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Green Development Policies for China's Manufacturing Industry: Characteristics, Evolution, and Challenges

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Abstract: Since the start of the industrial revolution, the manufacturing industry has been essential for economic growth but has also contributed to environmental pollution problems. The United Nations declared the 2030 Sustainable Development Goals (SDG) agenda to make sure that the well-being of the global environment is taken care of alongside the expansion of the world economies. As the leading manufacturing country worldwide, studying the evolution of China's green development policies in manufacturing has significant implications for pollution management in manufacturing in other countries. This research analyzes China's legal and policy documents on green development in the manufacturing industry based on planning objectives and actual effects with qualitative content analysis. It divides them into four periods: the exploring period (1949–1977), the formal establishment period (1978–2001), the improvement and strengthening period (2002–2011), and the comprehensive improvement period (2012 to present). Although the Chinese government has made progress in implementing green development policies, it still faces many challenges: (1) compatibility between economic development and environmental protection needs to be strengthened; (2) primarily command-and-control based policy structure needs to be reformed; (3) collaboration of multi-departmental management system needs to be enhanced. These challenges are the primary obstacles to China's manufacturing industry achieving its environmental goals. The future policies for the green development of the manufacturing industry should focus on three aspects: (1) aligning environmental and manufacturing policies in setting strategic objectives and benchmarks; (2) concentrating on the systemic nature of policies and the interdependence of policy tools; (3) enhancing processes for policy creation, implementation, monitoring, and evaluation.

Keywords: manufacturing; green development; policy evolution; characteristics

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1. Introduction

As a result of the industrial revolution and the realization of mass production, the level of human society's productivity increased dramatically, but at a tremendous ecological and environmental cost, which was not brought by industrialization, but arose during industrialization. Tang et al., (2022) found that during the stage of extensive economic development, there was a positive linear relationship between the economic growth rate and carbon emissions [1]. After industrialization, more countries and regions joined the industrialization process, and ecological and environmental problems, such as large-scale energy waste, water pollution, air pollution, and solid waste pollution, have become more severe. However, it is believed that the process of industrialization is an inevitable path of development [2]. Developed countries, including the United Kingdom and France, are often seen as prioritizing economic development over ecological concerns, despite the increasing environmental issues [3]. Lin and Xu (2018–2020) argue that China is currently undergoing rapid industrialization. However, due to the lack of scientific planning, environmental awareness, and effective regulation, this century of industrialization in China has led to

severe ecological problems, particularly in relation to the "three major sources of pollution": oil, coal, and iron and steel [4–6].

It is crucial to address the ecological and environmental challenges brought about by industrial civilization [7]. In recognition of the need to address ecological and environmental challenges, the United Nations has introduced the 2030 SDG agenda. This agenda aims to ensure that global environmental well-being is prioritized alongside economic growth [8,9]. Sustainable development is required to achieve the coordinated growth of the economy, society, and environment [10]. The traditional theory of industrialization, which contends that there is a contradiction between economic development and environmental protection and that the environment must be sacrificed to achieve economic growth, emerged after the Industrial Revolution and is regarded as a defining characteristic of industrial societies [3]. Its primary flaw is that it disregards the significance of the ecological environment to the economic system. Green development is a pathway and approach to achieving sustainable development. It involves promoting green technological innovation, improving resource efficiency, reducing environmental pollution, and mitigating carbon emissions. Silent Spring's 1962 publication prompted the 1972 United Nations Conference on the Human Environment in Stockholm, Sweden, where the Declaration on the Human Environment was co-sponsored [11]. The European Environment Forum was held in Paris in September 1974, the International Green Economy Conference was held in the United States in 1978, and the High-Level Forum on Global Environment and Development was held in Paris in March 1981. The implementation of these conferences and forums has promoted green development with a solid intellectual foundation and policy environment.

Deindustrialization, which refers to the decreasing share of manufacturing in total employment and industrial output, is another significant factor supporting green development [12,13]. Industrialized countries were among the first to propose green development [14].

In industrially developed countries, they have shifted their products to certain developing countries in pursuit of higher returns and to avoid environmental pressure. It is worth noting that while some industrialized countries have shifted their production to developing countries, this has led to the relocation of low-value-added and highly polluting industries or production processes. As a result, the human living environment in these countries has undergone significant improvements, benefiting from the exploitation of the first-mover advantage [15]. The industrialization of developing countries accelerated significantly in the 1970s and 1980s, but their ecosystems were more affected than those of developed countries [16,17]. This characteristic is due to the concentrated development of high-consumption and high-polluting industries in the short term; in addition, the limitations imposed by the level of economic development of developing countries and their poor ability to control the environment have made them relatively backward in energy and environmental applications [18]. Based on an in-depth examination of the Kuznets curve in developed countries, scholars have put forth various suggestions to mitigate the challenge of simultaneous resource depletion and environmental quality deterioration in future developed countries [19].

China, as the largest manufacturing country that has surpassed the United States for 11 consecutive years, has gradually formed and improved its manufacturing system and achieved rapid growth of its industry by receiving an industrial transfer from developed countries. However, it also faces serious environmental problems [20]. China is currently shifting its development paradigm away from a sole focus on GDP towards a more sustainable and environmentally conscious path. This transition aims to strike a balance between economic growth and ecological preservation, ultimately fostering an ecological economy [21].

Based on the above background, this study attends to SDG-7, 12, and 13 [22]. SDG-7 focuses on providing clean energy, which is vital for combating climate change (SDG-13) through reducing greenhouse gas emissions [23]. SDG-12 complements these efforts by promoting sustainable consumption and production patterns that help minimize environ-

mental impacts. Together, these goals promote a holistic approach to addressing energy, climate, and other environmental challenges for a sustainable future. Exploring the evolution of China's green development policy in the manufacturing sector is significant not only in understanding how China has enhanced its use of renewable energy and addressed climate concerns but also in examining the measures implemented to address other environmental challenges.

This research's objectives are as follows: (1) to describe the necessity for green development in manufacturing; (2) to comprehend the evolution of green development policies in manufacturing in China; (3) to identify the evolutionary characteristics of green development policies in manufacturing in China; (4) to identify the challenges of green development policies in manufacturing in China; and (5) to explore the prospects of green development policy for China's manufacturing industry. By analyzing the evolution of China's manufacturing green development policy, it is possible to provide suggestions to policymakers for achieving an eco-economy. It can also serve as a resource for policymakers in other countries. Additionally, China's policy roadmap of green development policies in manufacturing can provide a reference for other countries.

2. Intensified Environmental Pressure from the Development of Manufacturing Industry

Manufacturing is one of the industries with a high proportion of environmental pollution, so it is unavoidable for the Chinese government in formulating a green development policy for manufacturing in response to the growing demand for better quality of life. We have structured our analysis from two dimensions: global and China, and from the perspective of manufacturing development and pollution. Through comparative analysis, we aim to demonstrate the necessity of formulating policies for promoting green development of manufacturing.

2.1. Rapid Expansion of the Manufacturing Industry

2.1.1. Growth of the Global Manufacturing Industry

From a global perspective, global manufacturing value-added distribution is more concentrated, and the development gravitational center is primarily concentrated in a few countries, such as Europe, the United States, Japan, and China. From 2004 to 2021, even after the global financial crisis, the global manufacturing value added has been overgrowing since 2000. Following a temporary decrease in 2009, the global manufacturing value experienced a resurgence and began to rise again in 2010, as indicated in Figure 1. Even some deindustrialized countries, such as Germany and France, realized the negative impact of deindustrialization after the global financial crisis and started to pay attention to the development of the manufacturing industry, increasing manufacturing value added.

As shown in Figure 2, the development of the global manufacturing industry is more stable, and the manufacturing industry's contribution to global GDP continues to decline. In 2020, a new epidemic of crown pneumonia spread, the global economy contracted, and in 2021, the proportion of global manufacturing value added to GDP rose. Germany has resisted the wave of "deindustrialization", insisting on high-end and specialized development, and has maintained its status as a manufacturing power for many years. Japan's manufacturing industry has remained at roughly 20% of GDP for a similar period. Japan's manufacturing industry as a whole is experiencing a decline, but it remains the leading industry overall. The US manufacturing sector's contribution to GDP has decreased from 28.3% in 1953 to 11.19% in 2021, but it still exerts considerable global influence. While manufacturing demand in some countries is growing slowly, expanding demand from a wide range of other countries, such as China and India, provides a significant impetus for global manufacturing growth [24].

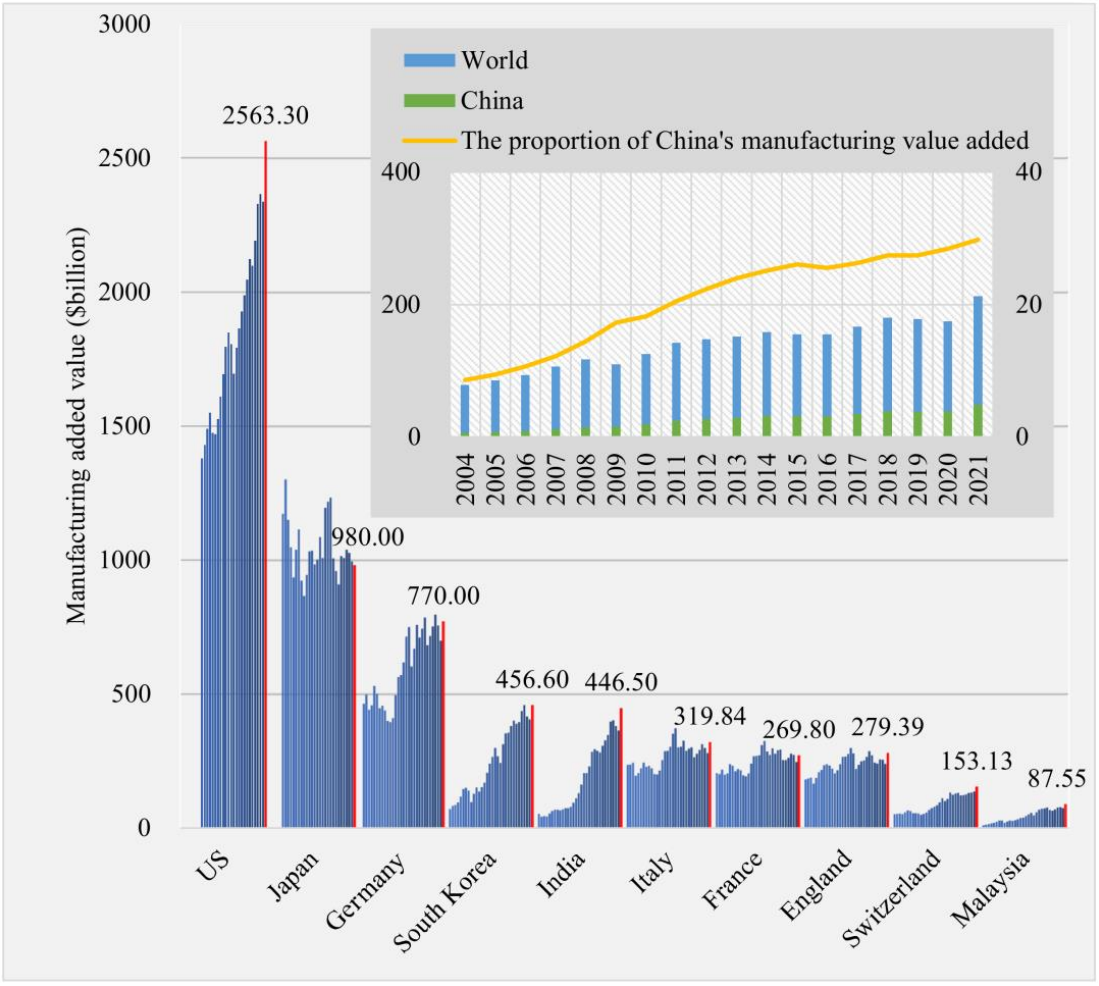

Figure 1. Manufacturing value added in significant manufacturing countries from 2004 to 2021. Data Description: The red line refers to data for 2021.

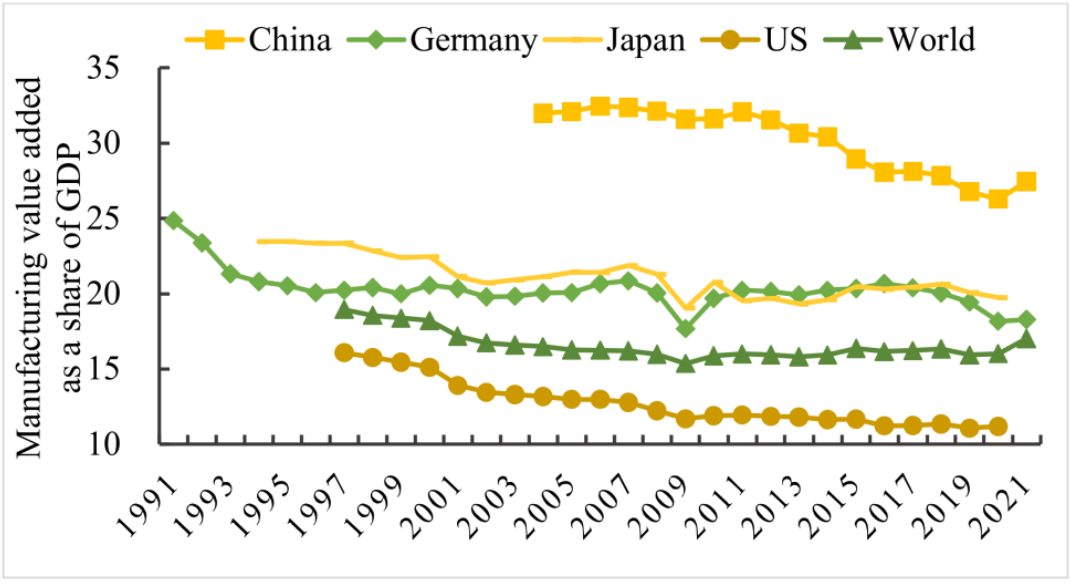

Figure 2. Global manufacturing value added as a share of GDP (%).

2.1.2. Growth of China's Manufacturing Industry

China's manufacturing industry has been expanding at an astounding rate, and its size has remained the largest in the world for many years, serving as an irreplaceable driving force in China's economic development and international competition participation. Since its reform and opening up (1978), the rapid development of China's manufacturing industry has pushed the economy and income level up continuously, propelling the country from a low-income to middle-income status, establishing the world's most stable and complete manufacturing system, and playing an irreplaceable role in the international division of labor.

China's manufacturing value added accounts for 27.7% of its GDP in 2022 [25] and 29.76% of global manufacturing in 2021. As depicted in Figure 3, the global share of China's manufacturing value increased dramatically from 2009 to 2021, with China's manufacturing value added accounting for nearly 30% of global GDP in 2021 and ranking first, followed by the United States, Japan, and Germany. China's manufacturing value added reached 27.4% of GDP in 2021, an increase of 1.1 percentage points from the previous year, achieving positive growth for the first time in a long time. This is partly attributed to China's manufacturing sector experiencing rapid growth, with a significant increase in China's exports as a proportion of global exports. Additionally, the containment of the epidemic and the rise of advanced manufacturing, which encompasses high-tech industries such as information technology and upgraded traditional manufacturing industries through advanced technology and management practices, have also played a role.

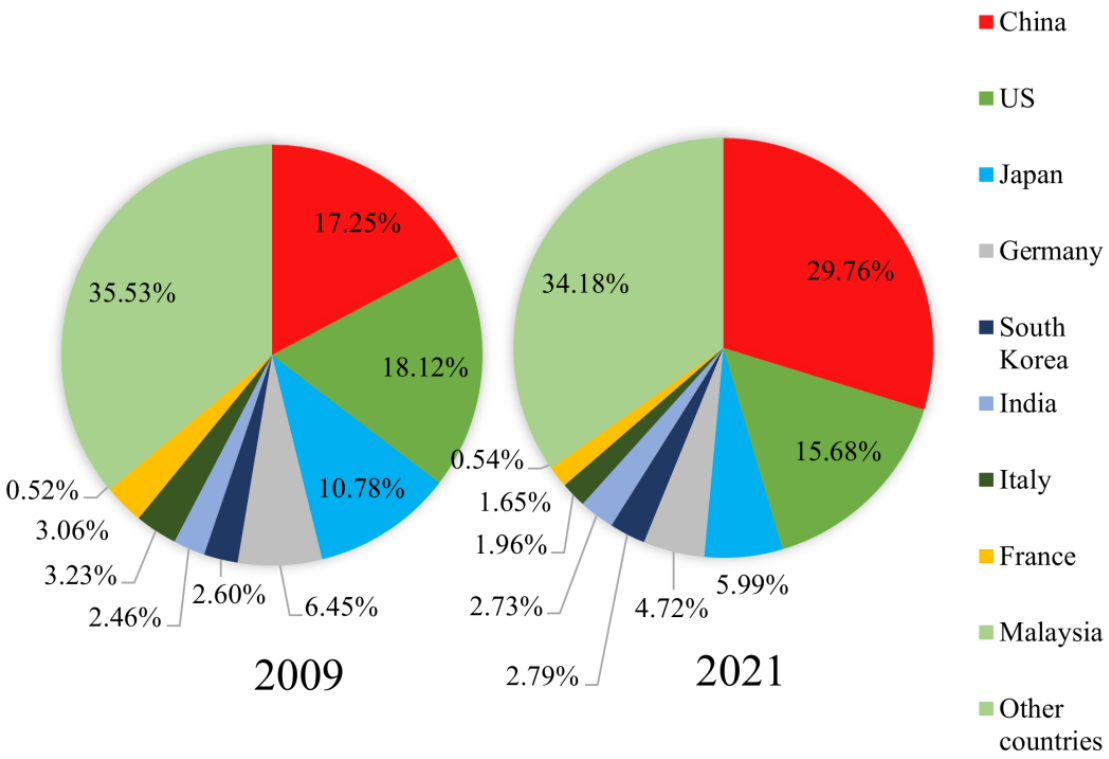

Figure 3. Share of manufacturing value added in significant countries worldwide in 2021.

2.2. The Manufacturing Industry Is a Major Source of Pollution

2.2.1. Global Manufacturing Pollution

Manufacturing pollution issues are increasingly prominent worldwide, mainly categorized as industrial waste, energy consumption, and climate concerns. Regarding industrial waste, it refers to the emissions of wastewater, exhaust gas, and solid waste produced by industries. These "three industrial wastes" contain various toxic substances that can

negatively impact industrial and agricultural production, as well as human health if not properly treated.

Energy, being a crucial production factor, contributes significantly to industrial pollutants and greenhouse gas emissions, largely stemming from the production and consumption of fossil fuels such as coal. Regarding energy consumption, on a global scale, Figure 4 indicates that global energy consumption continues to increase yearly, despite temporary decreases in 2009 and 2020 due to the financial crisis and the COVID-19 pandemic. And Figure 5 illustrates the energy consumption as a share of manufacturing value added in 2019. Switzerland, France, and Italy have energy consumption proportions below 0.5%, with Switzerland notably below 0.1%. This is attributed to these countries' manufacturing industries being at the forefront of green development.

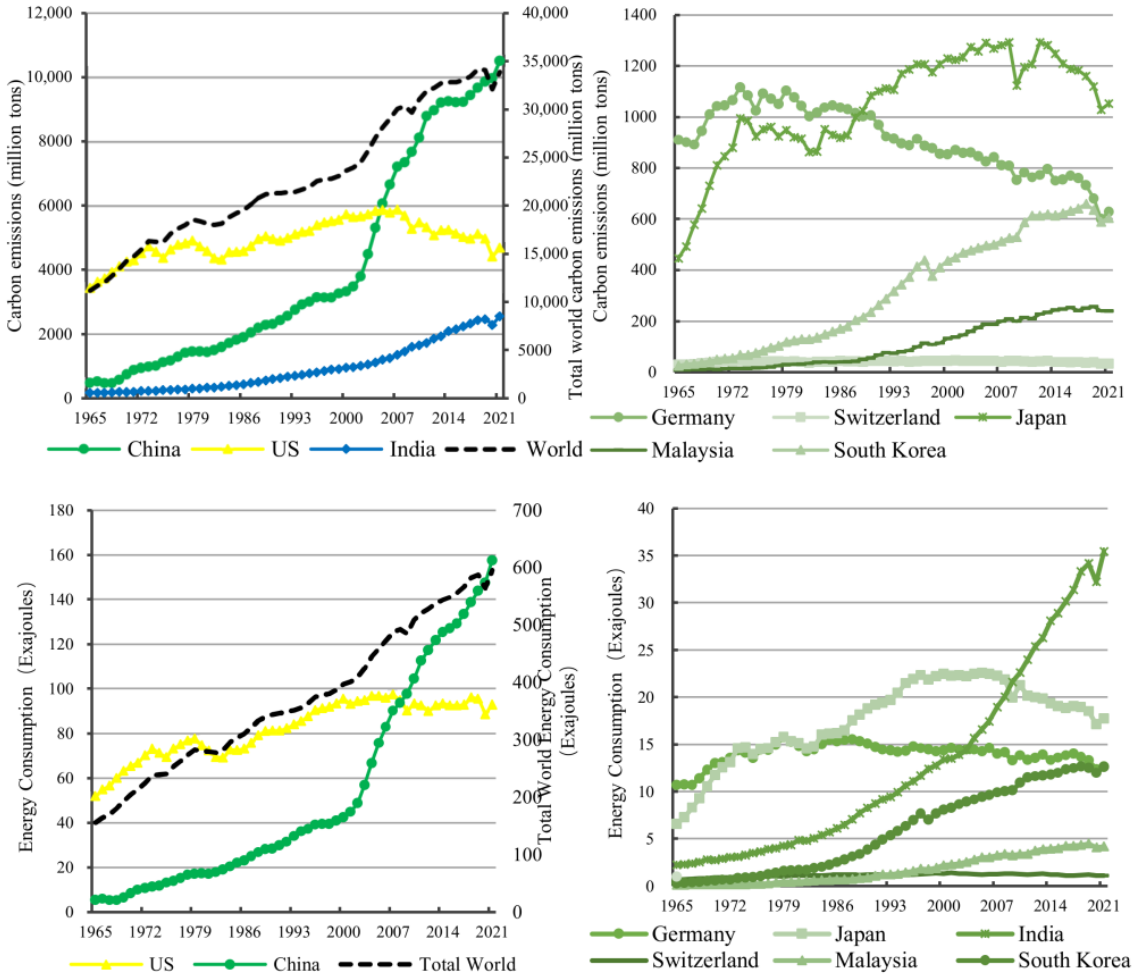

Figure 4. Global energy consumption (million metric tons) and global carbon emissions (million tons) (1965–2021).

Regarding climate issues, the current global average surface temperature is 1.09 °C above pre-industrial levels. It is internationally recognized that temperature increases must be kept below 1.5 °C to prevent irreversible environmental damage [26]. Additionally, limiting global warming to 1.5 °C poses a significant mitigation challenge, considering that manufacturing accounts for 36% of global CO_2 emissions [27]. Figure 5 presents global per capita CO_2 emissions, showing a steady increase between 1965 and 2021, with an overall rise of approximately 5.9%. China, the United States, and India, the largest carbon emitters, contribute 31.06%, 13.87%, and 7.53% of total global carbon emissions, respectively.

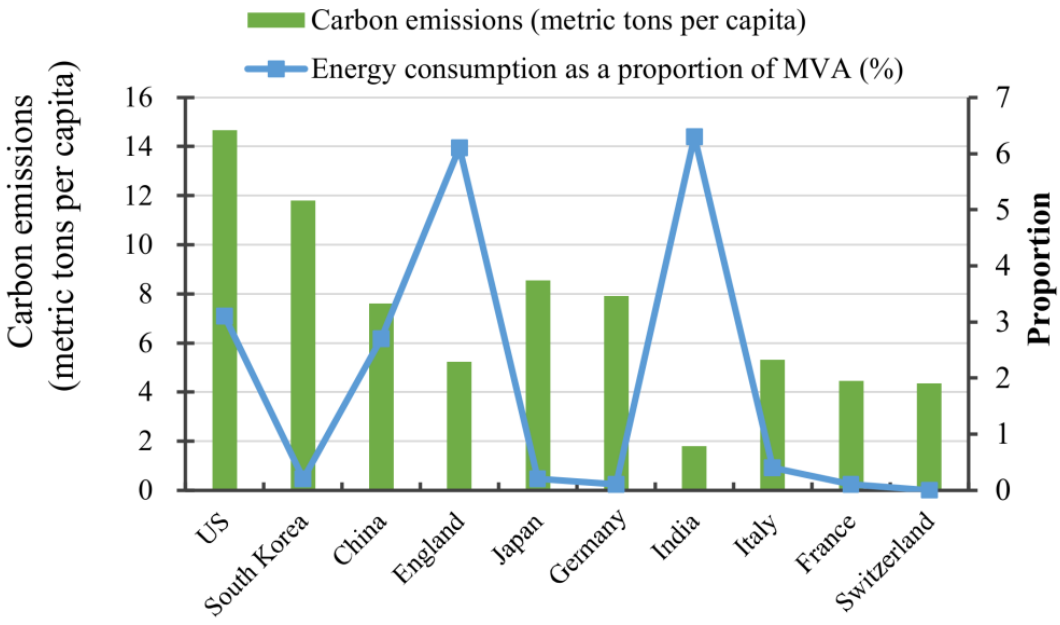

Figure 5. Per capita carbon emissions (metric tons per capita) and the proportion of energy consumption in manufacturing value added (%) in 2019.

The pollution situation brought about by the global manufacturing industry makes transforming the economic development mode of the manufacturing industry and harmonizing economic growth and environmental protection an essential task for all countries.

2.2.2. Pollution in China's Manufacturing Industry

China's manufacturing industry also faces multiple challenges. There is an overall rising trend in industrial waste gas emissions and industrial solid waste according to Figure 6. However, it should still be noted that China's industrial wastewater emissions have been decreasing over the past few years after reaching a peak in 2007. This indicates a positive trajectory in managing and reducing industrial pollution in this particular area.

In terms of energy consumption and climate issues, its energy consumption and carbon emissions have risen rapidly, and it is the world's largest energy consumption and carbon dioxide emissions country after the United States. According to the 2021 BP report, China's total energy consumption is 5.24 billion tons of standard coal, an increase of 5.2% over the previous year; carbon dioxide emissions per capita reached 7.2 tons, 44% higher than the world average, and total carbon dioxide emissions reached 10.523 billion tons, of which manufacturing carbon dioxide emissions exceeded more than 50% of total emissions [28].

On the one hand, the rapid growth of China's energy consumption and carbon emissions are due to sustained economic growth and industrialization process. China's rapid development over the past few decades has led to increasing energy demand, especially in the manufacturing sector. This has led to the use of large amounts of coal, oil, and natural gas, which, in turn, has generated large amounts of carbon dioxide emissions. On the other hand, China's energy consumption structure is relatively unreasonable, the proportion of clean energy is low, and traditional coal still dominates, so the carbon dioxide emissions are high.

Based on the global and the Chinese manufacturing development and pollution situation, China's manufacturing policy formulation is biased towards the direction of green development. Through specific and in-depth exploration, it is expected to provide reference for other countries' policy formulation and implementation.

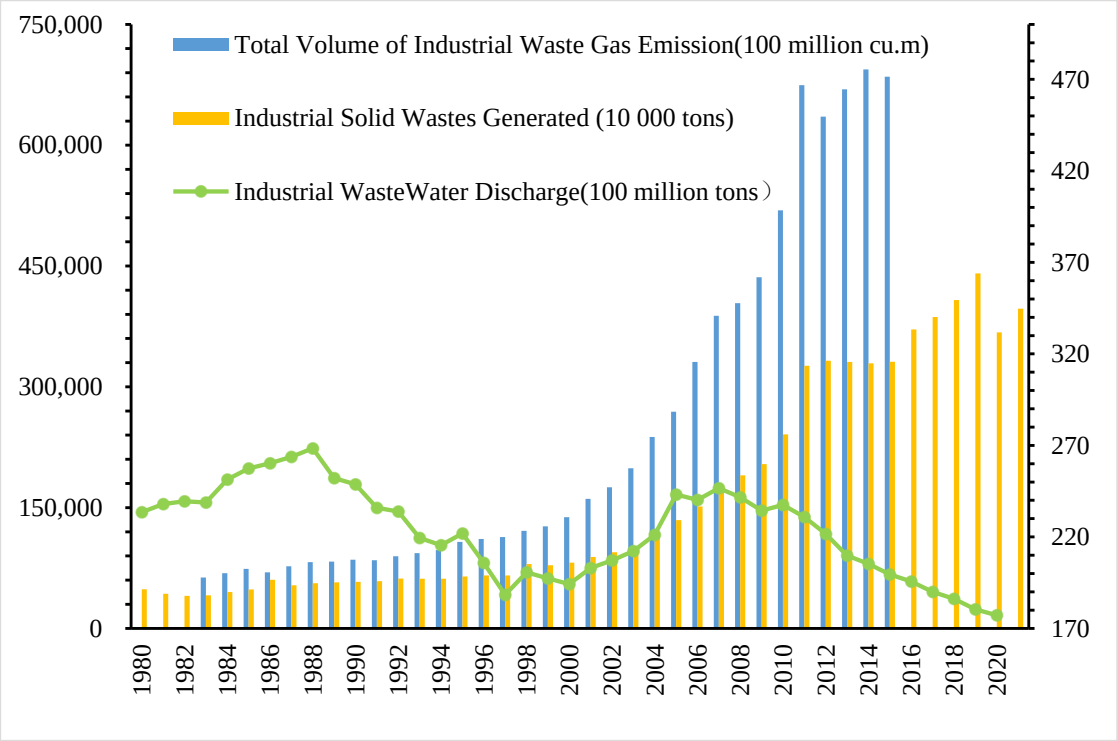

Figure 6. China's industrial waste emissions (1980–2021).

3. Methods and Data Sources

3.1. Methods

Qualitative content analysis is classified under the qualitative descriptive design. It is the technique used to analyze textual data and elucidate themes [29]. Due to the non-quantification, multiplicity, and organization of its content, green development policy documents must be systematically analyzed by qualitative content analysis, which can avoid uncertainty and reveal its evolution characteristics. The process of this study includes the following four steps: first, determine the characteristics and quantity of documents and establish a policy document library; second, according to the publication year of the policy document, it is arranged in chronological order; third, through the analysis of the policy structure, it is summarized to find out the evolution process and characteristics of China's manufacturing green development laws and policies since 1949.

3.2. Data Sources

The green development policy documents of the manufacturing industry include the laws related to green development in the manufacturing industry promulgated by the National People's Congress and the regulations, decisions, announcements, notices, opinions, and other policies promulgated by the central government and relevant ministries and commissions. The period of sample selection is from 1949 to 2022. All samples are selected from the State Council, the National Development and Reform Commission, the Ministry of Industry and Information Technology, and other relevant websites. It is worth noting that the policies of analysis in this paper are all at the national level, which can reflect the trend of national legislation and supervision. The policies issued by local governments are excluded because the policies of each province are different and uneven, which makes it challenging to analyze the trends of national and local governments simultaneously.

4. The Evolution of Manufacturing Policies for Green Development in China

The development process of China's manufacturing policy is a process of deepening and improving the concept of green development in practice. In order to fully present

the evolution of the manufacturing policies for green development in China, this research divided the policy into four phases: the exploring period (1949–1977), the formal establishment period (1978–2001), the improvement and strengthening period (2002–2011), and the comprehensive improvement period (2012 to present), as shown in Figure 7.

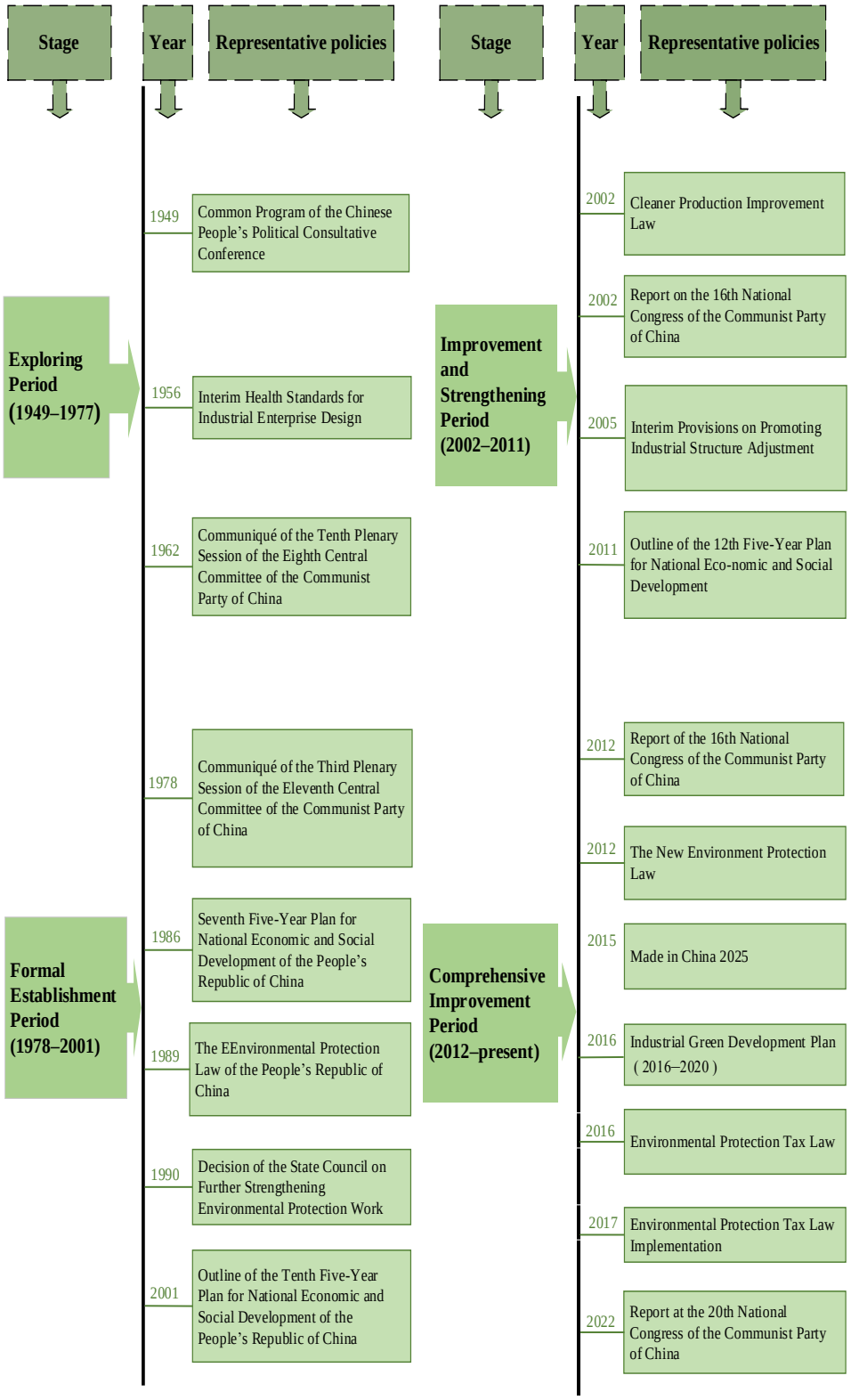

Figure 7. Time axis of China's green development policies evolution in manufacturing showing the representative policies.

4.1. The Exploring Period (1949–1977)

China's industrial base was significantly strengthened after the founding of the People's Republic of China. However, under the planned economic system, China's economy faced severe shortages, and the development of light and heavy industries was out of proportion, as evidenced by the chronic shortage of consumer goods, energy, and raw materials. After a long period of war and depletion, China's economy required a revival in the early years of the country's founding.

In 1950, China's total carbon emission was only 21.465 million tons, and the per capita carbon emission was only 0.03 tons. Therefore, environmental protection was less involved, focusing primarily on environmental sanitation and improving natural ecology. From 1949 to 1978, government policies were generally more focused on the initial industrialization of the country and the development of the national economy (Table 1) [30–32], while policies on environmental protection were relatively fragmented, with content more focused on general regulations, lacking specific, standardized environmental management procedures, and not forming a comprehensive environmental legal system.

Table 1. Representative policies of the exploring period in China and the main contents.

Year	Representative Policies	Main Potent
1949	Common Program of the Chinese People's Political Consultative Conference [30]	Focus should be placed on the systematic restoration and development of heavy industries in order to create the foundation for national industrialization. In addition, people's standard of living should be restored and expanded in order to meet their daily consumption needs.
1956	Interim Health Standards for Industrial Enterprise Design [31]	The policy is comprehensively to address the health and safety problems of industrial enterprises.
1962	Communiqué of the Tenth Plenary Session of the Eighth Central Committee of the Communist Party of China [32]	Agriculture should be the foundation, and industry the mainstay.

4.2. The Formal Establishment Period (1978–2001)

To meet the growing material and cultural needs of the population, the Chinese government decided to shift the focus of the Party and the state's work to economic construction and to initiate reform and opening up [33]. During this time, China focused on increasing manufacturing output and developing manufacturing technology and revitalizing the equipment manufacturing industry. China's manufacturing industry has developed rapidly based on high energy consumption and high emissions. However, as the process of global integration accelerates, China is confronted with soaring energy prices and rising ecosystem pollution [34]. In fact, the Chinese government has recognized the significance of energy saving and emissions reduction for sustainable and healthy economic growth (As shown in Table 2) [33,35–38]. The National People's Congress established the Environmental Protection Committee in 1993, with the primary responsibility of studying, deliberating, and formulating institutional regulations regarding environmental protection. Government entities at all levels and various industrial divisions have also established environmental management agencies.

During this period, the principle adopted in policies was "who pollutes, treats", with an emphasis on end-of-pipe treatment of pollution. However, due to the fact that governments and administrative agencies at all levels still prioritized economic development, there existed a significant gap between local environmental remediation policies and implementation strategies. Moreover, the policy instruments during this period were command and control-oriented, lacking incentive mechanisms in their execution, which resulted in the continuous deterioration of pollution and weakened the effectiveness of the policies.

Table 2. Representative policies of the formal establishment period in China and the main contents.

Year	Representative Policies	Main Potent
1978	Communiqué of the Third Plenary Session of the Eleventh Central Committee of the Communist Party of China [33]	It was decided to shift the focus of the Party and the state's work to economic construction and to initiate reform and opening up.
1986	Seventh Five-Year Plan for National Economic and Social Development of the People's Republic of China [35]	The need to accelerate energy development and conservation and vigorously strengthen the development of electrical equipment, mining equipment, and petroleum equipment in response to the bottleneck of coal, electricity, oil, transportation, materials, and other resources.
1989	The Environmental Protection Law of the People's Republic of China [36]	Priority procurement and use of environmentally friendly products, equipment, and facilities and the new five systems for strengthening environmental management.
1990	Decision of the State Council on Further Strengthening Environmental Protection [37]	To formulate eight systems of environmental protection which included the addition of the environmental impact assessment system, the "three simultaneous" system, and the sewage charging system to the original five systems.
2001	Outline of the Tenth Five-Year Plan for National Economic and Social Development of the People's Republic of China [38]	To study and formulate policies and measures to revitalize the equipment manufacturing industry, develop competitive manufacturing and high-tech industries, and energetically promote service industries.

4.3. The Improvement and Strengthening Period (2002–2011)

Since 2003, the rise of China's heavy industrialization, the rapid development of the real estate and automobile industries, the expansion of infrastructure investment, and the rising exports of electromechanical and chemical products have led to the rapid expansion of heavy industrial industries. China's energy consumption and pollutant emissions have also increased, posing a significant challenge to formulating "energy conservation and emission reduction targets" during the eleventh Five-Year Plan [39]. China's sulfur dioxide emissions reached 25.89 million tons in 2006, more than double the theoretical capacity of the environment, and the trend of ecological and environmental deterioration has attracted the Party Central Committee's close attention.

In 2002, announcement of the report of the 16th National Congress of the Communist Party of China developed the national strategic position of sustainable development and greater emphasis was placed on environmental protection. The Standing Committee of the Ninth National People's Congress passed the Cleaner Production Promotion Law, which, as the first circular economy law, signaled the beginning of a move from end-of-pipe management to whole-process control in China's pollution management paradigm [40] (Table 3) [41–43].

Table 3. Representative policies of the improvement and strengthening period in China and the main contents.

Year	Representative Policies	Main Potent
2002	Cleaner Production Improvement Law [40]	Pollution control mode begins to change from end treatment to whole process control.
2002	Report of the 16th National Congress of the Communist Party of China [41]	Taking a new type of industrialization road with high technological content, good economic efficiency, low resource consumption, and less environmental pollution, and the advantages of human resources are given full play.
2005	Interim Provisions on Promoting Industrial Structure Adjustment [42]	Promoting the optimization and upgrading of industrial structure and the healthy and coordinated development of the primary, secondary, and tertiary industries.
2011	Outline of the 12th Five-Year Plan for National Economic and Social Development [43]	Vigorously cultivate and develop strategic emerging industries.

During this period, total emission control, unit energy consumption target responsibility, and assessment system have been implemented by policymakers to address environmental concerns and the approach has shifted from after-the-fact treatment to prior supervision in order to better regulate and prevent pollution. Furthermore, the adoption of an industrial production full-process control mode ensures comprehensive oversight of the entire production process. However, the specific forms of total control, task decomposition, administrative accountability, and inspection visits do not effectively stimulate market innovation. Despite efforts, there still exists a contradiction between economic development and environmental protection.

4.4. The Comprehensive Improvement Period (2012 to Present)

At the 18th National Congress, the Chinese government emphasized that tighter standards for the path of the manufacturing industry's development should be proposed from the peak of ecological civilization construction, together with a more comprehensive theoretical system and policy actions. The New Environmental Protection Law in 2014 strengthens the responsibility of the government and enterprises for environmental management and imposing penalties for environmental violations (Table 4) [44–50]. In addition, Beijing, Tianjin, Shanghai, and other cities have implemented carbon emission trading pilot projects, gradually establishing a national unified carbon emission trading market across various industries. In addition, ecological compensation, green procurement, and green pricing policies have been introduced.

Table 4. Representative policies of the comprehensive improvement period in China and the main contents.

Year	Representative Policies	Main Potent
2012	Report of the 16th National Congress of the Communist Party of China [44]	Emphasizing that tighter standards for the path of the manufacturing industry's development should be proposed from the peak of ecological civilization construction, together with a more comprehensive theoretical system and policy actions.
2014	The New Environmental Protection Law [45]	The responsibility of the government and enterprises for environmental governance has been strengthened, and penalties for environmental violations have been greatly strengthened.
2015	Made in China 2025 [46]	In accordance with the "innovation-driven, quality first, green development, structural optimization, talent-oriented" basic policy to promote the development of manufacturing.
2016	Industrial Green Development Plan (2016–2020) [47]	Promoting green development of manufacturing industry.
2016	Environmental Protection Tax Law [48]	First separate tax law to embody a "green tax system".
2017	Environmental Protection Tax Law Implementation [49]	Environmental protection "fee to tax" officially completed.
2022	Report of the 20th National Congress of the Communist Party of China [50]	Promoting the high-end, intelligent and green development of the manufacturing industry.

During this period, green development has been included in the indicator assessment system to promote sustainable development. Efforts have been made to increase financial and taxation policy input to support environmentally friendly initiatives. The establishment of legal and policy-oriented systems for green production and consumption is being accelerated. However, it should be noted that although government departments have a deep understanding of green development, they have not yet formed a systematic and comprehensive policy support system for green development in the manufacturing industry. Even though the government has introduced some supportive policies for specific industries, such as providing significant subsidies for the new energy vehicle industry, scattered

and sporadic policy support has limited effects on the overall social green transformation. Blind support may even lead to resource mismatches.

5. Evolutionary Characteristics of China's Green Development Policies for the Manufacturing Industry

The green development policy for China's manufacturing industry was derived from the practical activities of China's environmental governance, and policymakers have gradually increased their understanding of green development, laying the groundwork for establishing a green development system for China's manufacturing industry. From advocating the economical use of energy and resources to proposing a new industrialization road, and from the new industrialization road to comprehensive green manufacturing with the objective of ecological civilization construction, it signifies the deepening of the green development of China's manufacturing industry and the transformation of China's manufacturing development in the intelligent, green, and low-carbon direction.

5.1. Policy Quantities from Less to More

The frequency and quantity of documents issuance has seen a gradual increase in the issuance of policies related to green development in manufacturing industry. Prior to the reform and opening up in 1978, there were limited policies focusing on environmental health and natural ecology improvement. However, since then, the number of green development policies for the manufacturing industry has been increasing year by year.

During the "13th Five-Year Plan" period, the Ministry of Industry and Information Technology placed a strong emphasis on green manufacturing as a key aspect of industrial green development. They issued the "Green Manufacturing Engineering Implementation Guide (2016–2020)". By the end of 2021, more than 300 major green manufacturing projects had been organized and implemented. Additionally, 184 green manufacturing system solution suppliers were issued, over 500 green manufacturing standards were formulated, and 2783 green factories, 223 green industrial parks, and 296 green supply chain enterprises were cultivated and constructed. These efforts have played a crucial role in leading the industry towards a green and low-carbon transformation.

In 2022, 46 policies were introduced, including 1 law, 4 administrative regulations, 40 departmental rules and regulations, and 1 inner-party legal system.

5.2. Policy Categories from "Government Intervention" to "Market Incentives" and "Public Participation"

The green development of China's manufacturing industry has gradually evolved from coordinated development with the plan to coordinated market development, from the emphasis on state intervention to the strengthening of market encouragement to the emphasis on public participation, and from the administrative focus to the joint role of administration, market, and public. With the gradual development and improvement of the market economy system, the inadequacies of methods of environmental regulation that rely solely on government intervention are becoming increasingly apparent. Therefore, China has initiated a profound reflection on its own previously implemented environmental management methods and has paid more attention to the full utilization of the guiding role of market signals in the subsequent policy formulation process, and market incentive-based environmental regulation tools, such as environmental protection tax and emission right trading, are rapidly developing [51].

Environmental certification, environmental hearings, and public participation are the primary approaches to environmental regulation today. The public participation system can simultaneously reduce the government's environmental regulation costs and increase the community's interests' adequate reflection and management [52].

5.3. Policy Concept from "Pollution Prevention and Control" to "Ecological Civilization"

As policymakers have gained a deeper understanding of the connection between manufacturing development and environmental protection, the policy philosophy has shifted

from pollution control and energy conservation to addressing climate change, developing a circular economy, and constructing an ecological civilization. China's environmental concerns evolved concurrently with industrialization, as they did in all industrialized countries, but the concept of environmental protection did not.

In 2007, the report of the 17th Party Congress initially recommended the "building of ecological civilization", establishing the socialist concept of ecological civilization in a formal sense. Ecological civilization is a systematic understanding of the relationship between humans and the ecological environment, which has gradually evolved in tandem with the ecological deterioration and environmental and social crises that have arisen during human social and economic development. Contrariwise, ecological civilization encourages us to liberate our thoughts and continuously optimize and improve the growth of high-quality green development. The report of the 20th Party Congress defines the strategic tasks of building an ecological civilization in China in the new era, proposes a series of new goals and requirements for the construction of ecological civilization, and makes new deployments, thereby providing fundamental guidelines and action guidelines for constructing a beautiful China.

6. Challenges for Green Development of China's Manufacturing Industry

6.1. Compatibility between Economic Development and Environmental Protection Needs to Be Strengthened

In the current environmental protection situation, some regions have adopted simplistic and even excessive measures, resorting to a "one-size-fits-all" approach, which has had adverse effects on local social development and stability. Some regions and departments frequently use different environmental protection indicators when formulating and implementing relevant environmental protection regulations, which creates great uncertainty for some businesses and leads to unreasonable environmental protection inputs. Under certain conditions, political negotiation is necessary to generate optimal decisions [53]. To achieve "green development" from the perspective of policy design, a set of rational trade-offs between the economy and the environment must be identified rather than favoring one side over the other, as is evident in China's current economic development process.

6.2. Primarily Command-and-Control Based Policy Structure Needs to Be Reformed

From the current institutional structure analysis, the command-based policy tools is still the core, and the development of market-oriented institutional instruments is slow. The "command and control" policy is often focused on the interests of the social actors, using a coercive approach to achieve the desired goal of environmental protection, while ignoring the incentive of economic profit for the social actors, and therefore does not bring long-term motivation to the market. The intervention approach centered on selective manufacturing policy focuses on the government's judgment and prediction in policy-making, expecting immediate results. Such a management model can achieve the desired environmental protection purpose in a short period, but it is outside the overall market development in the long run. The uncertainty and high-risk nature of new development models still in the exploration phase may cause the government-led intervention model to have a misleading effect on the entire market, thereby distorting the market mechanism [54]. Therefore, the compulsory command-and-control-oriented government management system needs to be further changed.

6.3. Collaboration of Multi-Departmental Management System Needs to Be Enhanced

China's multi-departmental collaborative management system has resulted in overlapping responsibilities among government departments [55]. For instance, the Ministry of Environment and the Ministry of Industry and Information Technology are involved in the adjustment and optimization of such a multi-departmental collaborative management system, likely leading to insufficient internal motivation and externally binding the implementing departments, thereby easily resulting in ineffective collaboration. Conse-

quently, it remains a matter of concern how to integrate the various departments and their respective issued policies and regulations so that the policy implementation is not twisted and deformed to the greatest extent possible to achieve the desired result. Therefore, it is necessary to clarify the functions of government departments and reorganize departments with similar responsibilities into a more scientific and effective management structure.

7. Prospects of Green Development Policy for China's Manufacturing Industry

Based on the current issues facing China's green industrial development policy, the following policy recommendations are made.

7.1. Aligning Environmental and Manufacturing Policies in Setting Strategic Objectives and Benchmarks

Supporting green development requires a coordinated approach to create a wide social consensus on the direction of change and its primary long-term objectives among stakeholder groups with various motives and ambitions. Based on this, the construction of a policy system for green development in manufacturing that fits China's reality must first clarify, through a broad value judgment, a green economic development approach that promotes socially inclusive growth in an environmentally sound manner, the inclusiveness that includes broader social goals, such as maintaining economic growth, avoiding environmental disasters, controlling inequality and poverty levels, and some other political isms. To steer market investments, the policy content of green development in manufacturing and the scope of its support should be designed in a directive manner.

7.2. Concentrating on the Systemic Nature of Policies and the Interdependence of Policy Tools

The policy objective of green development in manufacturing is to ensure ecologically sustainable economic and social development. Currently, the keys to achieving this objective are developing renewable energy and promoting environmentally friendly technical innovation. A combination of command-and-control, market-based, and voluntarily negotiated environmental policy instruments is required to attain this objective, as demonstrated by past experience [56]. Policy implementation cannot be "one size fits all", and policy initiatives must be varied based on the characteristics of the intended audience. Borrás and Edquist (2013) found that in some instances, a combination of specific policies can be more beneficial than a single policy [57].

7.3. Enhancing Processes for Policy Creation, Implementation, Monitoring, and Evaluation

In the context of China's current trend toward centralization of power, it is essential to determine whether the mechanism for assigning responsibilities at the national level is generally cost-effective and to clarify the responsibilities and obligations of environmental regulators and provide them with resources commensurate with their responsibilities to ensure that their functions are carried out effectively. On this basis, the internal authorities of the governance system should be clearly demarcated, and policy-making, monitoring and evaluation, and enforcement and inspection should be delegated to separate functional departments. We can optimize the effect of policy execution only with a defined division of work and mutual checks and balances. Based on government regulation, the regulatory role of social forces, such as citizens and non-governmental organizations, should be activated, and the system of information disclosure and public engagement should be enhanced to drive the transformation of the entire concept of societal development.

8. Discussion

We have identified that over past 70 years, green development policies for China's manufacturing industry have undergone transformation in policy quantities from fewer to more policies, more diverse policy categories, and a shift towards market incentives and public participation. We have shown that these policies can be divided into four periods:

the exploring period, the formal establishment period, the improvement and strengthening period, and the comprehensive improvement period.

A comprehensive national strength catch-up is the primary goal for many countries, especially developing countries. However, the catastrophic environmental consequences and social conflicts have raised widespread concerns about the balance between economic development and environmental protection for governments worldwide. Researchers on economic development and policy [53,58,59], as well as international organizations [56,60], have conducted in-depth studies on this issue, aiming to achieve an eco-economy through policy intervention. Nevertheless, addressing the challenges of sustaining economic growth and preventing environmental disasters requires more than just improving resource allocation efficiency by internalizing environmental costs [53]. It is crucial to pursue a development path that aligns with broader social objectives. This shift from externalities to social objectives in the development concept is not something that can be coordinated by mere environmental policy. The development experience of OECD countries shows that when the economic development of a country reaches a certain stage, it has both the reason and the necessity to combine industrial policy and environmental policy to promote green development of the economy and society. Currently, China is at this stage [61]. Therefore, we study the evolution of green development policies in China's manufacturing industry and, furthermore, explore the challenges of its development, and we propose improvement measures that can provide guidance for building a green development policy system that suits China's national conditions and serves as a reference for other countries.

However, it should be noted that this study has only examined green development policies in China's manufacturing industry without examining policies from other regions or exploring their actual impacts. Notwithstanding this limitation, this study does suggest that future work will expand the research scope, evaluate policy implementations, propose recommendations for sustainable development, and conduct additional field research. The goal is to guide policymakers and promote environmental sustainability in China's manufacturing industry.

9. Conclusions

In the process of industrialization, economic growth and environmental protection have always been at odds. Nowadays, the goal of environmental protection is becoming increasingly important. Relying solely on manufacturing industry policies centered on economic growth no longer meets the requirements of current targets. Against this backdrop, exploring how to achieve green development through influencing manufacturing industry policies has become an important issue for governments around the world.

Through research on the evolution of China's manufacturing industry green development policies, we note that such policies refer to those formulated by governments to achieve an eco-economy, originating from government environmental governance practices. It can be concluded that (1) the evolution can be divided into four periods: the exploration period (1949–1977), the formal establishment period (1978–2001), the improvement and strengthening period (2002–2011), and the comprehensive improvement period (2012 to present); (2) the characteristics of this evolution include policy quantities from less to more; policy categories from government intervention to market incentives and public participation; and policy concepts from pollution prevention and control to the ecological civilization. These results demonstrate that China is a country committed to following the SDGs and has made significant contributions to achieving SDGs 7, 12, and 13. With the continuous issuance of policies and a strong emphasis on green development, China has played a major role in these areas.

However, challenges still exist at the current stage. In the current environmental protection situation, some regions have adopted some simplistic and even excessively enforced measures, resulting in adverse impacts on local social development and stability by making measures rigidly uniform. Although China has formed a relatively complete environmental policy system mainly composed of command-and-control policy tools,

market-based policy tools, and voluntary negotiation policy tools, these policies still mainly address market failures caused by environmental problems and pay insufficient attention to achieving an eco-economy. Moreover, how to coordinate the various departments and their respective policy regulations and ensure that policy implementation is not distorted or reversed to achieve the desired goals maximally is also an issue.

In light of China's current development status, this paper proposes the following policy recommendations: (1) aligning environmental and manufacturing policies in setting strategic objectives and benchmarks; (2) concentrating on the systemic nature of policies and the interdependence of policy tools; (3) enhancing processes for policy creation, implementation, monitoring, and evaluation.

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