RESEARCH PAPER

Sustainability vs. Economic Development: A Comparative Analysis of Environmental Impact and Economic Growth in Developed and Developing Economies

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Abstract

This study examines the relationship between economic growth and environmental quality in the United States and China from 2004 to 2024 within the Environmental Kuznets Curve framework. Using a comparative analytical approach, the study employs GDP per capita as the indicator of economic growth and CO_2 emissions per capita as the indicator of environmental impact. Secondary data were obtained from World Bank sources, and historical trend analysis was used to compare a developed economy. The findings reveal clear differences between the two countries. In the United States, GDP per capita increased substantially while CO_2 emissions per capita generally declined, indicating stronger evidence of decoupling and suggesting that the country is positioned in the later stage of the EKC. In contrast, China experienced rapid growth in GDP per capita accompanied by an overall increase in CO_2 emissions per capita, reflecting the environmental pressures associated with industrial expansion and an earlier stage of EKC development. The study further shows that environmental outcomes are shaped not only by income growth but also by technological progress, policy design, and energy transition. Policy comparison indicates that the United States relies more on subsidies and regulatory measures, whereas China combines subsidies, regulations, and emissions trading mechanisms in a more integrated framework. The analysis also highlights that climate shocks, pandemics, and trade tensions can alter the growth–environment relationship. Overall, the study concludes that sustainable development requires coordinated environmental policy, innovation, and long-term planning alongside economic expansion.

Keywords: Economic growth, environmental sustainability, GDP per capita, United States, climate policy, sustainable development; economic growth

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1. Introduction

One of the pillars of national development is economic growth since it brings an increase in incomes, job creation, growth of infrastructure, and living standards. This process however has usually environmental costs and in instances where the grow is influenced by industrialisation, fossil fuel use, and production that consumes a lot of energy. In the growing economies especially, the correlation between economic growth and environmental sustainability is complicated, as the growth can eliminate poverty, at the same time exacerbating carbon emission and environmental pressure (Hunjra et al., 2024; Gazi et al., 2025).

One of the frameworks that is widely used to explain this relationship is the Environmental Kuznets Curve (EKC), which postulates that the first stage of environmental degradation is positively correlated with economic growth but later the relationship reverses at a particular income level. The recent comparative evidence of E7 economies indicates that the EKC could still be useful in discussing the growth-emissions nexus, but the time and form of the turning point vary among any given countries based on their developmental trajectories and structural circumstances (Ayik and Ozer, 2025). This means that growth does not have uniform environmental implications and its interpretation should be put in certain contexts of a country.

The relationship between the economic activity, the energy systems, and emissions is also being increasingly perceived as nonlinear (Odei et al., 2025). Projection models of the energy, economy and emission Elucidating long-term environmental patterns with single linear assumptions is not possible, since the

responsiveness of changes in energy consumption, technological shifts and economic shocks is frequently uneven and dynamic (Bennedsen et al., 2023). Moreover, energy resilience and adaptation systems are also getting on the environmental analysis agenda, with infrastructure reacting to disruption potentially not only affecting long-term patterns of consumption and emissions but also affecting long-term trends (Daniel et al., 2024).

The climate policy is thus highlighted as the key to the realisation of whether nations can continue to grow economically and minimise their destruction to the environment. Empirical evidence of carbon pricing and associated climate instruments suggests that well-constructed policy packages can have a negative impact on CO_2 emissions, and they do not need to incur a high macroeconomic cost (Kohlscheen et al., 2025). However, policy inconsistency is one of the significant issues. The further encouragement of fossil-fuel production, such as that, can undermine the process of decarbonization and cause conflicts between the environmental objectives and the economic interests (Magazzino and Mele, 2025). At the international scale, it has been demonstrated that certain economies have been able to achieve quantifiable gains of decoupling the growth of output and carbon emission, which indicates that long-term growth can and does not necessarily come with increasing levels of environmental degradation (Freire-Gonzalez et al., 2024).

Market-based and regulatory interventions are becoming more relevant in the developing and transition economies. Research on the carbon emission trading pilot of China indicates that the regulation of the environment may have an effect on both the consumption of energy and the adaptation of technology in the carbon-intensive industries (Guo et al., 2025). The studies on high-income economies also demonstrate that the implementation of renewable energy, the density of cities, and openness to trade can redefine the relationship between EKC and enhance environmental performance (Mata et al., 2024). The legal and institutional structures of carbon emissions trading are increasingly more important in China toward the wider shift to low-carbon development (Yu et al., 2025).

Institutional quality and coordination of policies also define cross-country differences in the sustainability outcomes. Comparative evidence reveals that more sustainable economies are likely to integrate growth with greener technologies and a superior environmental policy unlike economies that still depend on carbon-intensive growth (Teixeira et al., 2025). Simultaneously, international trade trends and protectionist forces can modify carbon emissions and ecological footprint and make the predicted pathway of EKC more complex (Wang et al., 2024). This problem was particularly evident during and after the COVID-19 era when, despite the short-term positive effects of environmental changes due to disordered activity, such improvements were compensated in the economic recovery (Ray et al., 2025).

Besides conventional regulation, other new tools like green finance are also being looked into as a tool of influencing capital to cleaner sectors and emissions intensity reduction (Rastelli, 2025). Evidence reviews also indicate that the effectiveness of carbon pricing and compensatory schemes should be largely based on the policy design and institutional coherence (Salguero, 2025). The mutual impact of the policy of emissions trading and renewable-energy support in China suggests that the design of the policy can be more effective at the long-term level compared to isolated interventions to support sustainable transition (Shuyue and Yue, 2025).

In this context, the current paper considers the correlation between environmental quality and economic growth in the United States and China between 2004 and 2024 based on GDP per capita and CO_2 emissions per capita in the framework of the Environmental Kuznets Curve.

2. Methodology

2.1 Research Design

The research design taken in the study is a comparative analytical research design to examine the relationship that exists between economic growth and environmental quality in both developed and developing economies. It will be analysed according to the Environmental Kuznets Curve (EKC) framework that environmental degradation increases at first, in the initial economic development stages, and then declines with the increase of the income levels and the improvement of environmental policy and technologies. The paper contrasts two nations that are at different levels of development in order to determine the interaction between economic growth and environmental outcomes.

2.2 Selection of Study Countries

A comparative analysis was done on two countries which are the United States carrying the developed economy and China carrying the developing economy. The countries were selected due to the differences in the levels of economic development and the implementation of environmental policies in them. The

US is regarded as a high-income economy that has witnessed great technological development and environmental control whereas China is a fast-growing industrial economy in which the growth of the economy has been correlated with the growth of industrial production and emissions.

2.3 Data Sources and Study Period

The research is based on the secondary sources that were gathered using the internationally known databases. As an economic measure, economic growth is gauged on the GDP per capita (current US dollars), whereas on the environment, CO_2 emissions per capita is used. Both data sets were taken from the World Bank, as mentioned in the document. The analysis will use annual figures that were collected over a 20-year span in case of 2004 to 2024 and this will enable investigating both long-term economic and environmental tendencies in the two nations.

2.4 Variables and Indicators

In this work, two variables are employed to investigate the connection between environmental sustainability and economic development. The first variable is the GDP per capita as it is a measure of economic growth and indicates the economic development of the countries. The second variable is the CO_2 emission per capita, which refers to the environmental impact and is employed to measure the quality of the environment. These variables enable the research to determine whether the growth of the economy has been linked to either the growing or the declining environmental degradation over time.

2.5 Analytical Framework

The theory that will guide the analysis is the Environmental Kuznets Curve (EKC) theory that explains the connexion between economic development and environmental degradation. The EKC hypothesis argues that the levels of environmental degradation rise in the early periods of economic growth as a result of industrialisation and a rise in energy demand. Nevertheless, with the development of the economies, the quality of the environment is improved by technological innovation, more stringent ecological rules, and higher awareness of people. In this theoretical framework, the study identifies the economic and environmental trends of both the United States and China in order to determine the presence of characteristics of the two nations which can be attributed to different stages of the EKC.

2.6 Data Analysis Approach

The research uses historical trend analysis and comparison interpretation. The GDP per capita and CO_2 emissions per capita annual data of both countries were considered and applied to determine the long-term trends in economic development and environmental effects. The trends have been plotted to analyse the increases in income and the corresponding increase or decrease in emissions. In the case of the United States, the analysis is based on the finding of evidence of decoupling, which is the continuation of economic growth and the reduction of emissions. In the case of China, the analysis is on whether economic growth is still linked with the growth in emissions, which is the nature of the relationship in the earlier economic development phases under the EKC model.

2.7 Policy and Contextual Assessment

Besides the quantitative analysis of the trend, the research incorporates a qualitative assessment of the environmental policy undertaken in the two countries. The policies addressed in the paper can be defined in three categories: fiscal policies and instruments, including green subsidies and green incentives, regulatory policies, including environmental policies and environmental controls, and market policies, including emissions trading policies. The paper also takes into account the impacts of significant disruptions of the world such as climate shocks, pandemics, and trade conflicts, on the relationship between economic growth and environmental quality of the chosen countries.

3. Results

The findings indicate different trends of the relationship between economic growth and the quality of the environment in the United States and China during the year 2004 to 2024. The historical trends based on the GDP per capita as the indicator of economic growth and the CO_2 emissions per capita as the indicator of environmental quality show that the United States had stronger evidence of decoupling between growth and emissions, whereas China had further development of emissions and economic growth.

3.1 Trends in the United States

The developed economy, the United States, registered a GDP per capita of USD 41,724.63 in 2004 which had grown to USD 84,534.04 in 2024. At the same time, the ratio of CO_2 emissions per capita fell from 20.08 to 13.62. These findings show that even though there were dramatic growths in the U.S. economy within the study period, there was a general decline in environmental pressure in terms of carbon emission per capita.

The year-by-year trend also indicates that the plasticity of the fall in emissions was not exactly continuous. As an illustration, the increase in CO_2 emissions per capita

was slight between 2009 (17.19) and 2010 (17.85), between 2012 (16.19) and 2013 (16.50), between 2017 and 2018 (13.47) and 2020 and 2021 (14.32) and 2022 (14.42). Although of these short-term fluctuations, the long-term trend is downward, GDP per capita stayed on an increase overall. This implies that the growth of the economy in the United States has been characterised to a large extent by the improvement of the environment over time. Table 1 shows the values of GDP per capita and CO_2 emission per capita in the United States between 2004 and 2024.

Table 1. GDP per Capita and CO_2 Emissions per Capita in the United States (2004–2024)

United States		
Year	GDP per capita	CO_2 emissions per capita
2004	41724.63163	20.08155979
2005	44123.40707	19.92499142
2006	46302.00088	19.40481771
2007	48050.22378	19.49566069
2008	48570.04598	18.70890263
2009	47194.94335	17.1890632
2010	48642.61002	17.84708431
2011	50024.8688	17.0203889
2012	51708.40116	16.1854221
2013	53179.01276	16.49597522
2014	54973.42075	16.42489531
2015	56572.9189	15.95010229
2016	57638.10184	15.50454822
2017	59635.09844	15.18471272
2018	62499.87444	15.57964566
2019	64746.45068	15.04396621
2020	63515.94918	13.47158217
2021	70205.05092	14.31611543
2022	76657.24888	14.41771488
2023	81032.26212	13.71194199
2024	84534.04078	13.6195685

This outcome is also supported by the figure of the Environmental Kuznets Curve of the United States as it demonstrates a trend that is similar to that of the late stage of the EKC where the higher the income levels the lower the rate of environmental degradation. This pattern in the file is reflected as an indication that the United States has undergone absolute decoupling, which implies that the nation has crossed the EKC turning point. The relationship between GDP per capita and CO_2 per capita is the relationship of the Environmental Kuznets Curve, which demonstrates the correlation between these variables in the case of the United States in Figure 1.

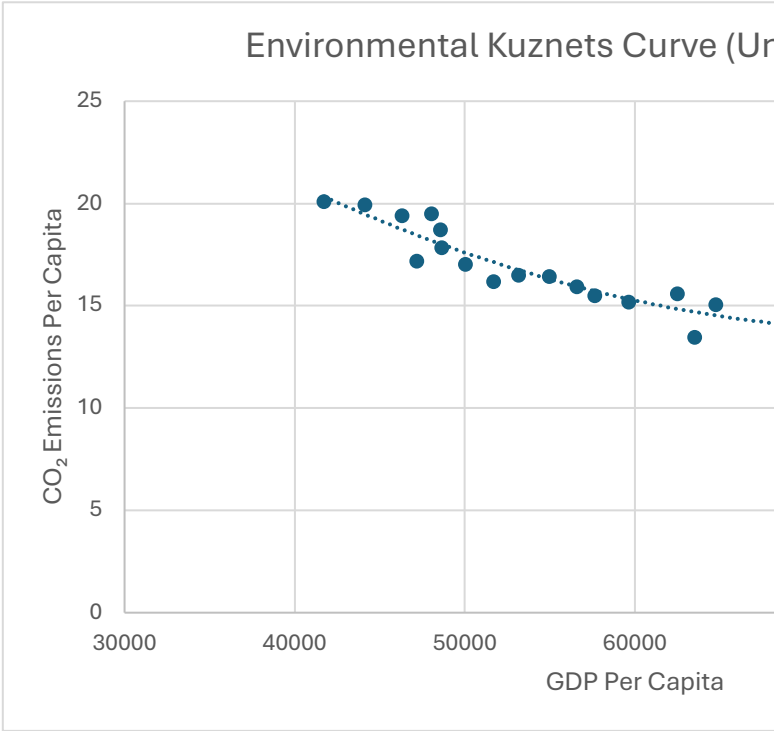

Figure 1. Environmental Kuznets Curve (United States): Relationship between GDP per capita and CO_2 emissions per capita (2004–2024)

3.2 Trends in China

China was chosen as the developing economy where the GDP per capita stood at USD 1,530.93 in 2004, and the figure rose significantly to USD 13,303.15 in 2024. During the same time, the per capita CO_2 emissions increased from 4.24 to 9.32. The same outcomes show that economic growth in China has been followed by general growth in carbon emissions per capita.

During the period of 2004-2014, the GDP per capita increase was accompanied by the CO_2 emissions per capita increase. There was an improvement of GDP per capita by USD 1,530.93 to USD 7,781.07 and also an increase in emissions between 4.24 and 7.93. The relationship between the two is positive as evidenced by this trend of economic growth and environmental degradation as observed in the early years of EKC. The decline in emissions growth can be noted after 2014. In 2017 the emissions went down from 7.93 in 2014 to 7.79 in 2015 and 7.76 in 2016, then increased again to 7.88 in 2017, 8.22 in 2018, 8.39 in 2019, 8.48 in 2020, 8.89 in 2021, 8.86 in 2022, 9.23 in 2023, and 9.32 in 2024. Therefore, the current year's trend is a bit contradictory in terms of the growth of emissions, still generally positive. Figure 1 shows the relationship between GDP per capita and the CO_2 emission per capita of the United States.

Table 2. GDP per Capita and CO_2 Emissions per Capita in China (2004–2024)

China		
Year	GDP per capita	CO_2 emissions per capita
2004	1530.927262	4.240697491
2005	1777.644968	4.782994201
2006	2129.25697	5.280525164
2007	2734.727099	5.707632457
2008	3523.443021	5.852258664
2009	3898.244592	6.249090185
2010	4629.245517	6.807184768
2011	5703.76028	7.401850658
2012	6405.057424	7.584416515
2013	7147.035186	7.893276312
2014	7781.065975	7.931643316
2015	8175.332851	7.790570493
2016	8254.868593	7.763224839
2017	8979.676527	7.878026522
2018	10085.66381	8.217736249
2019	10342.90095	8.391475871
2020	10627.4638	8.47858302
2021	12887.43572	8.887156603
2022	12970.60564	8.86482511
2023	12951.17824	9.230275535
2024	13303.14815	9.315089338

This trend is reflected in the Environmental Kuznets Curve figure of China as the country is still passing through a phase where economic growth is linked with an increase in environmental pressure. The file states that despite the improvement in carbon intensity due to the increase in energy efficiency and policy initiatives, the total levels of the economy have ensured that the total levels of the economy remain intense in the context of the overall emissions. Thus, it seems that China is shifting towards cleaner growth, although environmental improvement is yet to keep pace with the economic growth. The rapid economic growth could be observed as GDP per capita grew, as shown in Table 2, between USD 1,530.93 in 2004 and USD 13,303.15 in 2024. CO_2 emissions per capita had grown to 9.32 in the same period, which was 4.24 higher than in 1970. This is a trend that suggests that the growth of the economy in China has been characterised by growing carbon emissions, especially in the years when the growth of the economy was in the initial stages of growth. Figure 2 presents the Environmental Kuznets Curve association between China and China, which indicates that the rise in the GDP per capita is linked with the rise in CO_2 emissions per capita over the study period.

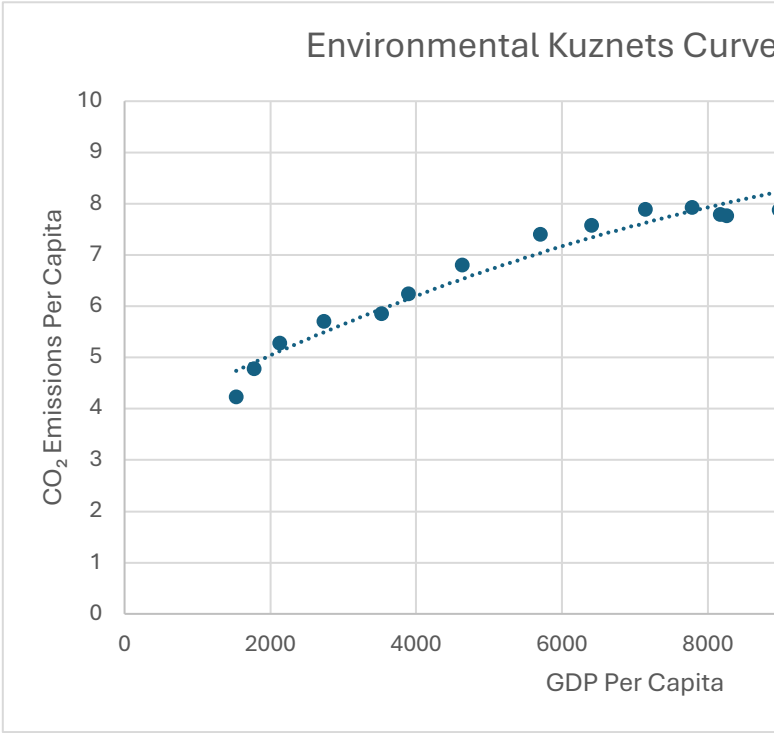

Figure 2. Environmental Kuznets Curve (China): Relationship between GDP per capita and CO_2 emissions per capita (2004–2024)

3.3 Comparative Results

When comparing the two countries, it is evident that there is a difference in the growth environment at the level. The growth in GDP per capita and a declining rise in CO_2 emission per capita in the United States represented greater decoupling and provided more support to the idea that the nation is at a later EKC stage. The level of GDP per capita and CO_2 emissions per capita both rose throughout most of the study period in China, meaning that the country is still nearer to the earlier stage of the EKC, as the increase in the economy is still accompanied by a decline in the environment.

The findings hence indicate that the identical economic growth process may not have the identical environmental implications in an economy of varying developmental levels. The United States exhibits long-term trends that are in line with the improvement of the environment coupled with further economic growth, but China exhibits high economic growth coupled with the structural environmental pressure in the country. In general, the results of the comparison indicate that the economic growth has been linked to various environmental outcomes of both countries during the study period.

4. Discussion

The findings of this research indicate that there are significant disparities in the connexion between economic development and environmental quality between the developed and the developing economies. When comparing the United States and China, it is evident that the environmental performance of economic growth is highly dependent on the level of economic development, the level of technological capabilities, and environmental regulations. The results are consistent with the general body of empirical studies that discuss the Environmental Kuznets Curve (EKC) and its regional variations.

Empirical research findings done in the recent past indicate that the EKC relationship is not consistent in all nations (Wang and Kim, 2024). As an illustration, the scholars have studied the economies of West Africa but have found that spatial relationships and economic systems can play a crucial role in the long-term mechanism of financial growth and carbon emissions (Tang et al., 2025). These findings can be interpreted to mean that various countries might pass through the various stages of the EKC at different rates with regard to the industrial structure, trade patterns and policy interventions.

The data, which is applied in this paper, is based on internationally accepted indicators of economic development and environmental pressure. GDP per capita is one of the most frequently utilised metrics of economic performance, whereas CO_2 emissions per capita are one of the most popular measures of environmental effects (World Bank, 2026). The indicators allow comparison of economic-environmental relationships in countries and long-term periods, which is consistent.

Policy frameworks are also very critical in influencing environmental outcomes. In developed economies, the reform of environmental policies is more oriented toward the integration of climate goals with economic policies. It has been proposed by policy research that climate reforms such as the use of incentives in investment, regulations, and policies on carbon can play a huge role in the national patterns of emissions despite maintaining economic stability (UCLA School of Law, 2024). In the case of developing economies, there is a rise in emissions when the economy is growing in the initial phases of industrialisation. Empirical evidence of the emerging economies indicates that industrial growth, foreign investment and structural transformation often lead to the creation of excessive carbon footprint in the early stages of development (Saeed, 2025).

Meanwhile, new governance frameworks of the environment are transforming the path of emissions. The study of the carbon emission trading system in China shows that the market-based environmental regulation can contribute to the decrease in energy use and the advancement of less-polluting production technologies in the branches with a high level of carbon emissions (Wang et al., 2025). Likewise, the literature researching the connexion between economic development and carbon emissions in China is indicative that the EKC turning point can be reached when energy efficiency gains and policy collisions start to exceed the burden on the environment of industrial growth (Chen and Tu, 2025).

Climate governance can also be impacted by interactions between environmental policies. Research conducted on overlapping environmental markets demonstrates that a lack of well-coordinated policy tools could lower the policy efficiency, whereas integrated policy frameworks could enhance environmental performance without deteriorating economic performance (Yang and Tol, 2025). These results emphasise how coordinated regulatory and market-based measures can be relevant to ensuring sustainable growth.

The role of data-driven methods in the study of the emission dynamics is additionally evidenced by the advances in environmental modelling and forecasting. As an illustration, neural network algorithm-based predictive modelling has been applied to predict the trend in the carbon emission rate and also recognise the salient factors contributing to the environmental change in fast-growing economies (Zhao et al., 2024). These types of analytical tools are becoming more and more relevant to long-term climate policy planning.

The correlation of economic activity and environmental results is another area impacted by global disturbances. The COVID-19 pandemic caused energy consumption in the world to decrease significantly with decreased economic activity, which led to temporary carbon emissions cuts (Liu et al., 2021). But later recovery periods frequently resulted in quick recoveries in the emissions as industrial production was restored.

Moreover, international economic ties and trade policies have the ability to affect environmental performance. Studies of the global trends of EKCs indicate that trade protectionism and changing production trends might change the emissions trends by shifting the carbon-intensive production to other nations (Wang et al., 2024). It means that the global economic policies have an indirect impact, through

restructuring the world production networks, on the environmental effects.

On the whole, the discussion indicates that environmental improvement is not necessarily the result of economic improvement. Rather, the effect of environmental outcomes relies on the complicated interplay of economic development, technological advancement, policy frameworks, and global economic processes. The experiences of the United States and China demonstrate that whilst the developed economies can decouple economic growth and emissions to relative success, the developing economies may struggle more to balance the growth in industries and environmental sustainability.

Conclusion

This study has compared the correlation between economic growth and environmental quality in the United States and China between 2004 and 2024 by the GDP per capita and CO_2 emissions per capita as a part of the Environmental Kuznets Curve. The results indicate that the two nations had divergent environmental trajectories although there was continued economic growth. In the US, GDP per capita grew significantly, and CO_2 per capita tended to fall, which is stronger evidence of decoupling, and it suggests entering the zone of strong indicators of moving past the EKC turning point. Conversely, China had witnessed a high rate of increase in GDP per capita and the overall increase in CO_2 emission per capita which is indicative of the environmental strains that are usually linked with the earlier phases of industrialisation. The comparison also indicates that the improvement of the environment is not always provided by economic growth. Rather, policy design, technological advances, energy transition and institutional capability determine the degree of environmental outcomes. Mature regulatory systems, cleaner technologies, and structural readjustments seem to favour the United States much more than China has to juggle between the need to develop fast and the necessity to cut emissions. It is also revealed in the study that changes in the growth environment relationship by global shocks like climate shocks, pandemics and trade tensions can complicate the desired pattern of the EKC. On the whole, the findings show that sustainable development does not only need economic growth but also a well-organised environmental policy, the innovative process, and long-term planning to make sure that growth does not contradict environmental protection.

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