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Analyzing China's sustainable development: A review to address carbon emissions and promoting environment social and governance practices

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Abstract

This study aimed to (a) review the literature on the 'China Social Economy' within the Scopus database, (b) explore the relationships between population size, gross domestic product (GDP) per capita, and annual carbon dioxide (CO_2) emissions in China from 1950 to 2021, using data obtained from Our World in Data, and (c) discuss these relationships from the perspectives of social, economic, environmental, and governance (ESG) aspects. Based on the Scopus database, a total of 75 papers with the keyword 'China Social Economy' in the article title were initially identified, which were subsequently narrowed down to 60 items, forming five major clusters of keywords using the VOSviewer (visualization of similarities) software. Two key findings from this study include the positive correlation between population growth and socio-economic progression, as well as the interconnected relationship between population growth, GDP, and CO_2 emissions in the context of ESG in China. In conclusion, this foundational study provides insights into the social, economic, and environmental dynamics within China, contributing to the understanding necessary for achieving sustainable development and effective ESG practices.

Keywords: Carbon footprint, China, Economic growth, Environmental impact, Population growth.

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1. Introduction

Once the world's most populous country, China has experienced remarkable economic growth in recent decades [1, 2]. However, this rapid development has come with significant environmental costs, as China's large population and industrialization have contributed substantially to global carbon emissions. In response, the Chinese government has implemented various measures to reduce emissions and promote a low-carbon economy [3-5].

China's economic growth, driven by globalization and reforms, has also led to severe environmental degradation [6]. The high levels of carbon emissions are largely a result of increased energy consumption and industrial activities spurred by population growth and rapid economic expansion [7]. Recognizing the long-term importance of sustainability, the government has introduced policies and initiatives to support sustainable development and cut emissions [8].

Researchers have examined the complex relationship between economic growth and carbon emissions, highlighting the challenges of balancing progress with environmental protection [9, 10]. Regional disparities in emissions further complicate the implementation of national policies [11]. While China's promotion of a low-carbon economy is noteworthy, its success hinges on the effective integration of ESG principles at both national and regional levels.

The introduction of the one-child policy in 1979 as a national family planning initiative significantly shaped China's demographic and socioeconomic development, though it also led to challenges such as an ageing population and shifting labour dynamics [12].

This study provides a comprehensive understanding of the evolving relationships between population growth, socio-economic development, and environmental impact in China, with a focus on ESG principles. By reviewing the literature on the 'China Social Economy' and analyzing over seven decades of data on population size, GDP per capita, and CO_2 emissions, this research links socio-economic progress with environmental and governance factors [13].

The structure of the paper is as follows: Section 2 outlines the methodology, including data collection and bibliometric analysis. Section 3 presents the results, identifying trends in population growth, economic development, and carbon emissions. Section 4 discusses these findings through the lens of ESG principles, emphasizing the need for integrated strategies to address economic and environmental challenges. Section 5 offers actionable recommendations and future research directions.

Key findings highlight the complex interactions between population growth, economic development, and environmental impact. While China's ESG policies have shown effectiveness in certain areas, further refinement is needed to ensure sustainable growth. Recommendations include promoting technological innovation, implementing carbon pricing, and creating region-specific policies to address emissions disparities.

One limitation of the study is the relatively small sample size for the bibliometric analysis, which may limit the generalizability of the findings. Future research should focus on a more detailed regional analysis of China's ESG policies and their impacts across different provinces. Expanding the dataset to include more recent data would also provide deeper insights into the long-term effects of these policies.

To better integrate economic growth with sustainability, China should prioritize economic policies such as a nationwide carbon pricing system, subsidies for green technology, and stricter industrial emission regulations. Policies promoting sustainable urban development and green infrastructure investment are also critical for reducing emissions while supporting continued economic growth.

China's approach to integrating economic growth with sustainability goals offers valuable lessons for other emerging nations. However, the adaptability of these strategies to different socio-economic contexts must be carefully considered. While China's efforts in implementing ESG principles are commendable, the framework presents challenges that other nations must assess based on their own governance structures, environmental priorities, and levels of industrialization.

Thus, the objectives of this study are to (a) review the literature on the 'China Social Economy' in the Scopus database, (b) explore the relationships between population size, GDP per capita, and CO_2 emissions in China from 1950 to 2021 using data from Our World in Data, and (c) discuss these relationships from an ESG perspective.

2. Methodology

On 24 May 2024, using the keywords 'China Social Economy', 75 papers were reached using the Scopus database, which had high relevancy. Bibliometric analyses are an established method to evaluate research literature, particularly in scientific fields benefiting from computational data treatment and witnessing increased scholarly output [14]. VOSviewer is a software that generates a clear graphical representation of bibliometric maps, especially for extensive datasets [15]. To highlight the trends of studies conducted on the topic of 'China Social Economy' from 1986-2024 (on 75 papers from the Scopus database), we performed a bibliometric analysis using the VOSviewer software (VOS stands for visualization of similarities – see www.vosviewer.com).

Scopus comprises many significant research papers and offers integrated analysis tools for creating informative visual representations [16]. VOSviewer was employed to analyze each keyword, calculate links, calculate total link strengths, and compare co-occurrences with other keywords.

The data on China's population, GDP per capita, and annual CO_2 emissions are obtained from United Nations World Population Prospects [1]; World Bank [17] and Global Carbon Budget [18] respectively, in the online database "Our World in Data," which was accessed on 24 May 2024. Using KaleidaGraphs, version 5.0, the given data's graphical histograms were produced (1986–2022 by Synergy Software, Eden Prairie, MN, USA).

3. Results

A total of 75 papers with the keyword 'China Social Economy' in the article title were narrowed down to 60 items (keywords) with five major clusters (Figure 1), based on the Scopus database searched on 24 January 2024. This gives a holistic overview of the past research based on keywords' co-occurrences with 'China Social Economy' (Figure 1). The analysis reveals a discernible prominence reflecting five clusters that can be identified based on visualization in Figure 1 (top panel). Many researchers [2019-2023] have recently focused on studies such as sustainable development, economic and social effects, ecological environment, environmental economics, etc. (Figure 1; bottom panel).

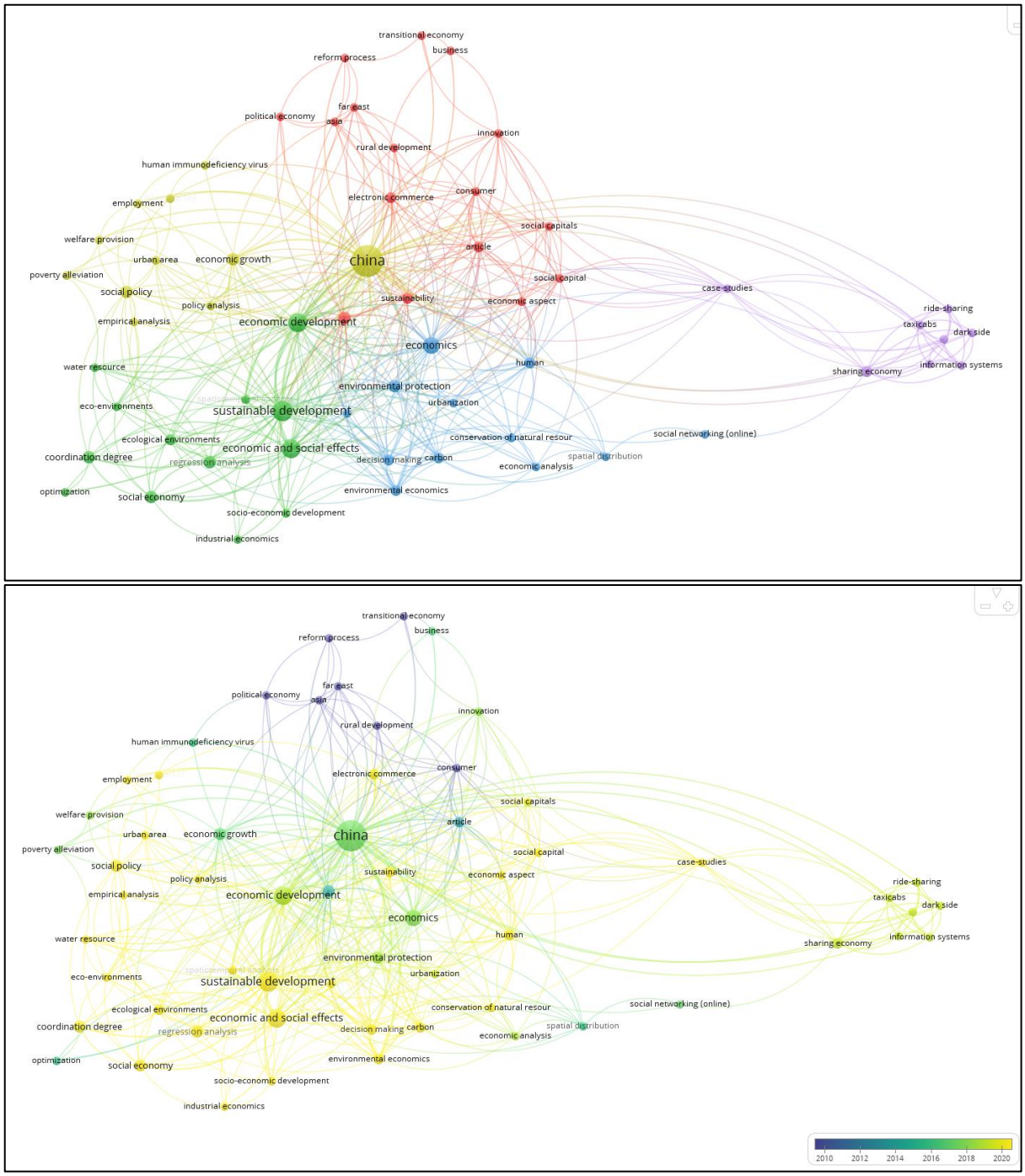

Figure 1.
A bibliometric analysis of research themes on 'China Social Economy'. Top Panel: Visualization of the paper network confirming the main themes of research. Bottom Panel: Evolution of research trends between 1986 and 2024 based on the Scopus database. The colours in the top panel indicate the themes of research that the papers are discussing, while the colours in the bottom panel indicate the year of publication.

Out of the 60 identified items, 39 items can be identfied to be categorised (manually with logics) from VOS into economy, social, environment and governance (Table 1). The Economy category includes business, economic analysis, economic aspect, economic development, economic growth, economics, electronic commerce, industrial economics, political economy, sharing economy and transitional economy. The environment category includes carbon, conservation of

natural resources, eco-environments, ecological environments, and water resources. The category of social-economy includes economic and social effects. The category of environmental economics includes environmental economics. The category of environmen-governance includes environmental management and environmental protection.

The governance category includes decision-making, policy analysis, and reform processes. The social category includes consumer, employment, labour market, social implication, and social networking (online). The social-governance category includes poverty alleviation, rural development, social development, social policy, urbanization and welfare provision. The social economy includes social capital and social economy. The social-economy-governance includes socio-economic development. The social-economy-environment includes sustainability. The social-economy-environment-governance includes sustainable development (Table 1).

Table 1.
The identification of items from VOS categorized (manually with logic) into economy, social, environment and governance.

No.	Items	Economy	Social	Environment	Governance
1	Business	√			
2	Economic analysis	√			
3	Economic and social effects	√	√		
4	Economic aspect	√			
5	Economic development	√			
6	Economic growth	√			
7	Economics	√			
8	Electronic commerce	√			
9	Industrial economics	√			√
10	Political economy	√			√
11	Sharing economy	√			√
12	Transitional economy	√			
13	Carbon			√	
14	Conservation of natural resources			√	√
15	Eco-environments			√	
16	Ecological environments			√	
17	Environmental economics	√		√	
18	Environmental management			√	√
19	Environmental protection			√	√
20	Water resource			√	
21	Decision making				√
22	Policy analysis				√
23	Reform process				√
24	Consumer		√		
25	Employment		√		
26	Labor market		√		
27	Poverty alleviation		√		√
28	Rural development		√		√
29	Social capital	√	√		
30	Social development		√		√
31	Social economy	√	√		
32	Social implication		√		
33	Social networking (online)		√		
34	Social policy		√		√
35	Socio-economic development	√	√		√
36	Sustainability	√	√	√	
37	Sustainable development	√	√	√	√
38	Urbanization		√		√
39	Welfare provision		√		√

In 2021, China's population reached 1.43 billion, and its GDP per capita was 17.6 thousand USD (Figure 2). Based on the power equation in Figure 2, the GDP per capita is expected to reach around 35 thousand USD when China's population reaches 1.50 billion. However, based on the logarithmic equation in Figure 2, there will be no significant increment in GDP per capita when China's population reaches 1.50 billion.

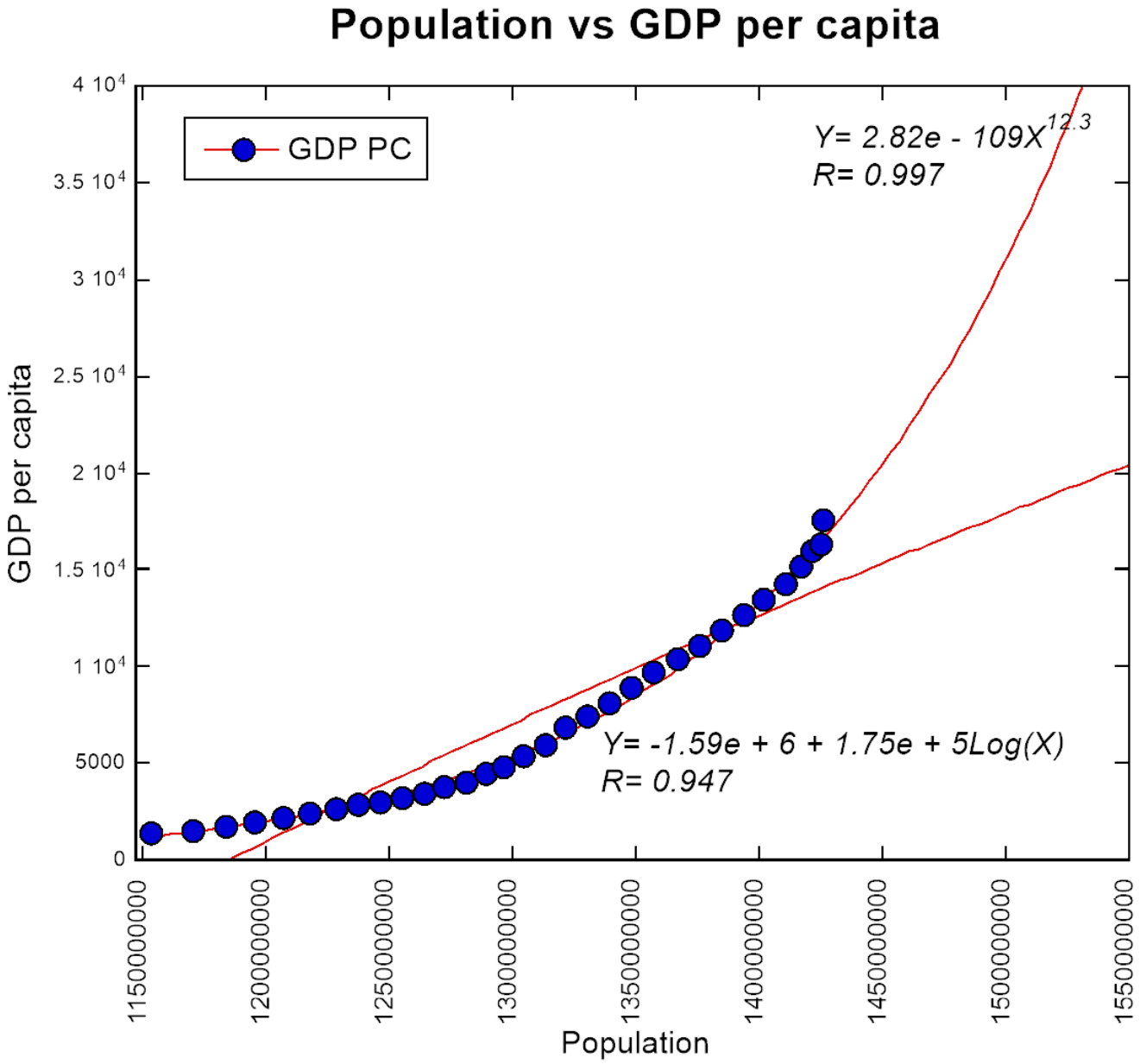

Figure 2.
Relationship between population of China and GDP per capita, based on 1990 and 2021 data, with an extrapolation to 15.5 billion. Two equations are included with power equation (upper) and logarithmic equation (below).
Note: This GDP per capita indicator provides information on economic growth and income levels from 1990 to 2021 based on Our World in Data.

In 2021, the population size of China was 1.43 billion, and the CO_2 emissions was 11.3 billion tonnes (Figure 3). Based on the power equation in Figure 3, the CO_2 emission is expected to reach more than 20 billion tonnes by the population size of China, which could reach about 1.525 billion. However, based on the logarithmic equation in Figure 3, there will be a slight increment of CO_2 emission to 12 billion tonnes when the population size of China reaches 1.525 billion.

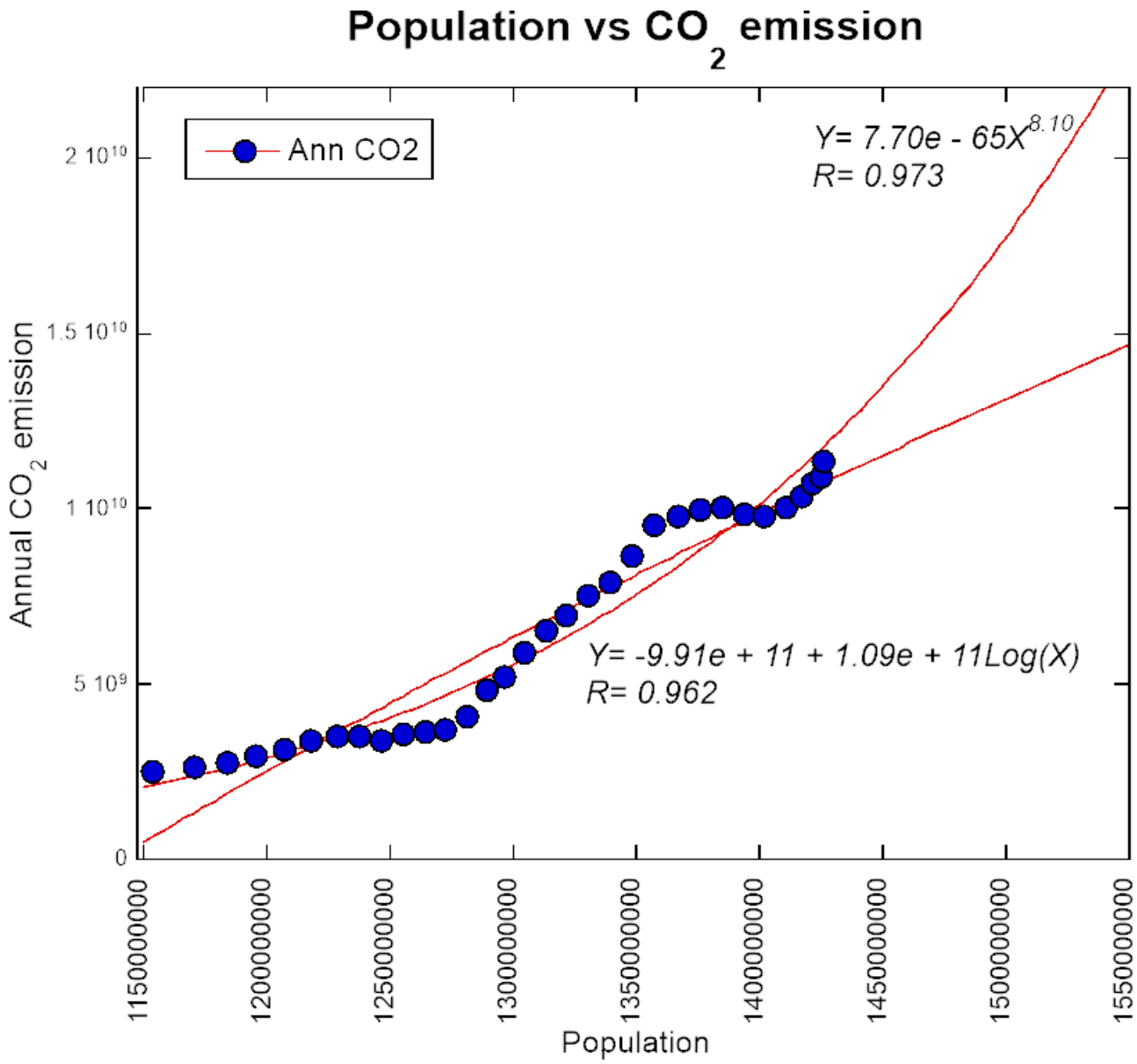

Figure 3.
Relationship between population of China and annual carbon dioxide (CO_2) emission (tonnes), with an extrapolation to 15.5 billion, based on 1990 to 2021. Two equations are included with power equation (upper) and logarithmic equation (below).
Note: Data on global emissions has been converted from tonnes of carbon to tonnes of CO_2 using a conversion factor of 3.664.

In 2021, the GDP per capita is 17.6 thousand USD and the CO_2 emission is 11.3 billion tonnes (Figure 4). There is a clear positive trend of increment from 1990 to 2021.

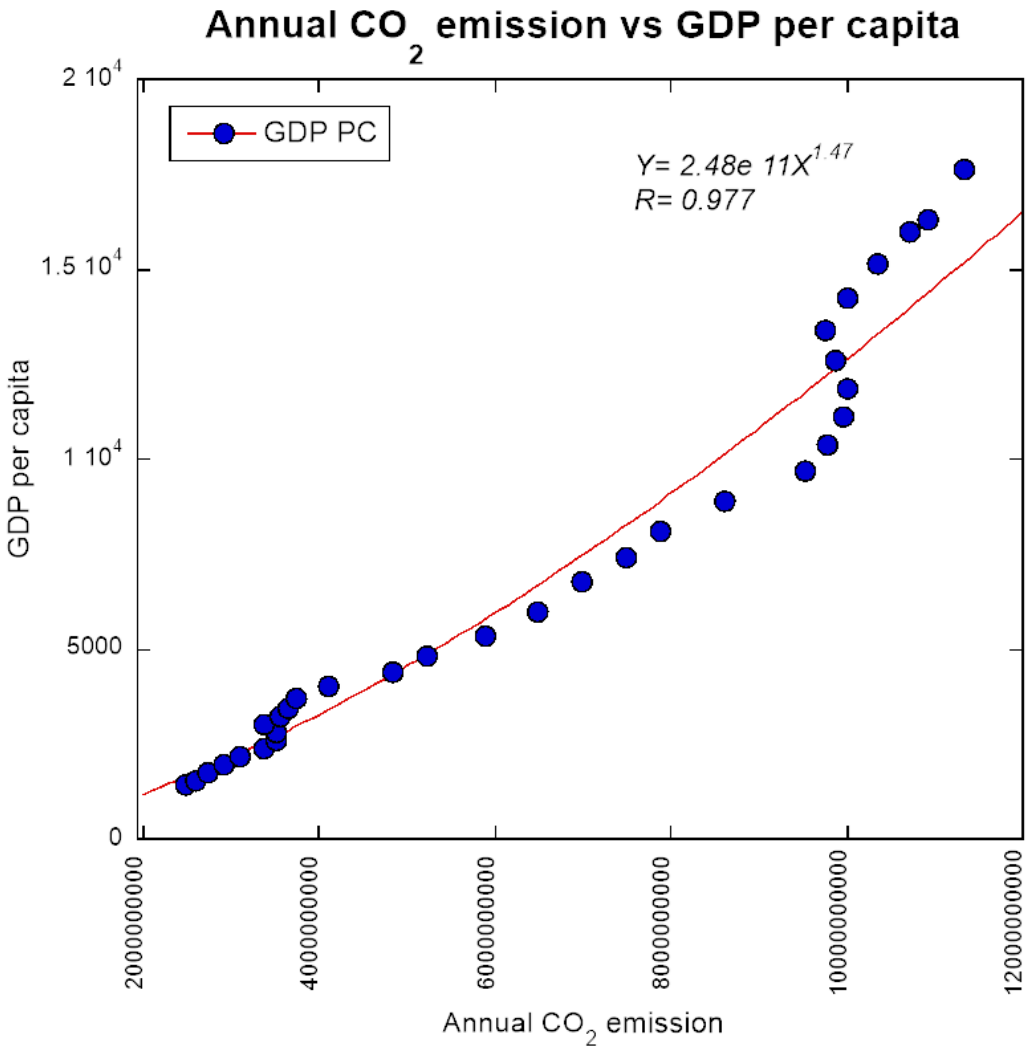

Figure 4.
Relationship between CO_2 emission and GDP per capita, based on 1990 to 2021 data. The power equation line fits the dots well with an R-value of 0.977.

4. Discussion

4.1. The Positive Connections of Population Growth to Socio-Economic Progression

China has experienced substantial population growth, rising from 0.8 billion in 1970 to over 1.4 billion in 2020 [1]. Although it has been surpassed by India as the most populous country [1], China's large population continues to provide a significant advantage in human resources, driving improvements in the economic sector, social life, and education investment. In 1979, the government implemented the one-child policy to curb population growth and alleviate poverty [19] aiming to reduce the strain on resources and boost economic development [20]. However, after several decades, challenges such as an imbalanced sex ratio [21] and concerns over long-term economic impacts [12] emerged. In response, the policy was abolished in 2016 to support human resources development and prevent economic stagnation [22, 23].

The correlation between population size and GDP per capita is evident, as demonstrated by both power and logarithmic equations (R = 0.997 and R = 0.047, respectively) (Figure 1). This highlights the role of a growing population in driving China's economic growth. Rather than individual leaders, the government is credited with shaping these population policies [19] reflecting China's evolving socio-economic strategies in response to demographic shifts.

As China's population grows, it has tapped into various economic resources at multiple levels, including packaging, technology, and research and development [24]. The government has also prioritized external economic relationships, exemplified by initiatives like the Silk Road Economic Belt, which has expanded trade with neighbouring countries, including Malaysia [25]. A notable example is China's involvement in Malaysia's MRT production, benefiting both nations economically. Additionally, talent programs such as the "Thousand Talents Plan" have aimed to attract Chinese scholars back from abroad to contribute to the domestic economy [26].

China's economic strategy increasingly emphasizes sustainability, particularly through natural hydropower as a key energy source, aligning economic growth with environmental goals [27]. This integration of sustainability is also reflected in China's education investments. With increased GDP allocated to education, China has improved access to and quality of education, including nine years of compulsory schooling to enhance human capital through skill-building [28]. Education is a tool for economic development and a driver of sustainable development by equipping citizens with the knowledge to manage natural resources responsibly [27].

Despite these achievements, regional disparities in educational and economic outcomes persist, indicating a need for more tailored policies across different provinces. Investments in education have significantly boosted China's Human Development Index (HDI), particularly in life expectancy, education, and income [29]. Furthermore, research and development (R&D) have been vital in fostering sustainable resource management while minimizing environmental impact, underscoring the necessity of integrating education with sustainability for long-term economic progress.

4.2. Balancing Economic Growth and Environmental Sustainability: Insights from China's Population and GDP Dynamics

The analysis of China's economic and environmental strategies, utilizing a keyword network and GDP-population correlation graph, offers a comprehensive framework for understanding how the country seeks to integrate economic growth with environmental sustainability and social welfare. Research underscores the challenges China faces in balancing rapid development with sustainability goals.

China's rapid economic expansion has contributed to its status as the world's largest carbon emitter [30, 31] highlighting the urgent need to address the environmental costs of growth. The complex relationship between economic progress and carbon emissions is further complicated by regional disparities. For example, the Eastern-Coastal economic zone emits significantly more CO_2 than the less developed Central and Western regions, underscoring the need for region-specific emission reduction strategies [9].

This study sheds light on how China's environmental policies, particularly those rooted in ESG principles, could be adapted based on regional differences. A more localized approach, considering economic and environmental conditions, is crucial for formulating effective strategies to lower emissions.

The Environmental Kuznets Curve (EKC) hypothesis provides insight into China's potential for sustainable development. It suggests that emissions initially rise as GDP per capita increases but eventually decline, provided sustainability is prioritized [32, 33]. Achieving the EKC, however, requires a major shift in China's energy consumption, especially reducing its dependence on coal, a significant source of emissions [32, 33].

Technological innovation is critical in reducing carbon emissions and enhancing energy efficiency. Research reveals that renewable and fossil energy innovation affects carbon intensity differently across regions [34, 35]. This indicates that region-specific technological policies are vital to China's low-carbon development strategy. Investments in green technologies and incentives for renewable energy adoption are essential recommendations for advancing low-carbon goals.

Agricultural efficiency also influences emissions, displaying an "inverted U-shaped" relationship where efficiency improvements can reduce emissions in high-efficiency areas, though low-efficiency regions may experience a temporary rise before emissions decline [30]. This emphasizes the need for sustainable agricultural practices as part of China's broader sustainability objectives. Future research should explore how technological innovations in agriculture can improve efficiency while minimizing environmental impact.

Urbanization presents both opportunities and challenges for China. While it stimulates economic growth and increases carbon emissions through urban land expansion [36]. Policies like the Low-Carbon City Pilot Policy aim to curb emissions through more efficient urban land use, but effectiveness varies across regions [37] indicating the need for adaptive policies that align urbanization with sustainability goals.

Land use patterns also contribute to China's emissions. Southern China, for example, serves as a significant carbon sink due to more efficient economic and land-use practices [31]. Formulating energy and land-use policies tailored to regional conditions is essential for effective emission reductions, and regional policy differentiation could enhance the effectiveness of national carbon reduction efforts.

In conclusion, China's policy landscape increasingly integrates sustainability into its economic development framework. Addressing the interconnected challenges of population size, GDP growth, and carbon emissions requires a multifaceted approach, including technological innovation, regional policy differentiation, and energy efficiency improvements. Aligning these strategies with ESG principles positions China to advance its sustainable development goals. These findings offer valuable insights into how ESG principles can guide policy development in China and other high-growth economies.

4.3. Analyzing the Dynamics of Population Growth, GDP, and Carbon Emissions in China

The relationship between China's population growth, economic expansion, and CO_2 emissions presents a significant challenge as the nation seeks to balance development with environmental sustainability. China's expanding economy and population have contributed to a marked increase in carbon emissions, further complicated by regional disparities and varying levels of development. Research indicates that 57% of emissions are linked to goods consumed outside their province of origin, illustrating the complexity of managing emissions through regional policies alone [20]. This interprovincial carbon leakage highlights how less developed regions struggle to meet emissions targets while more developed areas may achieve theirs by outsourcing emissions.

Recent studies reveal a growing divide in regional CO_2 emissions between 2007 and 2017, driven by industrial progress in some areas and persistent inequalities in development and emissions decoupling [11]. These findings underscore the need for region-specific policies that address each area's distinct capacities and limitations to prevent pollutant migration. A more equitable climate framework that accounts for these disparities is crucial for meeting national emission reduction goals.

Urbanization, trade liberalization, and financial development have been identified as major drivers of China's CO_2 emissions. These factors directly affect emission levels, suggesting that policies targeting urban expansion and trade will be key in shaping China's carbon footprint [38]. The EKC hypothesis further suggests that as GDP per capita increases,

emissions rise initially but eventually decline, presenting a possible pathway for sustainable development as China grows economically [32].

Demographic Factors: China's ageing population also influences CO_2 emissions. Research shows that demographic shifts, particularly the rise in the elderly population, have varying effects on emissions, with some regions seeing increases while others experiencing reductions. This highlights the importance of incorporating demographic factors into regional policy-making, as the ageing population impacts energy demand and consumption [39].

Technological Innovation and Energy Transition: To address these challenges, China must prioritize energy efficiency, foster technological innovation, and accelerate the shift toward greener energy sources. Coal remains a major contributor to emissions, making the transition to renewable energy and improvements in energy efficiency essential for achieving sustainability [32, 40, 41]. Technological advancements in renewable energy and energy efficiency are key to reducing carbon intensity and advancing China's low-carbon transition.

Corporate Sustainability and ESG Practices: Beyond national policy, corporate sustainability and integrating ESG principles into business strategies are critical for aligning economic growth with environmental objectives. By adopting ESG practices, businesses can reduce their carbon footprint while contributing to China's broader sustainability goals [36]. Incorporating ESG considerations across industries ensures that environmental sustainability becomes central to China's economic model.

Comprehensive Strategy: Addressing the interconnected issues of population growth, economic development, and CO_2 emissions requires a comprehensive approach. This strategy must integrate regional policy coordination, demographic considerations, and a focus on sustainability and innovation. A holistic approach that includes technological advancements, corporate ESG adoption, and equitable climate policies will enable China to align its economic goals with environmental sustainability, creating a more resilient development pathway.

4.4. The Interrelationships Between Population Size, GDP, Carbon Emission, and ESG in China

Recent international attention on China's ESG policies highlights the country's notable progress in sustainable development and environmental governance [42-44]. Data reveal a strong correlation between China's population growth, GDP, and CO_2 emissions, which significantly influence its ESG performance [45-47]. The link between economic expansion and CO_2 emissions underscores the challenge of integrating ESG principles into China's growth model.

Since 2015, China has made strides in decoupling major pollutants from economic growth, leading to improvements in healthcare, poverty reduction, and gender equality in education [48-50]. However, challenges such as income inequality between regions and rural-urban divides persist, underscoring the need for continued efforts to enhance sustainable development and ESG performance. The complex relationship between population growth, GDP, emissions, and ESG highlights the difficulty of balancing economic development with environmental sustainability [51-53].

Governance and Policy Initiatives: China's commitment to building an "ecological civilization" is evident in its policy measures, including pollution reduction, closure of polluting enterprises, and stricter enforcement of environmental regulations. These actions have reduced carbon emissions per unit of GDP and boosted ecological [46, 54-56]. Additionally, increased investment in clean energy has strengthened reliance on sustainable energy sources, aligning with ESG principles and reinforcing China's dedication to environmental sustainability [57, 58].

Social Advancements and Ongoing Disparities: Despite significant progress in healthcare, poverty reduction, and educational gender equality, China still faces socioeconomic disparities between regions and rural and urban populations. These inequalities emphasize the need for inclusive growth that benefits all segments of society [59, 60]. Balancing economic development with social equity is crucial for improving ESG performance. While environmental improvements, such as decoupling pollutants from growth, have been achieved, the ongoing link between GDP growth and CO_2 emissions signals challenges in reducing China's carbon footprint.

Technological Innovation and Energy Transition: China's path to a low-carbon economy relies on continued technological innovation to improve energy efficiency and reduce emissions [32, 40]. Industrialization and its resulting emissions remain obstacles, but advancements in renewable energy and stricter emissions regulations can help mitigate these effects [61]. Creating investments in sustainable energy technologies and promoting energy efficiency across industries will be key to achieving China's long-term sustainability goals.

Inclusive Social Growth and Economic Disparities: Addressing regional economic disparities and rural-urban inequalities is critical for fostering social development and improving ESG performance. Although progress has been made in healthcare and gender equality in education, narrowing the wealth gap remains a pressing challenge. Inclusive growth will ensure that all citizens benefit from China's economic development, contributing to a stronger overall ESG performance.

Interconnected Dynamics and Future Policies: The interconnected dynamics of population growth, economic expansion, carbon emissions, and ESG factors will shape China's future policy decisions and sustainability efforts. While rapid economic growth has led to significant environmental impacts, especially in terms of emissions, it also presents opportunities for China to develop an ESG-compliant framework. Future policies must integrate economic, social, and environmental considerations to enable China to meet its sustainability targets while maintaining robust economic growth.

5. Conclusion

In conclusion, China's approach to ecological civilization and ESG principles offers a comprehensive framework for addressing the interconnected challenges of population growth, economic expansion, carbon emissions, and sustainability. The country's proactive ESG strategy has addressed the environmental impacts of rapid industrialization while promoting

social equity and governance reforms to support sustainable development. This research underscores the intricate relationships between population size, economic performance, and emissions and illustrates how China's governance efforts aim to balance these factors for national success and global environmental preservation.

The findings emphasize the importance of integrating economic policies with sustainability goals, demonstrating that unchecked growth can have long-term environmental consequences. By aligning these policies with ESG principles, China aims to foster both economic and ecological health, providing a potential model for other nations to follow.

While China's strategy is tailored to its specific challenges, it offers valuable insights for other emerging economies facing similar pressures to balance growth with environmental sustainability. The global focus on sustainability highlights the need for effective ESG integration, policy innovation, and cross-sector collaboration. As climate change, resource scarcity, and social inequality intensify, ESG principles will play an increasingly critical role in shaping national and international policies.

China's plan demonstrates how a robust ESG framework can bridge the gap between economic growth and environmental stewardship. However, it should not be viewed as a one-size-fits-all solution. Instead, it provides a foundation for other countries to adapt ESG principles to their unique socio-economic contexts, enabling resilient and sustainable development pathways.

While China's progress with ESG principles has yielded positive outcomes, the framework has challenges. Other nations must tailor China's ESG model to their own governance structures, environmental priorities, and industrialization stages. Additionally, global collaboration among scientists, economists, policymakers, and citizens is essential to promoting green investment and sustainable resource management as part of the broader pursuit of global sustainability.

In summary, China's experience illustrates the potential of a well-implemented ESG framework to align economic ambitions with environmental goals and offer guidance for nations striving for sustainable global development.

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