon dioxide emission: evidence from BRICS countries. Environ Sci Pollut Res 30, 78825–78838 (2023).
7. Li Chunlin, Li Jingyi. Empirical Analysis of Influencing Factors of Manufacturing Industry Transformation and Upgrading [J]. Market Modernization, 2020(20): 127-129.
8. Qu Xiaoyi, Lu Ping, Wang Hongxia, et al. Empirical Analysis of the Impact of R&D Investment on the Transformation and Upgrading of China's Traditional Manufacturing Industry [J]. Statistics and Decision, 2020, 36(05): 120-123.
9. Liu Shuping. Research on the Mechanism and Path of "Internet+" Promoting Manufacturing Industry Upgrading [D]. Zhongnan University of Economics and Law, 2019.

10. Liao Anyong. Research on the Path of Manufacturing Industry Transformation and Upgrading in Northeast China [D]. Northeast Normal University, 2022.
11. Zhang Yujun. Research on the Green Transformation and Upgrading of Manufacturing Industry in Shandong Province under the "Dual Carbon" Goals [D]. Shandong Provincial Party School of the Communist Party of China, 2023.
12. Ma Mingyu. Research on the Transformation and Upgrading of Manufacturing Industry in Shaanxi Province under the Background of 'Dual Carbon' Goals [D]. Lanzhou University of Finance and Economics, 2023.
13. Xu Hong. Research on the Path of Green Transformation of China's Manufacturing Industry under the "Dual Carbon" Goals [J]. Enterprise Science and Technology & Development, 2023(08): 10-12+32.