Strategy for Improving the Quality of Manufacturing in Jiangsu Province During the Thirteenth Five Period

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***Abstract* — The Jiangsu manufacturing sector is characteristic of large-scale operations with good foundations, but, compared to other developed provinces in China, the proportion of high-tech industries in Jiangsu is relatively low. Here, by investigating the overall quality of manufacturing in Jiangsu Province during the Twelfth Five-year period, the Jiangsu manufacturing sector is shown to have developed quickly, but there are still problems, such as a weak foundation for the management of the quality of businesses and an imperfect quality service system. Using information collected from the United States, Japan, and Germany, key strategies including brand development, establishment of a strong foundation for manufacturing quality, and innovation-driven improvements in manufacturing quality and management are proposed and should be actively implemented in the Jiangsu manufacturing sector. This may improve the quality of manufacturing in Jiangsu during the Thirteenth Five-year period.**

Keywords - Quality upgrading; Jiangsu manufacturing sector; Strategy; Thirteenth Five-year Plan

I. INTRODUCTION

Jiangsu Province is currently transitioning from a middle-late industrial economy to a service economy. From the perspective of global industrial division of labor, the industrial structure of Jiangsu Province is still on the low end of the industrial chain. Upgrading product quality in the manufacturing sector of Jiangsu is an important means of promoting economic restructuring, and it is one primary objective in the realization of innovation-driven strategy. Analysis and assessment of the overall level of the manufacturing sector in Jiangsu Province during the Twelfth Five-year period her forms the foundation and premise of the present studying and of the strategy for improving manufacturing quality.

II. OVERALL MANUFACTURING SECTOR QUALITY IN JIANGSU PROVINCE DURING THE TWELFTH FIVE-YEAR PERIOD

A. Steady increase in the manufacturing competitiveness index (MCI)

According to Figure 1.(the national manufacturing quality and competitive analysis report), released by General Administration of Quality Supervision, Inspection, and Quarantine (AQSIQ) in August 2014, in 2013, the MCI of Jiangsu Province was 88.64, placing it fifth in the country, higher than the national average (83.14) and the average of the Eastern Region(86.52). Since 2005, AQSIQ and the National Bureau of Statistics have been jointly issuing annual manufacturing competitiveness indices, including two second-level indicators (quality level and development capacity), six third-level indicators (standards and technical level, quality management level, quality supervision and inspection level, research and development and technological innovation capability, core technical capability, and market adaptability).

With regard to the changes in MCI over time (as shown in Figure 2.), since 2008, the MCI of Jiangsu Province has shown an overall steady upward trend, increasing from 86.95 in 2008 to 88.64 in 2013, by 1.69% [1].

B. Continuous improvement in the level of business quality management

Due to efforts to become a province with high quality products, the quality of Jiangsu businesses has continued to improve. By the end of 2014, three companies in Jiangsu have won the China Industry Award, and 14 companies have won the National Quality Award. In 2014, three businesses, including Xugong Group Construction Machinery Co., Ltd., won the National Quality Award. This was the first time that Jiangsu Province ranked first in the number of businesses receiving this award.

C. Positive progress in industrial standardization

As of October 2014, Jiangsu Province has 14 established national-level and 65 provincial-level standardized circular economy pilot projects, of which seven national-level and 24 provincial-level pilot projects have passed inspection; there have been 78 provincial-level standardized high-tech

innovation pilot projects, of which 45 have passed inspection; there have been 125 provincial-level standardized strategic emerging industry pilot projects, of which 48 have passed inspection [2].

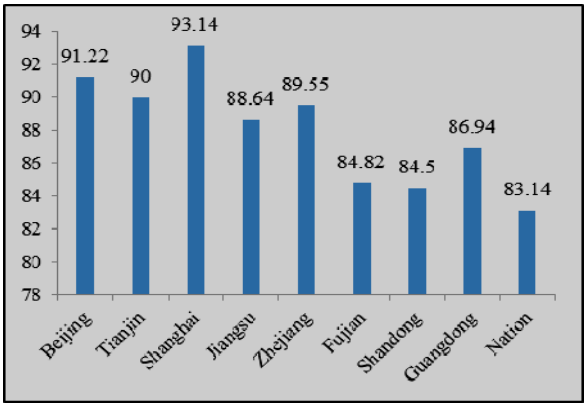

Figure 1. National and major cities' manufacturing competitiveness indices in 2013

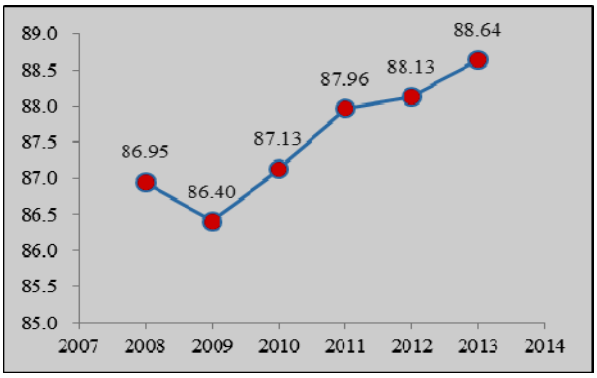

Figure 2. Changes in the manufacturing competitiveness index of Jiangsu Province since February 2008

D. Steady progress in the establishment of the quality credit system

In 2014, there were 100 newly established AA grade industrial quality credit businesses and 40 newly established AAA grade businesses in Jiangsu. In some industries, Jiangsu has taken a leading position in the country. For example, in 2013, a total of 60 pharmaceutical businesses were granted the name of quality credit companies in China, and, among these, 27 businesses are located in Jiangsu, accounting for nearly half of the total.

E. Gradually notable effectiveness of the trademark brand strategy

Since the start of the Twelfth Five-year plan, Jiangsu Province has vigorously promoted the trademark brand strategy. As of the end of 2014, 564 famous trademarks from Jiangsu Province have been approved by the State Administration For Industry and Commerce (SAIC). In this way, Jiangsu has assumed a leading position in the country. Table 1 shows the progress that has been made in the area of industrial product quality and intellectual property rights (IPR) in Jiangsu Province.

TABLE I. PROGRESS IN QUALITY OF INDUSTRIAL PRODUCTS AND INTELLECTUAL PROPERTY RIGHTS IN JIANGSU PROVINCE

item	2012	2013	2014
Provincial key projects on research of product quality	1	1	5
Industrial product quality control and technical evaluation laboratories	8	8	16
China Industry Award	1	1	3
National Quality Award	9	11	14
Industrial cluster and regional brand construction pilot projects	—	—	3
National quality benchmarks designated by the Ministry of Industry and Information Technology	1	4	6
Brand Development Demonstration (pilot) Businesses designated by Ministry of Industry and Information Technology	15	46	152
Brand Development Demonstration Businesses designated by Ministry of Industry and Information Technology	6	6	12
Cultivation of the intellectual property rights of pilot businesses designated by Ministry of Industry and Information Technology	16	91	143

F. Orderly advances in key areas of research on product quality

Jiangsu provincial plan for organizing and implementing tender projects on research of product quality in key areas has been issued. Four fields, industrial robots, ultra-high-speed elevators, rail transportation equipment, and advanced treatment of sewage and sludge, have been identified as the provincial key areas of quality-related research. In 2014, specific tasks in two fields, industrial robots and high-speed elevators, have been assigned. Provincial financial subsidies of 14,850,000 RMB have been allocated, and various research projects are progressing smoothly as scheduled.

III. ASPECTS OF MANUFACTURING QUALITY IN JIANGSU PROVINCE THAT CURRENTLY NEED IMPROVEMENT

A. Lack of social structure for co-governance of quality

For some local governments, the work on quality improvement is merely a matter of formality. Reinforcement in quality regulations is weak, and various departments have not properly performed their supervisory duties [3]. For most small and medium-sized businesses (SMEs), the main responsibility for the quality management has not been established, and corporate self-regulation [4] is weak. Industrial organizations have not fully played their roles in quality improvement or in the guiding of businesses.

B. Weak foundation for management of business quality

First, the level of business standardization is less than satisfactory. The ability of businesses to participate in the formulation and revision of international standards, national standards, and industrial standards are still weak. Second, internal quality management is lax. Businesses pay attention to the management of problems after the fact, rather than on preventing problems in advance. As a result, product quality cannot be guaranteed. Third, brand awareness is weak. Some companies do not pay attention to and are not good at product promotion or market development and fail to establish brand advantage or market advantage [5]. Fourth, the businesses are short of qualified quality care professionals, and this restricts the improvement of product quality and business efficiency.

C. Imperfections in the quality service system

Testing and inspection services are poorly concentrated in management. Rather, a competition pattern including a large number of small-scaled organizations is formed. Some measurement technology institutions lack qualified testing professionals [6]. Other testing teams are aging; some equipment is out of date, and these impediments to testing limit inspection capabilities and service capacity.

D. Weak quality of SMEs, which are numerous and cover a wide range of areas

Quality management of SMEs is not strong, and the constructions of their quality management, measurement, testing, and standardization systems are not yet complete. Problems include the following. First, SMEs do not pay sufficient attention to quality management. Second, product quality is unstable. Third, in some SMEs, intentional fraud, production, and sales of fake and shoddy products, and other illegal violations are still too common.

IV. EXPERIENCE AND INSIGHT INTO MANUFACTURING QUALITY IMPROVEMENT IN FOREIGN COUNTRIES

United States, Germany, and Japan, are home to the world's three leading manufacturing sectors, and they affect globalization considerably. Analyzing the cumulative improvements made to the quality of manufacturing in these three countries may help to serve a reference for manufacturing quality improvement in Jiangsu Province.

A. Manufacturing sector in the United States – novelty

The invention and wide application of new technologies provides a powerful impetus for the development of the U.S. manufacturing sector. Improvements in the management techniques further reduce production costs and enhance product competitiveness, directly contributing to the rise of the U.S. manufacturing sector. Meanwhile, in order to protect technological research and innovation, the U.S. government has taken a series of positive patent-based measures, such as increasing the number of examiners in the Patent Office, simplifying the patent review process, and transferring management of the patent bureau from the Ministry of Interior Affairs to the Ministry of Commerce. These changes in patent policies have improved the efficiency of patent application and review. Regarding the internal management of businesses, leading U.S.-based manufacturing companies usually employ a team of experts who specialize in internal quality management and research and in self-designed and developed quality management systems. Because of these specialized personnel and systems, the businesses can ensure that the production process and the quality level are maintained at a leading position.

B. Manufacturing sector in Japan – cost-efficiency

Japanese-made products are world-famous for their high quality, durability, and high price-performance ratio. "To produce the same product with the world's lowest cost" was a slogan of the Japanese business community from more than 20 years ago. Lean production (LP) is a praise term for the Japanese Toyota Just-In-Time (JIT) manufacturing philosophy proposed by several international motor vehicle program (IMVP) experts from the Massachusetts Institute of Technology. In the U.S., LP has two meanings. The first meaning is the production of a small number of essential products. This keeps investments in production efficient. Only at the appropriate time is a necessary amount of product produced, and then only to meet urgent market demands (though intermediate products may also be made in preparation for the next step of production). The second meaning is that all operations must be beneficial, effective, and economical. This interpretation of LP implementation is the pursuit of perfection. In quality management, the Japanese companies have tirelessly committed to improving methods of quality management and they have developed statistical quality control (SOC) methods originating from

U.S. into total quality management (TQC). In practice, the industry standard is to keep the defective rate below a certain level. Japanese businesses, especially well-known businesses with good reputations, require their products to be perfect. Japanese-style TQM has been developed under the idea of zero defects.

C. Manufacturing sector in Germany – precision

"Made in Germany" has the following four basic features: durability, reliability, safety, and precision. That has made the label an enduring symbol, and maintaining a leading position in the era of globalization is mainly due to the protection from three German systems. The first system is the science and technology innovation system. The strong vitality of the "Made in Germany" brand relies heavily on the fact that many German products involve leading technology. The second system is the standardization and quality certification system. Germany has long implemented stringent industrial standards and quality certification, which contribute substantially to the leading position of the German manufacturing sector in the world. Two-thirds of the machinery manufacturing standards in the world come from the Deutsches Institut fur Normung (DIN) in Germany. It is fair to say that Germany is the birthplace of the world's industrial standardization. DIN [7] standards cover machinery industry, chemical industry, automotive, service industry and all other industrial categories. It contains more than 30,000 standards. The third system is the dual-track vocational education system. The success of the "Made in Germany" brand could not have been achieved without high-level technical workers.

V. EMPIRICAL ANALYSIS OF JIANGSU MANUFACTURING QUALITY

A. Empirical analysis

(1) Data sources. Data collected from Jiangsu Province Enterprise Technology Center include 1052 different large, medium, and small businesses, and the sample size was large. As of the time of sampling, businesses were mainly concentrated in the machinery industry, which accounted for 43.2% of all businesses. The next largest group was that of businesses in chemical industry, 12.7%. There were 111 businesses in light industry, accounting for 10.6% of all businesses. In terms of size, the businesses 100–300 million RMB in size made up the largest group of businesses, accounting for 34.6% of the total. There were 243 businesses 300–500 million RMB in size, accounting for 23.1% of the total. Descriptive statistics regarding the distribution of these businesses in different industries are given in Table 2.

(2) Calculation of factor scores. SPSS19.0 software was used for data normalization. After normalization of the sample indicators, the mean value was 0 and the variance was 1. Sample testing showed the sample size to be sufficiently large to conduct factor analysis for comprehensive assessment of the development in quality of manufacturing businesses. The factor score coefficient matrix of various corresponding indicators after normalization is shown in Table 3.

TABLE II. ESCRIPTIVE STATISTICS ON BUSINESSES IN DIFFERENT INDUSTRIES

businesses /industry category	number	percentage
Electronics industry	102	9.7%
Textile industry	80	7.6%
Chemical industry	134	12.7%
Machinery industry	454	43.2%
Building materials industry	18	1.7%
Pharmaceutical industry	62	5.9%
Petrifaction industry	10	1.0%
Metallurgical industry	41	3.9%
Nonferrous metals industry	22	2.1%

TABLE III. FACTOR SCORE COEFFICIENT MATRIX

	main factor			
	1	2	3	4
Relative number of businesses acquiring brand names X1	0.092	0.599	-0.386	0.003
Standard ratio of businesses hosting and participating X2	-0.077	0.733	0.286	0.016
Sales growth rate X3	-0.007	0.014	-0.026	0.995
Proportion of funding for research and experimental development X4	0.710	-0.024	-0.202	-0.067
Proportion of personnel engaged in research and experimental development X5	0.558	0.015	0.146	0.058
Output rate of new products X6	-0.024	0.055	0.822	-0.026

From the factor score coefficient matrix, the following can be found:

$$F_1=0.092ZX_1-0.077ZX_2-0.007ZX_3+0.710ZX_4+0.558ZX_5 -0.024ZX_6 \quad (1)$$

$$F_2=0.599ZX_1+0.733ZX_2+0.014ZX_30.024ZX_4+0.015ZX_5 +0.055ZX_6 \quad (2)$$

$$F_3=-0.386ZX_1+0.286ZX_2-0.026ZX_3-0.202ZX_4 +0.146ZX_5+0.822ZX_6 \quad (3)$$

$$F_4=0.003ZX_1+0.016ZX_2+0.995ZX_3-0.067ZX_4 +0.058ZX_5+0.026ZX_6 \quad (4)$$

Here, Z represents the normalizing constant.

Finally, the weighted total of the four main factors is calculated. The weight is set to the ratio of the contribution rate of the main factor in explaining the total information to the contribution rate of total variance. The factor model established is as follows:

$$F=0.280F1+0.252F2+0.240F3+0.227F4 \quad (5)$$

After normalization, data were substituted into F1, F2, F3, and F4 to calculate the integrated evaluation scores on the quality development level of the 1052 businesses. In addition, in order to facilitate intuitive understanding, integrated evaluation scores were converted to percentages using to the following formula:

$$Y' = \frac{Y}{Y_{\max} - Y_{\min}} \times 40 + 60 \quad (6)$$

B. Overall quality of Jiangsu manufacturing

With the methods described above, the estimated overall quality of Jiangsu manufacturing was 58.236 in 2012. Distribution of businesses in different score ranges is shown in Figure 3. Figure 4 plots the score distribution, showing the mean and variance values. Overall the pattern fit a normal distribution, in line with the general law for distribution of a large number of independently observed samples in statistics.

Based on this sample distribution structure, corresponding criteria were set for grading the quality development levels. There are a total of four categories, A, B, C, and D. Category D includes scores lower than 50, representing poor quality; C includes scores between 50 and 60, representing medium quality; B includes scores between 60 and 70, representing relatively high quality; A includes scores above 70, representing high quality.

As shown in Table 4, 50% of the businesses examined had a score below 60 points, meaning that their quality levels were medium, and there was considerable room for improvement.

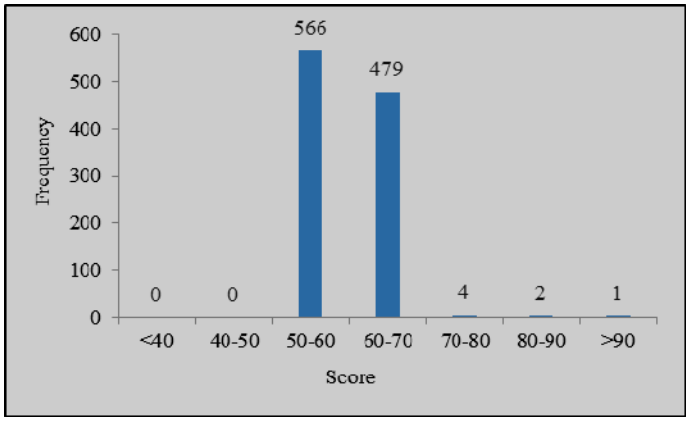

Figure 3. Distribution of businesses in different score ranges

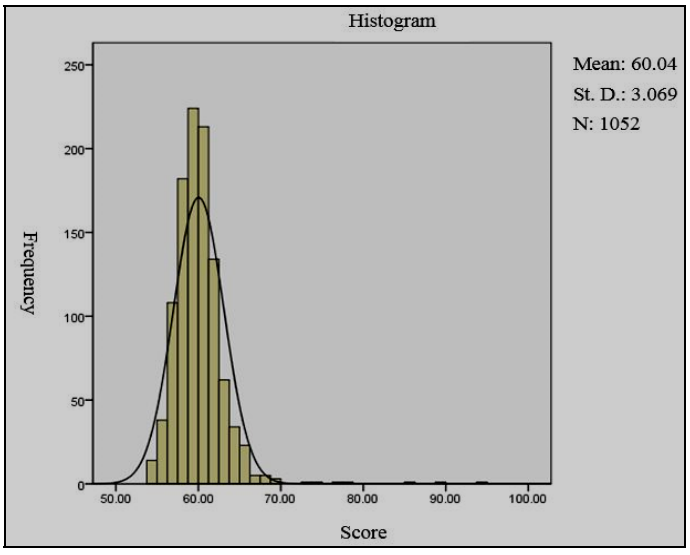

Figure 4. Quality development levels of businesses in the manufacturing sector

TABLE IV. DISTRIBUTION OF BUSINESS QUALITY DEVELOPMENT IN JIANGSU PROVINCE

level		score	number of businesses	proportion
A	High quality	Over 70 points	7	0.7%
B	Relatively high quality	60–70 points	479	45.5%
C	Medium quality	50–60 points	566	53.8%
D	Low quality	Below 50 points	0	0%

With regard to the scores of different factors in the evaluation model, overall manufacturing businesses in Jiangsu Province showed satisfactory levels of quality performance and technical output capacity, but substantial improvements can still be made in availability of technical resources and foundation for quality development (Figure 5).

C. Quality assessment in different sectors

From the perspective of difference between different industries, the quality development levels of businesses in emerging industries are relatively high (Table 5). For example, for businesses in the pharmaceutical and electronics industries, the weighted total scores were both above 60. For these two industries, the score on the factor of availability of technical resources and that on the factor of technical output capacity are rather high. In comparison, for businesses in traditional labor-intensive industries, such as metallurgical industry, light industry 2, and textile industry, the overall level of quality development is relatively low.

TABLE V. SUMMARY OF BUSINESS QUALITY DEVELOPMENT IN DIFFERENT INDUSTRIES

	availability of technical resources	foundation for quality develop-ment	technical output capacity	quality perfor-mance level	wei-ghted score
Electro-nics industry	60.54	59.04	60.91	59.89	60.15
Textile industry	58.70	59.17	57.46	59.90	57.26
Chemical industry	58.65	59.08	58.15	59.89	57.47
Machinery industry	59.09	59.13	60.44	59.90	58.88
Building materials industry	58.74	59.96	59.14	59.92	58.54
Pharmaceu-tical industry	61.37	59.89	60.09	59.77	60.84
Petrifac-tion industry	59.08	58.98	60.21	60.01	58.57
Metallurgi-cal industry	58.20	58.46	57.76	59.88	56.57
Nonferr-ous metals industry	58.41	59.24	61.36	59.83	58.76
Light industry 1	58.46	59.00	60.41	59.90	58.29
Light industry 2	58.17	59.03	58.30	59.90	57.14

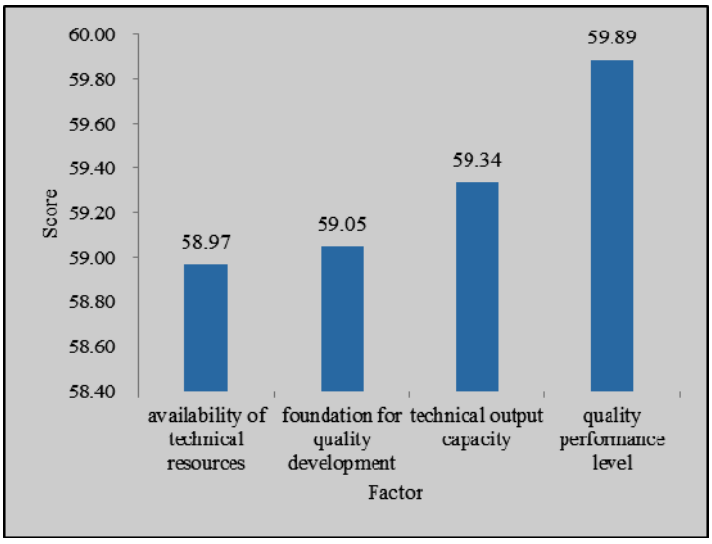

Figure 5. Overall levels of different factors in the evaluation model

VI. KEY STRATEGIES FOR UPGRADING MANUFACTURING PRODUCT QUALITY IN JIANGSU PROVINCE DURING THE THIRTEENTH FIVE-YEAR PERIOD

A. Implementing the Jiangsu manufacturing brand strategy

First, corporate brand building needs to be promoted. This includes enhancing advanced manufacturing brands, cultivating modern service brands, and optimizing brands in traditional industries. The second is to promote regional brand building. Objectives and supporting policies for regional brand development need to be clarified to accelerate the transformation from industrial clusters to brand clusters. Regional brand promotion and protection should be strengthened [8].

B. Implementing the strategy of strong foundation for manufacturing quality

First, the industrial quality system needs to be improved. This includes deepening the construction of the mechanism [9] for cooperation between businesses, research institutes and universities, strengthening in-depth integration between industrialization and informationization, comprehensively promoting the applications of intelligent manufacturing equipment and systems, and constructing industrial technology quality systems. The second is to strengthen the establishment of product quality-related human resources and internal structure within businesses, and fully implement the chief quality officer system. Third, advanced management concepts and methods need to be actively promoted. This should be carried out on three levels: quality control methods, quality improvement methods, and quality strategy assessment. Fourth, the level of product quality should be improved. The industrial processes and equipment need to be optimized to strengthen quality assurance in the production process, and the level of quality management level needs to be improved.

C. Implementing the innovation-driven quality improvement strategy

First, research needs to be done to formulate a guiding opinion on Jiangsu manufacturing quality restructuring and upgrading. The specific goals, key areas, and supporting policies with regard to the restructuring and upgrading of Jiangsu manufacturing must be clarified. Second, construction of supporting carriers for quality improvement needs to be strengthened. In fields such as new materials, new energy sources, and equipment manufacturing, a number of high-level national and provincial key laboratories should be established to form a distribution pattern for local and regional center laboratories with distinctive features and proper layout. The construction of resource sharing platforms needs to be promoted. Third, IPR protection in the field of quality technology innovation should be strengthened. IPR risk control and early warning mechanisms in the field of key industries need to be improved, and the fight against quality-related counterfeiting needs to be strengthened.

D. Implementing the strategy of enhancing quality in special fields

First, research on product quality in key areas should continue to be promoted. The focus should be on improving the quality of intelligent manufacturing equipment, and to improve technology, quality management, and the overall product quality. The second is to improve the quality standards system. Businesses in new materials, equipment manufacturing, building materials, electronic information, light-emitting diode (LED), bio-pharmaceutics, and the chemical industry should be encouraged to participate in the formulation of international standards, national standards, industry standards, and local standards [10].The work on industry standardization pilot projects should continue, and circular economy standardization pilot projects should be improved. For all businesses, the construction of an internal standard system should be strengthened. Third, the supporting measurement basis needs to be improved. This includes stimulating businesses to strengthen the establishment of measurement infrastructure, metrology laboratories, and measurement control centers and improving the measurement and management system.

E. Implementing the strategy of developing business quality management systems

Businesses need to play a leading role in this part of the processes. They should define quality objectives and responsibilities, establish a sound, fully-staffed, comprehensive, whole-process quality system, and ensure its effective operation. Second, a quality responsibility system needs to be implemented. It needs to be established that the corporate legal representative or the person in charge assumes the primary responsibility for quality and safety, and the enterprise quality executives assume a direct responsibility for quality and safety. Third, organizational leadership should be strengthened. Jiangsu Province needs to improve overall planning and organizational leadership, targeting improvements in product quality in the manufacturing sector, improve quality assessment and the methods by which it is evaluated, and promote in-depth execution of quality-related tasks. Fourth, policy support [11] needs to be strengthened. Supporting policies and measures that promote the development of manufacturing industries need to be formulated in order to strengthen policy support in the environment, technology, finance, taxation, and he training.

VII. CONCLUSION

In the 13th five-year development planning, Jiangsu's manufacturing industry quality upgrading strategy clarifies future development direction, objectives, and requirements. In addition, it puts forward specific strategic measures. It is critical to improve the overall quality of the manufacturing industry in Jiangsu Province, as well as promoting industrial transformation and upgrading.

ACKNOWLEDGMENT

This work is supported by Jiangsu Economic and Information Technology Commission and Jiangsu Quality Management Association. Also thanks to the Business School at Nanjing University for their help.

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