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Balancing Growth and Sustainability: The Role of Manufacturing and Renewable Energy in CIVETS Countries

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ABSTRACT

This study investigates the relationship between renewable energy consumption, manufacturing value added, CO_2 emissions, and economic growth in CIVETS countries – Colombia, Indonesia, Vietnam, Egypt, Turkey, and South Africa – from 2005 to 2020. Using panel data techniques (common, fixed, and random effects models), the results reveal that manufacturing significantly and positively affects GDP growth, confirming its role as the primary driver of economic performance in emerging economies. Conversely, CO_2 emissions exert a negative but marginal influence on GDP growth, indicating that higher emissions may hinder sustainable economic expansion. Renewable energy consumption, although showing a limited short-term impact, demonstrates potential to contribute to long-term inclusive growth once effectively integrated into industrial structures. These findings emphasize the need for policies promoting green industrial transformation, investment in clean technologies, and enhanced renewable energy integration to achieve balanced growth and environmental sustainability. The study offers empirical evidence to support policy design in emerging economies pursuing the dual objectives of industrial competitiveness and carbon neutrality.

Keywords: Manufacturing; Renewable Energy; CO_2 Emissions; Economic Growth; Sustainable Development; CIVETS Countries
JEL Classifications: Q43, O44, C33, Q56

1. INTRODUCTION

CIVETS includes Colombia, Indonesia, Vietnam, Egypt, Turkey, and South Africa, six of the world's ten greatest emerging economies. CIVETS' population exceeds 750 million, and their GDP is over 5 trillion USD (Li et al., 2023). CIVETS have a solid base for growth and the ability to sustain major economic expansion in the future. Despite the financial crisis of 2008, the CIVETS markets were less damaged due to their adaptability and strength.

The movement of capital, goods, labor, and knowledge has had a significant impact on world events (Kaplinsky and Kraemer-Mbula, 2022; Folke et al., 2021). Turkey's CO_2 emissions rose by roughly 3% throughout this time. Similar energy-hungry producers in Asia include Indonesia, the Philippines, Thailand, and China (Li et al., 2023).

Civil activist organizations are critical in maintaining green space and addressing issues. However, there has been little research on the role of civic organizations and their relationship to energy plans and sustainable urbanization. As a result, the CIVETS countries were approved as new investment targets. The chairman of the group then offered the term "CIVETS" to the business world. All CIVETS countries are members of the G20. Except for Turkey, CIVETS are also members of the G20 Emerging Markets. Indonesia, Vietnam, Egypt, and South Africa are part of the Association of Southeast Asian Nations Plus. Colombia and Turkey are G20 members due to their status as recently industrialized countries in macroeconomic terms. CIVETS countries have varying GDP growth rates.

Turkey's GDP per capita in 2018 exceeded $10,000. Colombia and South Africa ranked third and fourth, with per capita GDPs ranging from $6,300 to $9,000. Turkey, Colombia, and South Africa were classified as upper middle-income countries alongside Indonesia, which has a GDP per capita of more than $3,900. Egypt and Vietnam were the remaining two lower middle-income countries, with per capita GDP ranging from $1,900 to $3,900.

In terms of renewable energy consumption, CIVETS countries' overall share of renewable energy consumption has increased, with Indonesia having the greatest level (46%) and South Africa having the lowest (8.49%). Except for South Africa, all CIVETS countries saw an increase in renewable energy use between 2000 and 2019. However, in terms of final sustainable energy consumption, South Africa's renewable consumption growth has been more negative. The average growth rate across all countries was 1.53%. In 2000, the renewable energy consumption to GDP ratio in all CIVETS countries ranged from 11% (South Africa) to 1.8% (Indonesia) (Qamruzzaman and Karim, 2023).

In Africa, this category includes Egypt and South Africa. This group saw significant economic expansion and urbanization, resulting in a per capita GDP of $7,000 to $10,000 in 2018. However, these countries will see an increase in CO_2 emissions, creating new obstacles for the global CO_2 peaking and neutrality approach. Smart energy solutions are required to transition to renewable energy use without impeding GDP growth (Supartoyo, 2025).

This study delves deeply into the relationship between renewable energy usage, CO_2 emissions, manufacturing, and economic growth in CIVETS countries from 2005 to 2020. The study goes beyond traditional countries to conduct a detailed examination of the development pattern of renewable energy consumption, CO_2 emissions, manufacturing, and economic growth in CIVETS countries throughout time and cross-sectionally.

The study is innovative, yet timely, and has significant theoretical, empirical, and methodological implications. It is expected to add to theoretical and methodological literature for the reasons listed below. This broad approach is designed to provide varied viewpoints on the relationship between GDP growth, CO_2 emissions, renewable energy usage, and manufacturing. In terms of empirical contribution, the findings are expected to be useful for policymakers and stakeholders.

Motivated by the most recent renewable energy development breakthrough, which represents a significant shift in development patterns and policies, the analysis is extremely important in formulating renewable energy consumption policies and economic development policies for developing-country governments. Understanding renewable energy consumption distribution and co-evolution patterns could assist governments in developing renewable energy consumption promotion programs in regions with similar development conditions. Furthermore, the panel estimation of the interrelationships between renewable energy use, CO_2 emissions, manufacturing, and economic growth has instructive implications for governments in designing appropriate policies to promote renewable energy consumption.

2. LITERATURE REVIEW

These economies are politically poised for economic recovery from the COVID-19 pandemic, and they represent prospective markets and manufacturing hubs for developed nations. Manufacturing policy must prioritize clean technology, product and service innovation, emission reduction initiatives, and complete market growth plans. Unfortunately, few biodiesel-producing industries exist in Indonesia, hence biodiesel usage is modest (maximum 10% in the transportation sector) (Süsler, 2025).

The analysis begins by looking at historical data for the variables explored in this study, which include CO_2 emissions, manufacturing, renewable energy use, and GDP. In terms of CO_2 emissions growth trends, rising emissions were observed in all CIVETS countries, with South Africa (ZAF) having the highest value (99.43) and the most dramatic growth trend. In 2019, ZAF-CO_2 had increased by an amazing 367% from its initial value of 21.25 in 2000.

The rise in temperature as a result of anthropogenic greenhouse gas emissions is attempting to minimize global warming temperature by lowering greenhouse gas emissions (Atedhor, 2023). One of these is air emissions, namely carbon dioxide (CO_2) emissions, which have been linked to temperature rises in CIVETS countries throughout the current epoch (Qamruzzaman and Karim, 2023)

According to the descriptive analysis of manufacturing growth trends, Colombia, Indonesia, and South Africa experienced much greater growth rates than other countries in this category. Manufacturing growth in all CIVETS countries was lower on average (4.91%). A two-phase growth trend in manufacturing was also seen, with high increase up to 2014 and then smooth growth after that.

In 2000, the manufacturing-to-GDP ratio in the CIVETS countries ranged between 50% (Colombia) and 18% (South Africa). From 2000 to 2019, the value of this ratio increased or fell in four nations, while it remained stable in the remaining countries. In 2019, Ecuador (ECU) had the greatest manufacturing-to-GDP ratio, followed by Peru and Indonesia. The lowest ratio came from South Africa (ZAF). Overall, Indonesia and Peru experienced the highest average growth rates, followed by Colombia and South Africa. Importantly, South Africa's manufacturing growth was relatively lower than its CO_2 emissions but higher than GDP growth (Ran et al.2023; Aristizabal-H et al., 2023)

In recent years, many emerging economies have relied more heavily on manufacturing activities and energy-intensive production processes to shape their economic development strategies (Avenyo and Tregenna, 2022; Hosan et al., 2022; Tushar et al., 2024)

Analyzing the effects of manufacturing, energy consumption and regulations, CO_2 emissions, GDP growth, and their interactions has steadily taken center stage in the era of climate change and industrial transformation. Notably, the majority of the research focused primarily on industrialized or transitional economies, leaving emerging markets relatively untouched. The various circumstances of these economies may result in diverse industrial sector dynamics and interactions with energy consumption and emissions. Manufacturers' production operations are increasingly focused in emerging economies. As a result, the evolution of CO_2 emissions from the manufacturing sector has become an urgent and widely discussed problem (Belhadi et al., 2022).

The industrial industry can be a double-edged sword depending on the circumstances. The mechanisms and threshold effects of the relative influences on emissions from the two sectors are conditional and varied. In general, economies attract manufacturing through energy-intensive activities, which results in huge capital inflows, RandD investments, and intensive energy use. However, if the service sector expands in tandem with economic growth but the manufacturing sector shrinks in relative scale, the transition to a low-carbon economy may be severely limited.

Decarbonizing the sector or limiting energy-intensive manufacturing appears crucial to reducing emissions. The sustainable usage of biomass requires additional attention. Such countries have vast timber resources that may be exploited to generate biomass energy and economically develop rural areas, but the huge demand for biomass is in direct conflict with forest protection (Mobarakeh and Kienberger, 2022).

Manufacturing emissions will be divided into two categories: production-based (i.e., total emissions per sector) and consumption-based (i.e., net emissions per sector) (Wu et al., 2022). It is predicted that increased manufacturing emissions will stimulate GDP growth. The following are the probable avenues for justifying the impact of manufacturing emissions on GDP growth. The manufacturing sector is the driving force behind economic growth, particularly in developing countries. This is owing to the fact that manufacturing industries, particularly those generating consumer goods, have a high number of forward linkages, which results in backward ecosystems. (Peter et al., 2023; Bogdanov et al., 2021).

In this sense, wealthy countries have safeguarded their manufacturing sectors through tariff and non-tariff obstacles. GDP growth in a nation's economy continues with extensive backlinks and linked industries. As a result, an assessment of sustainability without accounting for emissions from this sector would be incomplete.

With the implementation of Global Value Chains (GVCs), cross-country product commerce in the global economy has shrunk as well. A nation's manufacturing industry create significant fuel combustion-related emissions, which are exchanged here and there. As a result, manufacturing sub-sector emissions from CIVETS countries are estimated using income-based total emissions and normalized indicators such as per capita (Xu et al., 2024).

CO_2 emissions have increased dramatically in recent decades as a result of industrialization, urbanization, and population development. To limit greenhouse gas emissions and ameliorate global warming, environmental damage, and adverse climate changes, a variety of protocols, treaties, and agreements have been implemented. Carbon dioxide (CO_2, 69%) is the most significant contributor to climate change. Rapid economic growth, industrialization, growing energy consumption, population growth, and urbanization are the primary sources of increased CO_2 emissions in emerging countries.

Although CO_2 emissions increased drastically from 150 tons in 1990 to 830 tons in 2018, there is a significant disparity amongst the CIVETS countries. In 2018, emissions totaled 91.2 million tons in Colombia, 71 million tons in Indonesia, 32.9 million tons in South Africa, 13.7 million tons in Egypt, and 1.8 million tons in Turkey. All of these countries exhibit an ever-increasing pattern of emissions, albeit at varying speeds. Colombia's emissions were constant from 1990 to 2005, then progressively climbed at a pace of approximately 4 million tons per year.

Since 1995, Indonesia's emissions have steadily climbed at a rate of 6 million tons/year. South Africa had the highest CO_2 emissions at the end of 1990, whereas Egypt's emissions increased at the fastest annual pace (0.06 million tons/year) thereafter. CO_2 emissions in Turkey increased rapidly, from 1.8 million tons in 1990 to 12 million tons in 2010, before stabilizing at roughly 13 million tons per year until 2018. Some countries made major changes to traditional practices.

In Mexico, emissions were recorded at 470 million tons in 1990 and steadily increased to 530 million tons in 2017, before dropping drastically to 470 million tons in 2018. Nigeria's large CO_2 emissions of roughly 0.21 million tons fell to 0.16 million tons in 1995, and then progressively increased at a pace of about 0.015 million tons per year until reaching 0.22 million tons in 2017 (Li et al., 2023).

CO_2 emissions in Peru (PER) increased at a slower rate of roughly 210% compared to the other countries in this category. The average growth rate of CO_2 emissions experienced significant growth in two phases, with the first stage in 2000-2013 having a lower growth rate (10.9% on average) and the next 7 years (2014-2020) consisting of a considerably larger growth rate (11.7%).

Furthermore, more urgent policy consequences include market competitiveness, adequate engine maintenance, and biodiesel production and use development. Although policy implications range from country to country, energy and environmental policies are crucial for achieving CO_2-neutrality targets (Khan, 2024).

Rising CO_2 emissions have severe consequences for environmental quality and public health. Controlling growing CO_2 emissions has become a huge concern for the world, as they are associated not only with energy consumption but also with industrial growth, urbanization, transportation expansion, and other factors. Following the rising global temperature trend, global stakeholders convene each year to discuss climate discussions and develop enforceable policies to reduce CO_2 emissions by encouraging renewable energy use and improving energy efficiency (Clery et al., 2021; Engvall et al., 2023). World-leading economies have signed similar, enforceable treaties to increase their focus on climate change mitigation (van Asselt, 2021).

Economic growth has an impact on environmental quality since it leads to increased energy consumption and the usage of fossil fuels in its early phases (Magazzino et al., 2022; Pata et al., 2023). Poorer countries with ample resources are likely to follow an environmentally unfriendly high fossil energy consumption path, resulting in degradation of environmental quality (Pata et al., 2023).

The driving causes behind CO_2 emission changes in various rising economies are explored, and a general understanding of their diverse driving forces is gained. The impact of economic structure on CO_2 emissions is substantially greater than that of other development elements. The importance and intensity of early warming indicators and consumption structure indicators vary according to the level of development achieved. Population-related and standard of living variables provide relatively small contributions.

In the absence of emission-reduction initiatives, CO_2 emissions are expected to rise at a pace of roughly 1.5% per year, totaling over 114GtC by the end of this century, which is almost 5.4 times that of 2000. CO_2 emissions may diverge from a low, medium, or high trajectory. Under a low road trajectory, emissions are expected to peak about 2060 before stabilizing and declining. Under a middle-road trajectory, emissions are expected to peak about 2020 before rapidly stabilizing and declining thereafter. In contrast, under a high road trajectory, emissions are expected to constantly accelerate, resulting in excessive temperature change.

3. DATA, METHODOLOGY AND RESULTS

This study focused on six CIVETS countries: Colombia, Indonesia, Vietnam, Egypt, Turkey, and South Africa. The data set is taken from the aforementioned database by selecting the key variables (CO_2 emissions, renewable consumption, and industrial output) and altering the year ranges. The complete data set is thoroughly prepared and verified to ensure that there are no discrepancies. The data set is then limited to CIVETS in order to maintain homogeneity. The year ranges (2005-2020) are chosen based on the availability of data for each variable in each CIVETS country (Li et al., 2023). The econometric specification of a panel dataset is an adequate instrument of analysis with software EViews 12.

Equation (1) represents a general panel data regression model:

$$Y_{it} = \alpha_{oi}+\beta_1 x_{1it}+\beta_2 x_{2it}+\beta_3 x_{3it}+\varepsilon_{it} \quad (1)$$

Equation (2) specifies the model in the context of economic growth and environmental variables:

$$GDP\ growth = \alpha_{oi}+CO_2\ emissions+Manufacturing,\ value\ added+Renewable\ energy\ consumption+\varepsilon_{it} \quad (2)$$

This implies that GDP growth is projected to be impacted by carbon dioxide emissions, manufacturing value added, and renewable energy use, with an error component reflecting additional unobserved factors.

Table 1 shows how CO_2 emissions, manufacturing value added, and renewable energy use affect GDP growth using a common effect model. CO_2 emissions have a negative and marginally significant influence on GDP growth (coefficient = −0.273, P = 0.082). Higher emissions may be associated with slower economic growth, presumably due to environmental deterioration and long-term economic losses. Manufacturing value added, on the other hand, has a positive and very significant influence on GDP growth (coefficient = 0.283, P = 0.000), showing that the expansion of the industrial and manufacturing sectors continues to be a vital economic engine.

Meanwhile, renewable energy consumption exhibits a negative but statistically insignificant association (coefficient = −0.012, P = 0.677), showing that renewable energy development has not yet advanced to the point where it can contribute meaningfully to economic growth over the investigated time. The model's R-squared value of 0.217 indicates that the included variables account for approximately 21.7% of the variation in GDP growth, and the F-statistic (8.504) validates the model's joint significance. Overall, the findings show that traditional industrial activities continue to drive economic growth in the sample, with renewable energy adoption having a limited short-term impact.

Furthermore, the result that manufacturing has a positive influence on GDP growth is consistent with prior studies that revealed that industrial and manufacturing output growth aids GDP growth in middle-income nations (Sohag et al., 2017).

Table 2 shows the results of panel least squares estimation using a fixed effect specification, which accounts for unobserved heterogeneity

Table 1: Panel least squares (common effect)

Variable	Coefficient	Std. error	t-statistic	Prob.
C	0.586	1.606	0.364	0.716
CO_2 emissions	−0.273	0.155	−1.758	0.082
Manufacturing, value added	0.283	0.078	3.619	0.000
Renewable energy consumption	−0.012	0.029	−0.417	0.677
R-squared		0.217		
F-statistic		8.504		

Table 2: Panel least squares (fixed effect)

Variable	Coefficient	Std. error	t-statistic	Prob.
C	−0.431	4.400	−0.098	0.922
CO_2 emissions	−0.485	1.028	−0.471	0.638
Manufacturing, value added	0.350	0.166	2.104	0.038
Renewable energy consumption	0.014	0.096	0.150	0.880
Cross-section fixed (dummy variables)				
R-squared		0.280		
F-statistic		4.232		

across cross-sectional units. CO_2 emissions have a negative but statistically insignificant relationship with GDP growth (coefficient = −0.485, P = 0.638), indicating that variations in emissions across countries or regions do not significantly affect economic growth after accounting for country-specific effects. Manufacturing value added, on the other hand, continues to have a positive and statistically significant impact on GDP growth (coefficient = 0.350, P = 0.038), supporting the idea that industrial expansion remains an important contributor to economic performance.

In contrast, renewable energy consumption has a positive but insignificant correlation (0.014, P = 0.880), demonstrating that, while renewable energy development has growth potential, its current contribution to GDP growth is modest. The R-squared value of 0.280 indicates that the model accounts for approximately 28% of the variation in GDP growth, and the F-statistic (4.232) validates the explanatory variables' joint importance. Overall, the fixed effect results are consistent with the common effect model, with manufacturing playing the main role and renewable energy adoption having a relatively small short-term growth impact.

Table 3 shows the results of the Chow test, which is used to determine if the fixed effect model is preferable to the common effect (pooled OLS) model. The results demonstrate that the cross-section F-statistic (1.524) and the cross-section Chi-square (8.060) have P-values larger than 0.05 (0.190 and 0.152, respectively). Because these probability values exceed the customary 5% significance level, the null hypothesis that the common effect model is adequate cannot be rejected. This suggests that the fixed effect model has no substantial advantage over the common effect specification in terms of regression explanatory power. The common effect model is more suited to explain the relationship between GDP growth, CO_2 emissions, industrial value addition, and renewable energy usage in this study.

Table 4 shows the results of the random effect model calculated with panel EGLS to account for variances between cross-sections, assuming that these differences are random rather than fixed. The study found that CO_2 emissions have a negative but small effect on GDP growth (coefficient = −0.251, P = 0.351), indicating that environmental degradation does not have a substantial short-term impact on economic performance in the sample. Manufacturing value added, on the other hand, continues to have a positive and statistically significant effect on GDP growth (coefficient = 0.297, P = 0.007), underscoring industrial activity's continued relevance as a primary driver of output expansion.

Meanwhile, renewable energy consumption is still statistically negligible (coefficient = −0.001, P = 0.976), showing that renewable energy deployment has yet to yield major economic benefits, probably due to its small scale or early growth stage in many nations. The R-squared value of 0.114 indicates that the included variables account for approximately 11.4% of the variation in GDP growth, and the F-statistic (3.971) validates the model's overall importance.

Overall, the random impact results are consistent with prior models, highlighting the manufacturing sector's crucial role in driving economic growth, whereas environmental and renewable energy variables have weaker direct effects.

Table 3: Chow test

Effects test	Statistic	d.f.	Prob.
Cross-section F	1.524	(5.87)	1.190
Cross-section Chi-square	8.060	5	0.152

Table 4: Panel EGLS (cross-section random effects)

Variable	Coefficient	Std. error	t-statistic	Prob.
C	0.039	2.373	0.016	0.986
CO_2 emissions	−0.251	0.268	−0.936	0.351
Manufacturing, value added	0.297	0.108	2.736	0.007
Renewable energy consumption	−0.001	0.046	−0.030	0.976
Weighted statistics				
R-squared		0.114		
F-statistic		3.971		

Table 5: Lagrange multiplier test

LM Test	Test hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	0.092 (0.760)	31.268 (0.000)	31.361 (0.000)

Table 5 shows the results of the Breusch-Pagan Lagrange Multiplier (LM) test, which is used to select between the common and random effect specifications in the panel regression model. The results demonstrate that the cross-section LM statistic (0.092) has a P-value of 0.760, which is greater than the 5% significance level, showing that the null hypothesis of no random effects is not rejectable.

However, the time and both effects tests produce statistically significant results (P = 0.000), indicating that time-specific factors exist and play an important role in explaining variances in GDP growth. Given these findings, the random effect model is not statistically superior to the common effect model in terms of cross-sectional variance; nevertheless, time effects may still be meaningful. The common effect model is the best fit for examining the link between GDP growth, CO_2 emissions, industrial value added, and renewable energy usage in this dataset.

4. CONCLUSION

Climate change has emerged as the most pressing global environmental concern in recent decades, and the United Nations Framework Convention on Climate Change identified it as a catastrophe at its most recent meeting. The primary cause of global climate change is excess greenhouse gas (GHG) emissions. Floods, extreme weather events, and melted glaciers are just a few of the apparent consequences of the earth's massive temperature rise. Carbon dioxide (CO_2) is the primary GHG, accounting for 76% of global GHG emissions. To reduce emissions increase, countries might focus on climate-friendly economic policies such as boosting renewable energy development and enhancing energy efficiency in all sectors.

The goal of this study is to determine the effects of CO_2 emissions, manufacturing energy consumption, and renewable energy consumption on GDP. The study also gives updated numbers for data obtained for research purposes. The primary goal of this research is to evaluate the simultaneous effects of renewable energy consumption, CO_2 emissions, and manufacturing on GDP development in CIVETS countries. Given their large populations, burgeoning young labor force, and fast developing economies, these emerging countries deserve special attention. Nevertheless, several CIVETS countries have faced criticism for their environmental policies and tactics as a result of their rapid industrialization.

The findings imply that, while manufacturing remains an important driver of economic growth, reliance on carbon-intensive industrial activities may face long-term sustainability difficulties. The negative correlation between CO_2 emissions and GDP growth highlights the need for legislation to promote cleaner, more energy-efficient production processes. Policymakers should boost green industrial policy to encourage technical innovation, energy efficiency, and low-carbon production. At the same time, the low impact of renewable energy consumption suggests that renewable sectors in the sample countries (or regions) may remain underdeveloped or inadequately integrated into the larger economic system.

As a result, governments should prioritize investment incentives, budgetary assistance, and regulatory frameworks that promote renewable energy deployment and integration into industrial and economic institutions. Strengthening the link between industrial growth and environmental sustainability would help to achieve long-term economic resilience and the Sustainable Development Goals (SDGs), specifically SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), and SDG 13 (Climate Action).

In summary, the empirical data suggest that manufacturing remains the primary engine of economic growth, while environmental issues such as CO_2 emissions have a minor negative impact on growth performance. The minimal influence of renewable energy consumption shows that the green transition process is still in its early stages, necessitating increased institutional and financial assistance. Overall, these findings highlight the importance of pursuing balanced development policies that maintain industrial productivity while accelerating the transition to cleaner, renewable energy systems in order to achieve inclusive and sustainable economic growth.

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