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An Econometric Analysis of Carbon Footprints and Life Expectancy in China

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ABSTRACT

China is currently the global largest emitter of greenhouse gases, with a significant portion of its emissions coming from coal-fired power plants and heavy industries. This high level of carbon emissions has not only contributed to global climate change but also to air pollution and respiratory diseases, affecting the health and well-being of the Chinese population. Against this backdrop, this study employed an econometric method to provide an empirical answer to how carbon footprints affected life expectancy in China. The study made use of secondary data from the World Development Indicators, and the data spanning from 2000 to 2021. Consequently, the data was analyzed empirically with the following results: Carbon footprint in China experienced a noticeable rise, which persisted till 2020 before it slumped sharply in 2021. Similarly, the carbon footprints had an average value of 5.8 metric tons per capita. On the other hand, on an average basis, life expectancy in China was 78 years. Carbon footprints and life expectancy had a significant positive relationship in the country. Moreover, government health expenditure contributed a significant positive impact to life expectancy in China. Therefore, this study submits that China has been able to increase life span of humans in the face of the current climate change with evidence showing that this may be due to increased resilient health sector.

Keywords: CO_2, Life Expectancy, GDP Per Capita
JEL Classifications: H11, H51, Q53

1. INTRODUCTION

Carbon footprints and life expectancy are two crucial aspects that reflect the environmental and public health conditions of a country (Azuh et al., 2020; Jakovljevic et al., 2021). In recent years, China has faced significant challenges in both areas due to rapid industrialization and urbanization (Azuh et al., 2020; Chen et al., 2019; Zhang et al., 2020). The carbon footprint of a country is a metric of the total volume of greenhouse gases emitted into the air because of human activities, like burning fossil fuels to generate energy for transportation, production and industrial processes (Mohamed et al., 2024; Chen et al., 2019).

China is currently the global largest emitter of greenhouse gases, with a significant portion of its emissions coming from coal-fired power plants and heavy industries. This high level of carbon emissions has not only contributed to global climate change but also to air pollution and respiratory diseases, affecting the health and well-being of the Chinese population (Zhang et al., 2020). On the other hand, life expectancy in China has been consistently rising over the past few decades, thanks to advancement in healthcare, sanitation, and living standards. However, the high levels of air pollution and carbon emissions in the country have raised concerns about their impact on public health and life expectancy.

Several studies have highlighted the link between carbon footprints and life expectancy in China. For example, a study by Chen et al. (2019) found that exposure to high levels of air pollution, mainly caused by carbon emissions, related to a decline in life expectancy in Chinese cities. Another study by Zhang et al.[4] demonstrated that reducing carbon emissions through clean energy policies could lead to significant improvements in public health and life expectancy in China. In summary, addressing carbon footprints and reducing emissions is essential for improving public health and increasing life expectancy in China. By implementing sustainable energy policies and transitioning to cleaner sources of energy, China can mitigate the negative impacts of carbon emissions on public health and create a healthier environment for its citizens. In contribution to the frontiers of knowledge, this study is one of the very few to empirically, examine the impact of carbon footprints on life expectancy in China.

2. LITERATURE REVIEW

Mahalik et al. (2022) investigated how the overall lifespan was affected by greenhouse gases for the years 1990 to 2017 in 68 nations with moderate and low incomes. The findings from the study emphasized that an adverse correlation existed between greenhouse gases and overall lifespan across the low-income nations. Also, the research revealed that through the manufacturing of hazardous substances, both the consumption and the manufacturing process might shorten the lifespan of individuals in in countries low-income categories. On the other hand, the research found that greenhouse gases, emitted from all sources increased the lifespan of those living in emerging economies. Farooq et al. (2019) examined the outcome of carbon dioxide emissions on medical difficulties in China. Quantile regression analysis revealed that there was a direct correlation between rising greenhouse gas emissions and a rise in medical problems in the country. Conversely, the processes of greening showed an adverse coefficient, indicating that the expansion of woodlands may be a helpful tool in managing health problems. Consequently, Nansai et al. (2020) looked at the domestic carbon footprint and medical spending in Japan. Utilizing input-output evaluation, the analysis discovered that the primary causes of the rise in the overall environmental impact are medications and health services. The research also showed a rise in carbon footprints related to the usage of healthcare facilities.

Bilgili et al. (2021) examined the relationship between economic expansion, greenhouse gas emissions, and both government and private medical service spending for 36 Asian nations from 1991 to 2017. The fully modified ordinary least squares and quantile regression modeling were employed in the research. It was discovered that both public and private medical spending reduced emissions of greenhouse gases in the country. Wu (2019) assessed the Chinese medical services system and greenhouse gas emissions. The National Bureau of Statistics, several Chinese government-published yearbooks, and the national input-output table for 46 economic industries in China were the sources of the research's data. Using structural path analysis and ecologically extended input-output estimation, the research found that government hospitals, non-hospital purchases of medications, and building were the main sources of greenhouse gas released in the medical sector. The findings showed that due of the nation's overall economic structure and ecological footprint, its greenhouse gases per unit medical spending were comparatively high. Rodríguez-Jiménez et al. (2019) assessed how medical services affected environmental factors, from August to October 2022. A systematic review was carried out in the Medline, Web of Science, CINAHL, and Cochrane archives. According to the research evaluated, pharmaceuticals, medical and non-medical equipment, and recyclables accounted for the largest share of emission levels.

Khan et al. (2022) examined the relationships between carbon footprints, the area covered by climate-controlled environments, utilization of green power, and chemical-based fertilizer usage with agrarian economic expansion in China in order to achieve environmentally friendly targets. From 1980 to 2020, secondary time series data for each year were collected from China's agricultural division, British Petroleum's energy statistics, and the World Bank's development indicators. The research used the novel Kripfganz P-value, the innovative dynamic autoregressive distributed lag (DYARDL) simulations approach, and the autoregressive distributed lag (ARDL) bounds analysis. The unit root test results validated that each of the research variables has stationary characteristics. It proved that the variables were cointegrated using the ARDL bounds checking. The DYARDL simulations model showed that raising emissions area and green power utilization both boosts agrarian economic expansion in the near and long haul.

Khan et al. (2019) examined the effects of both ecological cleanliness and power utilization on the total economic output in five South Asian nations between 1990 and 2015. To obtain the outcomes, the Granger Causality Test and the error correction approach were used. The research findings demonstrated co-integration between the variables and suggested a significant correlation between GDP, power usage in the agricultural industry, and ecological cleanliness.

Latif et al. (2020) analyzed the dynamic causal connection between greenhouse gas emissions, GDP, green power, agricultural value-added, and population for the thirteen industrialized and emerging Asia Pacific nations from 2005 to 2017. Through the use of Granger causality and panel co-integration techniques, the study discovered that factors such as GDP growth, unchecked population growth, agricultural value-added loss, and an insufficient of focus on green power are all associated with emission levels.

Sun et al. (2023) examined the rising pattern of province-level greenhouse gas disparity in China and calculated the ecological impact of various programs aimed at reducing poverty, as shown by rising greenhouse gases. The findings showed that eliminating poverty will not prevent the country from meeting its environmental goals, with a 0.1–1.2% yearly rise in household greenhouse gas emissions. But in developing areas, the growth in greenhouse gases might reach 4.0%, nearly five times greater than in prosperous areas. Eradicating poverty places a larger pressure on areas with fewer resources due to climate change, potentially counteracting measures to reduce carbon emissions.

Jia et al. (2022) examined how emissions neutrality affected URI. The reduction in benefits on the consumption aspect of rural families is greater than that of urban families, as evidenced by the outcomes, which also demonstrated that rural inhabitants have less greenhouse gas emissions but more intense consumption. Refraining from taking the greenhouse gases income reprocessing into account, nearly all emission pricing schemes will result in higher URI. Recycling strategies that take population and electricity use into account are better suited to achieving emissions equity and reducing the URI by means of source-side utility effects.

3. METHODOLOGY

Figure 1 above describes the conceptual framework of the study. This shows the network of relationships between the principal variables in this study. The inclusion of GDP per growth and health expenditure as control variables was motivated due to the important roles income and health expenditure play in enhancing good living standards (Sikwela et al., 2025; Jia et al., 2025; Sikwela and Aderemi, 2025).

3.1. Data

This study covered the periods that span between 2000 and 2021. Data for CO_2 emissions (metric tons per capita), life expectancy, domestic general government health expenditure per capita rate, and GDP per capital growth were extracted from the secondary source, which is the World Development Indicators published by the World Bank (2023). These data are published by the research unit of the World Bank for consumption of the public. Therefore, this study made use of the data for its empirical analysis.

3.2. Model Specification

To develop a robust model in the assessment of the nexus between carbon footprints and life expectancy in this study, insight was drawn from the studies such as Afolayan and Aderemi (2019), Osabohien et al. (2021), Zhou et al. (2023) and Olayemi et al. (2019) in this form;

Life Expectancy (LE) = f (Carbon Footprints, CF, domestic general government health expenditure per capita, GGP, GDP per capital growth, GDPG). (1)

From equation (1), it is important to state that life expectancy is the dependent variable. While the independent variable is carbon footprints. In addition, two more control variables, domestic general government health expenditure per capita and GDP per capital growth were added to the model to improve the robustness of the model.

In transforming equation (1) into an econometrics model, equation (2) emerged as follows:

$$LE_t = \alpha_0 + \beta_1 CF_t + \beta_2 GGP_t + \beta_3 GDPG_t + \mu_t \quad (2)$$

In Table 1, the operational definitions of various variables in the study are discussed as follows.

3.3. Estimation Technique

The appropriate method of estimation for the study is fully modified least squares. This is the analytical technique used to estimate unknown parameters in the study. This is a regression that includes deterministic variables, integrated processes and their powers as regressors. The errors are allowed to be correlated across equations, over time and with the regressors. Also, the regression is constructed in such a way that the usual least squares procedure yields asymptotically efficient estimators. Moreover, Eviews 10 econometrics software was used to run the analysis.

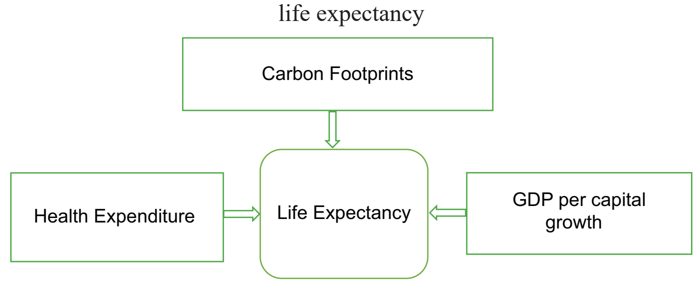
Similarly, the study considered the use of graphs and descriptive statistics as well. This further provides a historical perspective to the assessment of the studied variables over the years. Whereas the descriptive statistics show how variables under consideration were distributed over the periods of the analysis, and the mean value was estimated by summing up all the observations from 2000 to 2021 and divided by the number of the years, which is 22.

4. RESULTS AND DISCUSSION

The Figure 2 shows carbon footprints in China between the periods of 2015 and 2021. In 2015, carbon footprints were 7.145 metric tons per capita which slightly reduced in 2016. However, in 2017, there was a noticeable rise in carbon footprints. It is important to stress that this rise persisted till 2020 before it slumped sharply in 2021.

In showing the pattern of life expectancy in China within the periods of 2015 and 2021, the Figure 3 has been designed to provide the following useful information. From the figure, China

Figure 1: A schematic graph about the impact of carbon footprints on life expectancy



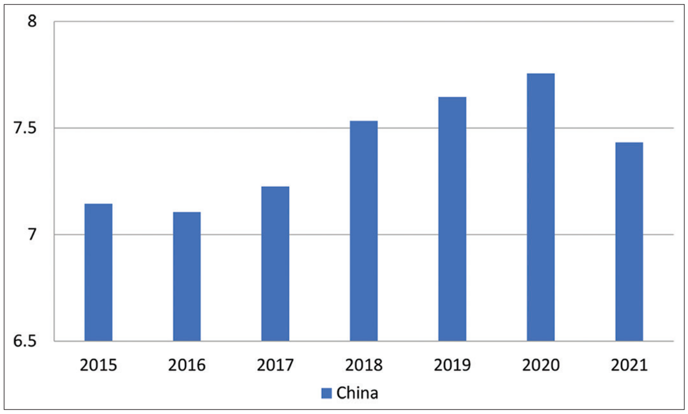
Source: Authors' (2025)

Table 1: Measurement of variables

Abbreviation	Variable	Operational definition	Expected sign
LE	Life expectancy.	Life expectancy at birth (years)	
CE	Carbon footprints.	Co_2 emissions (metric tons per capita). This is an average household carbon footprint.	-
GGP	Health expenditure	Domestic general government health expenditure per capita.	+
GDPG	Gross domestic product	GDP per capital growth	+
μ	Error term	Other variables that affect the study but not captured in the study.	
t	Scope of the study	2000-2021	

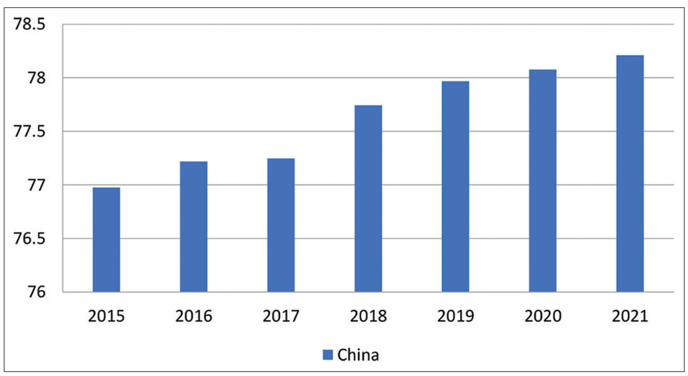
Source: Authors' (2025)

Figure 2: Carbon footprints (metric tons per capita) in China



Source: Authors' (2025)

Figure 3: Life expectancy at birth, total (years)



Source: Authors' (2025)

had a life expectancy of 76 years in 2015 after which it was improved to 78 years in 2021. It is worthy of note that, each year, life expectancy has been improving in China.

In Table 2, all descriptive statistics of both the dependent and the independent variables associated with the study were presented with a view to summarizing their distribution over the time. Starting from life expectancy, which is the dependent variable, from the periods of 2000-2021, 71 years was the minimum life expectancy while 78 years was the maximum life expectancy simultaneously. But the mean value of life expectancy was 78 years. However, the minimum value of carbon footprints was 2.6 metric tons per capita, and the maximum value was 7.7 metric tons per capita, while, it had an average value of 5.8 metric tons per capita. Consequently, the mean value of domestic general government health expenditure per capita was $138. Similarly, $326 and $9 were respectively both the highest and the lowest per capita domestic general government health expenditure. GDP per capita growth rate recorded 13.6% as its highest value and 1.9% as its lowest value respectively. Meanwhile, the mean value of this variable is 8%.

In Table 3, the estimated results of the relationship between life expectancy and carbon footprints in China were shown with the following interpretations. Firstly, R-squared validates the robustness of the adopted model because its value which is 0.98 indicates that about 98% of the variation in the dependent variable, life expectancy was explained by all the explanatory variables. Meanwhile, carbon footprints and life expectancy had a significant positive relationship. Government health expenditure and life expectancy possessed a significant positive relationship. In addition, the growth rate of GDP per capita had a positive and significant influence on life expectancy.

Table 2: Descriptive statistics of the variables of the study

Descriptive statistics	LE (years)	DGHE ($)	CO_2 (metric tons per capita).	GDP (%)
Mean	75.56768	138.1009	5.838085	8.088908
Median	75.75100	113.5411	6.618384	7.995159
Maximum	78.21100	326.2770	7.756138	13.63582
Minimum	71.88100	9.447972	2.650409	1.995558
Standard deviation	1.896463	115.3479	1.761143	2.433732
Skewness	−0.301327	0.308890	−0.631734	−0.003935
Kurtosis	1.977697	1.563383	1.924562	3.900019
Jargue-Bera	1.290937	2.241728	2.523509	0.742587
Probability	0.524417	0.325998	0.283157	0.689841
Sum	1662.489	3038.219	128.4379	177.9560
Sum Sq. deviation	75.52804	279407.8	65.13415	124.3841
Observations	22	22	22	22

Source: Authors' (2025)

Table 3: Fully modified least squares (FMOLS) of carbon footprints and life expectancy in China

Regressors	Coefficient	Standard error	t-statistic	Probability
CO_2	0.469349	0.068436	6.858168	0.0000
DGHE	0.011129	0.001241	8.968603	0.0000
GDP	0.111631	0.030703	3.635893	0.0020
R-squared	0.989349			
Adjusted R-squared	0.987926			

Source: Authors' (2025)

Having estimated nexus between life expectancy and carbon footprints in China, a comprehensive discussion of the results regarding this subject matter is as follows; carbon footprint in China experienced a noticeable rise, which persisted till 2020 before it slumped sharply in 2021. Similarly, the carbon footprints had an average value of 5.8 metric tons per capita which contradicts the SDG 13 target. This shows that China is currently lagging in meeting the SDG 13 target. As such, the policymakers in China needs to embark on policy measure that will reduce CO_2 emissions metric tons per capita to at least 2.3 tons if the SDG 13 will be achieved in the country by 2030. On the other hand, each year, life expectancy has been improving in China. Within the scope of the analysis, the country had an average life expectancy of 78 years. This finding is supported by Sun et al. (2024). This reflects China's commitment to the promotion of policies and programmes that enhance healthy lives and well-being for all and sundry in the country.

Furthermore, carbon footprints and life expectancy had a significant positive relationship in China. According to the finding, a unit change in carbon footprints increased life expectancy by 4.6 years in the country. This is an indication that carbon footprints are not a threat to the lives of people in China. This finding is supported by submission of Mahalik et al. (2022)who asserted that greenhouse gases emitted from all sources increased the lifespan of those living in emerging economies. However, this study contradicts submission of Wu and Hao (2024) who enunciated that agricultural carbon footprints contributed an insignificant positive impact on life expectancy in China. It is pertinent to submit that one the major reasons for this positive result in China could be attributed to the country's resilience to the disastrous effect of carbon footprints which is a menace in most countries in the global south. In the same vein, in mitigating hazardous effects of carbon footprints, China's continuous commitment towards the usage of advanced technologies in health sector in enhancing healthy lives and well-being for all and sundry could not be undermined. In this regard, the policymakers in the global south, especially the Sahel region where carbon footprints are threat to human security, should emulate China by building resilient health sector that has the capacity to increase life span of humans in the face of the current climate change.

Moreover, domestic general government health expenditure per capita in China had a mean value of $138 which is far bigger than its sub regional counterpart, India which has a domestic general government health expenditure per capita of $69 (WDI). As such, government health expenditure contributed a significant positive impact to life expectancy in China. Based on this empirical finding, a unit change in general government health expenditure per capita led a rise in life expectancy by 1.1 years. In view of the above, the policymakers in China and the rest of the global south should prioritize investment in the health of individual citizen in line with the global commitment to improving life expectancy in 2030. Also, GDP per capita growth exhibited a significant positive impact on life expectancy. Based on this, a unit change in GDP per capital growth increased life expectancy by 11 years in China. This shows that a vibrant economic resource is a strong factor that catalyzes a rise in life span in the country. Therefore, policy that will ensure a sustainable growth of GDP per capita should be embarked by policymakers in China and other middle-income countries.

5. CONCLUSION

This study therefore concludes that carbon footprint in China experienced a noticeable rise, which persisted till 2020 before it slumped sharply in 2021. Similarly, the carbon footprints had an average value of 5.8 metric tons per capita. On the other hand, each year, life expectancy has been improving in China. On an average basis, life expectancy in China is 78 years. Carbon footprints and life expectancy had a significant positive relationship in the country. Moreover, domestic general government health expenditure per capita in China had a mean value of $138. As such, government health expenditure contributed a significant positive impact to life expectancy in China. GDP per capital is a vibrant economic resource that catalyzes a rise in life span in the country.

Besides well stated research question, the emergence of new empirical evidence using both comprehensive descriptive and quantitative analysis serves as the strengths of this study. Meanwhile, the limitation of this study is enshrined in its scope, as it focuses on only China. The results might not be strong enough for generalization of the situation reports of the entire Asia. Further investigations could therefore be conducted in each of the entire Asian countries to provide a robust policy implication for the entire continent.

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