Constructing the Environmental GDP and the Role of Technology

Hiroaki Iwama[1]

1. Introduction

Since Grossman and Krueger (1995), the EKC (Environmental Kuznets Curve) hypothesis has been a widely regarded metric that depicts the rise and fall of pollution as a country's income level rises. However, its practicality towards policymaking has not always been evident. In this research, we construct the EGDP to bridge the gap between such an issue by incorporating GHG emissions into GDP as a single unified variable. The objective of this research is to create simplified methods for cross-country comparisons, showing the relationship between growth and pollution of the EKC over time. We also empirically tested the impact of energy efficiency on our EGDP data using OLS (Ordinary Least Squares) estimation. Our analysis reveals a significant shift in GDP rankings once GHG emissions are factored in, with countries demonstrating balanced economic growth and a greater reliance on clean energy sources experiencing improved rankings. We found a negative relationship between GHG emissions and energy efficiency across most countries, supporting that enhanced energy efficiency leads to a reduction in GHG emissions. While there was a positive relationship between energy efficiency and GHG emissions in some countries, these results did not attain statistical significance at the 10% level.

2. Methodology

The calculation of EGDP involves two steps. Firstly, we calculate the EGDP for our base year. Then, using the base year EGDP values, we calculate EGDPs for the subsequent years. The base year EGDP was calculated by dividing GDP by the growth rate of GHG (Greenhouse Gas) emissions in the previous year. The EGDP for subsequent years was calculated as:

$$EGDP_{it} = EGDP_{it-1} * (1 + \Delta GDP_{it}) * \left(\frac{1}{1+\Delta GHG_{it}}\right) \dots (1)$$

Where ΔGDP_{it} and ΔGHG_{it} represent the percentage changes of GDP and GHG emissions in a given country i at time t. This way, positive values of ΔGHG_{it} contributes to an increase $EGDP_{it}$, and vice versa for negative GHG emissions. The values of our subsequent EGDP aim to capture the compounding effect over time based on the previous year's EGDP because a country's emission may contribute to climate change exponentially rather than through a simple accumulation effect (Hertig *et al.*, 2020). Should there be a shift in GDP rankings when factoring in GHG emissions, it would be advisable to delve into the reasons behind fluctuations in GHG levels within the sample countries. Given backup from the theoretical explanations of the EKC, we test our hypothesis that technology and innovation are the key drivers of reducing GHG emissions. The EKC hypothesis for our study was tested by estimating the relationship between GHG emissions and energy efficiency with several additional variables. We chose to focus on energy efficiency as our key variable of interest due to the well-established recognition of the energy sector as a major contributor to global

[1] Graduate School of Economics, Kyoto University, Yoshidahonmachi, Sakyo-ku, Kyoto 606-8501, Japan
E-mail: iwama.hiroaki.72r@st.kyoto-u.ac.jp

GHG emissions (Gillingham *et al.*, 2009). We formed a log-log model for our equation of our OLS estimates which can be described as:

$$\ln(GHG_{it}) = \beta_0 + \beta_1 \ln(GDP_{it}) + \beta_2 \ln(Energy\ efficiency_{it}) + \beta_3 \ln(Population_{it}) + \beta_4 ln(Export_{it}) + \beta_5 ln(Import_{it}) + u_{it} \ldots (2)$$

All data were sourced from publicly available datasets, including the World Bank (2023) and the Energy Institute Statistical Review of World Energy (2023). Environmental variable data were taken from the Global Carbon Project (2022). Our country of focus consisted of G7 and BRICS countries and our period of analysis ranged from 1960 to 2019.

3. Results

Our GDP values shifted dramatically when we incorporated environmental measures. Among the countries examined, certain nations experienced significant negative differences between their GDP and EGDP ranks, underscoring the varying degrees of environmental consideration in economic performance. Conversely, other countries showcased positive differences between their GDP and EGDP values, indicating their proactive stance toward incorporating environmental considerations into economic growth. There was also a minor change in rankings when adjusting for time and trade, but this was relatively moderate. We also discovered a negative relationship between GHG emissions and energy efficiency in most of our sample countries.

Table 1. Comparative Analysis of EGDP in 2019 (billion USD)

	GDP (rank)	EGDP (rank)	Difference (Δ)
USA	2,1381 (1)	13,068 (1)	-8,312 (-38.9%)
Canada	1,743 (10)	1,038 (8)	-705 (-40.4%)
Germany	3,888 (4)	6,184 (2)	2,295 (+59.0%)
France	2,728 (7)	2,947 (4)	218 (+8.0%)
Italy	2,011 (8)	903 (10)	-1,107 (-55.1%)
UK	2,857 (5)	5,042 (3)	2,185 (+76.5%)
Japan	5,117 (3)	1,650 (7)	-3,467 (-67.7%)
Brazil	1,873 (9)	926.04 (9)	-947 (-50.6%)
Russia	1,693 (11)	2,378 (5)	685 (+40.5%)
India	2,835 (6)	746 (11)	-2,089 (-73.7%)
China	14,280 (2)	1,965 (6)	-12,314 (-86.2%)
South Africa	388 (12)	142 (12)	-246 (-63.5%)

4. Conclusion

The main findings of our study was that countries pursuing balanced growth paths of GDP and clean energy sources exhibited positive growth and improvement in their EGDP rankings. This underscored the importance of adopting energy mix policies that promote increased energy consumption from cleaner sources and support the transition from fossil fuel-based energy consumption. Another implication from our study is that we discovered a negative relationship between GHG emissions and energy efficiency in the majority of the countries studied, suggesting that energy efficiency may play a crucial role in emission reduction.

Reference:

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