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TO BE RICH OR TO BE GREEN- THE DILEMMA BETWEEN GDP AND CO2 EMISSIONS PER CAPITA

Abstract:

The offered study tackles the problem of whether a country can be synchronously rich and "green". The toolkit applied to resolve this dilemma, on the one hand, involves a review of theoretical sources on the issue, and on the other hand, necessitates a conduct of an empirical study of the dependencies between economic growth, and in particular GDP per capita and carbon dioxide emissions (CO2) per capita. This is an assessment method of the eventual impact of economic growth on environmental degradation. An evaluation of the theories indicates that a relationship exists between economic growth and environmental degradation, however it is multidimensional. The outcomes of the in-depth analysis of the relationship between economic prosperity and environmental sustainability, after applying correlation and regression analyses, along with the RANSAC regressor, actually reveal that there is a positive relationship between CO2 emissions and GDP per capita. The visualization of the results gives a clear idea of the relationship for each year of the research period. These findings contribute to the current debate concerning the balance between economic growth and environmental protection.

Keywords:

Green transition, GDP per capita, Economic growth, CO2 emissions per capita

JEL Classification: E01, O40, Q01

Introduction

The climate deterioration and the environmental pollution are problems which impact the European and the world economy in general. This fact functions as a trigger for the EU's climate policy to set ambitious goals such as the one of Europe to become the first climate neutral continent by 2050. The launch of the European Green Deal and the Energy Union, one of the most essential instruments of the energy policy, become major contributors to the achievement of this goal in the EU. Similar policy basically requires the transformation of all sectors of the economy as well as the energy system in order to reach decarbonisation levels. Other ambitious legal frameworks for global climate change regulation are the Paris Agreement (2015), the United Nations Framework Convention on Climate Change, and the Kyoto Protocol. Their purpose is improving the climate and the environment.

The pressing challenges facing the environment and the resulting problems for the economic and social development raise serious questions about the causes for and consequences of these circumstances. This is the reason why the study of the relationship between economic growth and the environment, as well as, in particular, between GDP per capita and emissions per capita has been especially relevant in recent years, as there are multiple viewpoints for their research. On the one hand, it is argued that higher income causes environmental degradation and the necessity to implement policies to reduce carbon dioxide emissions during growth (Onofrei et al. 2022; Nosheen et al. 2021; Mitić et al. 2023). Respectively, some authors hold that rapid economic growth and a simultaneous reduction in carbon dioxide emissions are possible, provided that emissions are separated from growth and countries harmonise their economic growth and energy consumption patterns with environmental policies (González-Álvarez et al. 2023).

All in all, this study contributes to the existing literature by implementing an appropriate methodology, including the use of correlation and regression analyses, along with the RANSAC regressor, to clarify the relationship between economic prosperity and environmental sustainability.

2 Literature review

An adequate opportunity to shed light on the dilemma of higher income per capita or lower carbon footprint per capita is the analysis of contemporary theoretical approaches in the existing literature which tackle this problem and explore it through a different prism. For the purposes of the analysis, it is assumed that there is a causal relationship between the factors considered and that ecological sustainability is assessed in terms of carbon dioxide levels as one of the crucial factors in the greenhouse effect and the resulting climate changes.

In the course of time, theoretical developments of the dependencies between environmental sustainability and economic prosperity have been modified, with earlier theories assuming that economic progress significantly corrupts the environment.

Another assumption of the economic theory, however, holds that the relationship between economic prosperity and environmental degradation is embedded in the hypothesis of the environmental curve of Kuznets. This curve dismisses the widely accepted belief that richer countries damage the environment faster than poorer countries, and this is due to the increase in income which triggers rise in environmental degradation. However, after a certain income level is attained, degradation begins to subside. If the environment continues to deteriorate, then this is explained by the fact that the necessary level of income per capita is not reached (MacDermott, et al. 2019). The inverted "U" shape of the environmental curve of Kuznets between economic growth and environmental degradation is explained by three effects, i.e. the scale, the composition and the technique effects. Through these, economic growth can influence the ecological state of a country. In the scale effect, a positive relationship is observed between the two researched variables, since the growth of the economy stimulates production, along with the resources used and, accordingly, the pollution of the environment. For the other two effects, the investigated relationship becomes negative. In the composition effect, this is due to a restructuring of the production from a heavier and more intensive one to a less polluting one. In terms of the technological effect, this dependence is interpreted by technological innovation in terms of environmental improvement (Ozcan et al. 2020; Stern, 2004; Bagliani et al., 2008; Akbostanci et al., 2009).

Besides the hypothesis of the environmental Kuznets curve, two more hypotheses are debated in the sources, confirming that the level of GDP affects the deterioration of the environment, but in alternative ways. For instance, the Brundtland curve hypothesis offers another explanation, according to which the poorest and richest countries show the highest levels of pollution. One more hypothesis is the Daley curve, which assumes that environmental pollution grows with GDP growth and this process continues without any breaking point. Bratt (2012) discusses the different aspects of environmental degradation which are addressed by the three hereby discussed curves describing the relationship between environment and GDP. He interprets the hypothesis of the environmental Kuznets curve as a possibility to measure emissions or concentration; the Brundtland curve - to measure production and the Daly curve - to measure consumption.

Other researchers suggest alternative views on the studied relationship and shift the focus from industrial to developing countries. By means of an econometric analysis, they provide a solution to the problem of whether developing countries with an increase in income reduce the release of carbon dioxide emissions. According to Narayan (2010), this is achievable, but only provided that short-run income elasticity is compared with long-run income elasticity. The results indicate that with less income elasticity in the long run, the change in income over time leads to a reduction in carbon dioxide emissions.

The literature review reveals that a relationship between economic growth and environmental degradation exists, however with a variable impact. The empirical analysis of the current study actually shows that there is a positive relationship between CO2 emissions and GDP per capita.

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3. Methodology

The data for this study is obtained from the World Bank, specifically focusing on CO2 emissions (metric tons per capita) and GDP per person for each country. The dataset will cover a period of nine years, from 2012 to 2020, allowing for a comprehensive analysis of trends and changes over time.

To explore the relationship between CO2 emissions and GDP per person, three common transformations will be applied: square root (sqrt), reciprocal transformation and logarithmic (log) transformations. These transformations help address potential nonlinear relationships and ensure that the analysis captures the underlying patterns in the data more effectively.

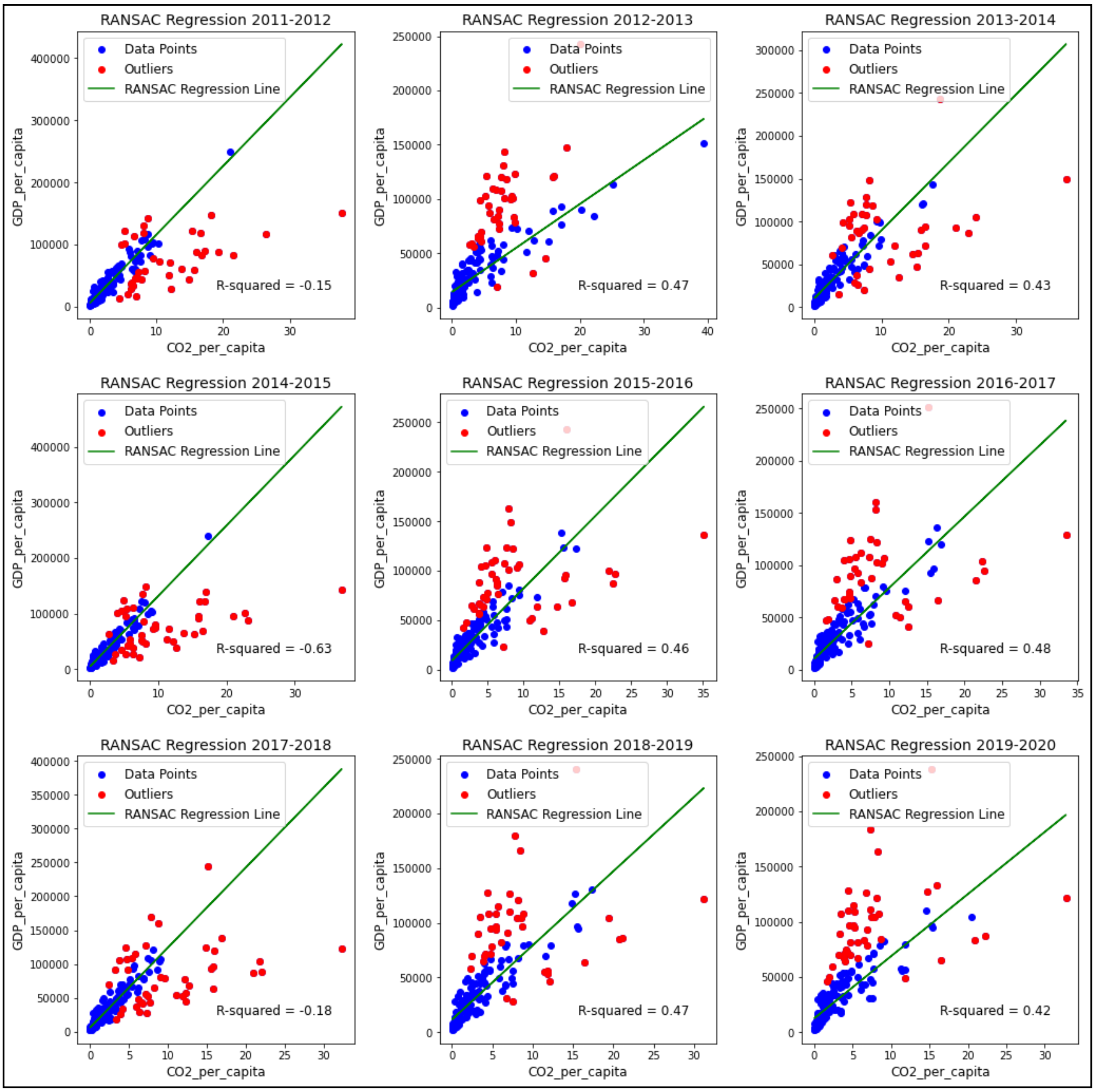
The first step in examining the relationship between CO2 emissions and GDP per person will involve calculating the correlation coefficient. This statistical measure will provide an indication of the strength and direction of the linear relationship between the two variables. To gain a deeper understanding of the relationship, regression analysis will be conducted. Regression models, including the RANSAC regressor, will be fitted to the data to identify the best-fitting line that represents the relationship between CO2 emissions and GDP per person. The RANSAC regressor is robust to outliers, making it suitable for this analysis. In addition, the analysis will also include Ordinary Least Squares (OLS) and Weighted Least Squares (WLS) regression models to further explore the relationship between CO2 emissions and GDP per person. For the OLS regression, the data will be fitted using the OLS method, which assumes equal importance for all data points. The resulting regression line will represent the best-fitting linear relationship between CO2 emissions and GDP per person. Weighted Least Squares (WLS) regression will also be employed, considering the weights assigned to each data point. The weights can be determined based on specific considerations, such as the importance or reliability of certain data points. These weights will be used to adjust the regression line, giving more emphasis to the data points with higher weights.

Visual representation of the correlation and regression analysis results will be provided through plots and charts. These visualizations will showcase the positive correlation between CO2 emissions and GDP per person for each year. Additionally, the inliers and outliers identified by the RANSAC regressor will be highlighted to illustrate the impact of extreme values on the relationship.

4. Conducting research and results

Figure 1 shows a grid of 9 scatter plots to visualize the relationship between GDP per capita and CO2 emissions per capita over a period of 9 years, from 2012 to 2020.

Figure 1 RANSAC regression on CO2 and GDP per capita in the world for 2012 – 2020 period.



Source: World bank.

Each scatter plot represents one year, and it displays the data points representing the connection between GDP per capita and CO2 emissions per capita. To analyse the relationship between the variables, Im using the RANSAC regression algorithm. This algorithm fits a regression line to the data while accounting for outliers. The regression line represents the best-fitting line that captures the relationship between GDP per capita and CO2 emissions per capita.

In the scatter plots, to enhance the visualization, the different colours are assigned to the data points and the outliers identified by the RANSAC regression algorithm. This colour distinction

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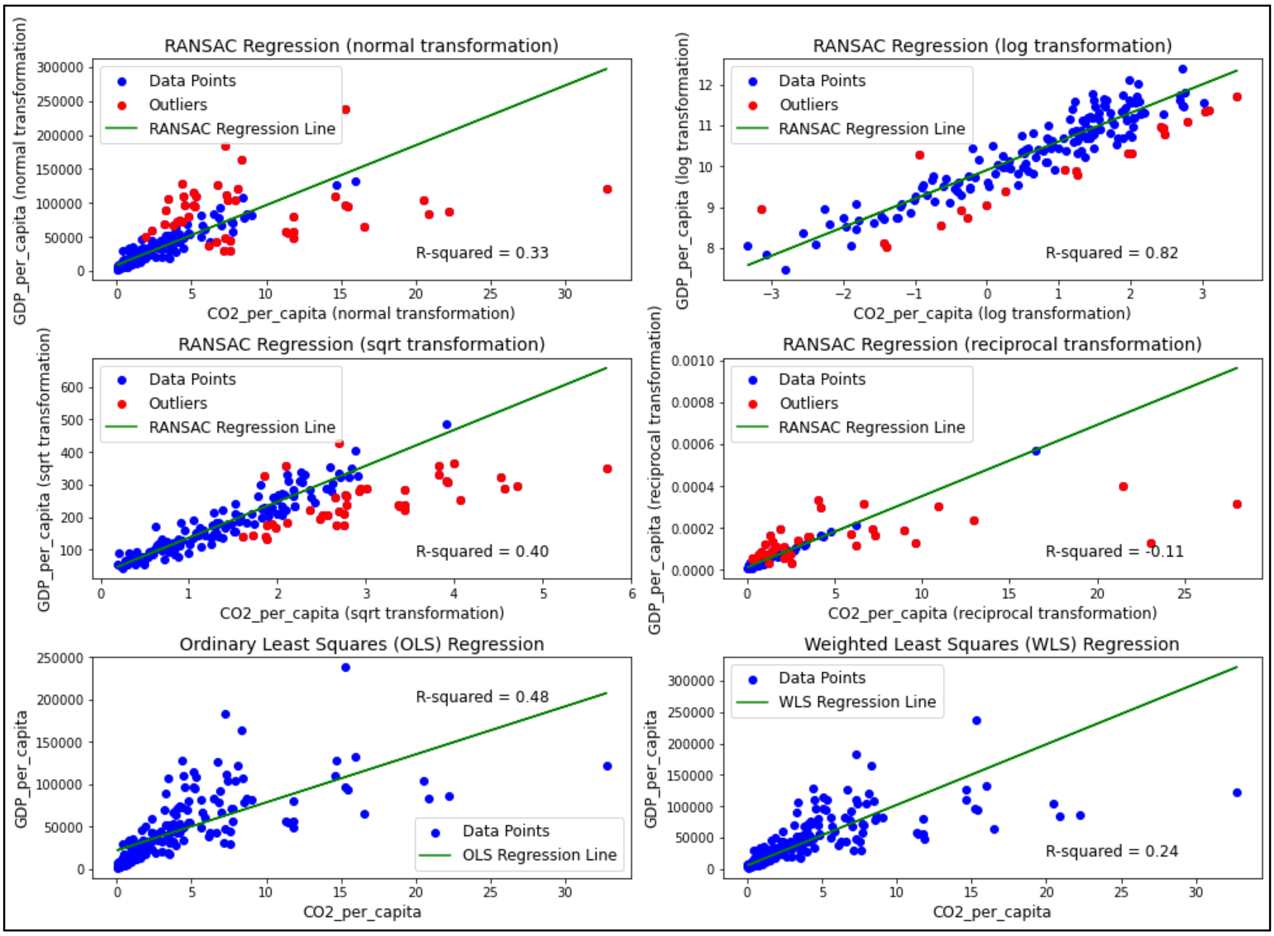
allows for a clear differentiation between the overall data trend and the extreme values. This allows to identify and examine extreme values that deviate from the overall trend.

Furthermore, it is visible that there is a presence of heteroscedasticity in the data. This means that the variability of CO2 emissions per capita differs across different levels of GDP per capita. This observation is reflected in the varying spread of data points around the regression line as the GDP per capita increases. As a result, the R-squared values ranging from 0.15 to 0.48 indicate the goodness of fit of the regression line to the data for each year.

In the next step we address the issue of heteroscedasticity by exploring different methods of data transformation. Figure 2 shows 6 subplots, each representing a different data transformation technique.

Figure 2 Regression and transformation techniques for optimizing the data of CO2 and GDP per capita in the world for 2012 – 2020 period.



Source: World bank.

The first subplot showcases the RANSAC regression performed on the original, untransformed data. Despite the presence of heteroscedasticity, the idea is to compare the results of this method with the transformed data to assess its effectiveness. In the second subplot, a logarithmic transformation is applied to both the GDP per capita and CO2 emissions per capita data. This transformation aims to capture the underlying patterns in the data by reducing the impact of extreme values. The RANSAC regression performed on the log-transformed data showed a significant improvement in the R-squared value, reaching 0.83. This indicates a strong linear relationship between the transformed variables. The third subplot showcases the RANSAC regression performed on the square root-transformed data. This transformation also aims to address the heteroscedasticity issue. However, the results showed a lower R-squared value compared to the logarithmic transformation, suggesting that the log transformation is more effective in capturing the relationship between the variables. In the fourth subplot, a reciprocal transformation is applied to the data. This transformation calculates the reciprocal of both GDP per capita and CO2 emissions per capita. The RANSAC regression performed on the reciprocal-transformed data yielded a lower R-squared value compared to the logarithmic transformation.

To further evaluate the relationship, two additional subplots are included, the Ordinary Least Squares (OLS) and Weighted Least Squares (WLS) regressions. These regression techniques provide alternative approaches for modeling the relationship between the variables. However, the R-squared values obtained from both methods were lower than the RANSAC regression with logarithmic transformation, confirming the effectiveness of the latter approach.

In summary, the analysis demonstrated that the logarithmic transformation of the data resulted in the highest R-squared value (0.83) when applying the RANSAC regression. This transformation successfully addressed the issue of heteroscedasticity, allowing for a more accurate representation of the relationship between GDP per capita and CO2 emissions per capita.

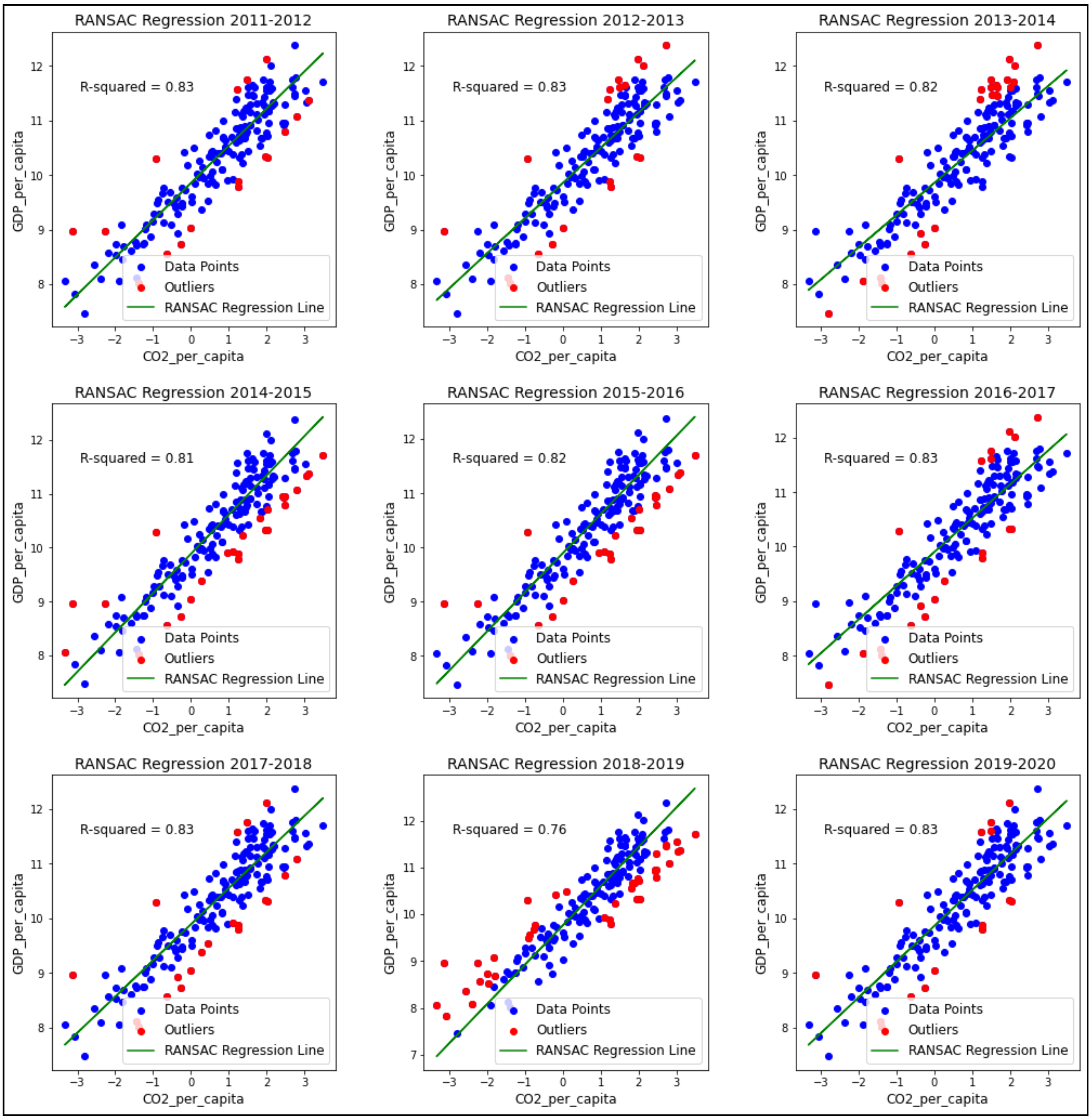
Based on the analysis conducted so far, which highlighted the effectiveness of the logarithmic transformation in boosting the RANSAC regression's performance, the next step is to create a new graph.

This graph, Figure 2 consists of subplots for each of the 9 years, focusing on the log-transformed values of the two indicators: GDP per capita and CO2 emissions per capita. In each subplot, the RANSAC regression is applied once again, incorporating a regression line and differentiating the inliers and outliers through distinct colours. The purpose of this graph was to observe the relationship between the two indicators for each year while taking into account the logarithmic transformation.

The results obtained from this analysis were quite consistent across all nine years. The R-squared values ranged from 0.81 to 0.83, indicating a strong positive correlation between the rise in GDP per capita and the corresponding increase in CO2 emissions per capita. This means that as the GDP per capita of a country increased, there was a corresponding increase in its CO2 emissions per capita.

The graph provided a visual representation of this relationship for each specific year, allowing for a better understanding of the patterns and trends over time. The clear positive correlation observed in all years further supports the notion that economic growth, as reflected by GDP per capita, is closely linked to higher levels of CO2 emissions per capita.

Figure 3 RANSAC regression on log data CO_2 and GDP per capita in the world for 2012 – 2020 period.



Source: World bank.

By considering the logarithmic transformation and utilizing the RANSAC regression approach, we were able to obtain more reliable and accurate results, with higher R-squared values, compared to the initial analysis conducted on the untransformed data. This further emphasizes the importance of addressing heteroscedasticity and employing appropriate data transformations when analysing the relationship between these two indicators.

5 Conclusion

The methodology described in this study enables an in-depth analysis of the trade-off between economic prosperity and environmental sustainability. By utilizing correlation and regression analyses, along with the RANSAC regressor, the positive association between CO2 emissions and GDP per person is explored. The visualization of the results provides a clear understanding of the relationship for each year in the study period. These findings contribute to the ongoing discussion on balancing economic growth with environmental conservation.

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