Enablers of Green Growth in the European Union: The role of Green Technology and Green Energy

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Extended abstract

Climate change has become a significant threat to human life, both socially and economically. Climate complexities have intensified due to economic development, posing serious risks to environmental quality and sustainability (Tariq et al., 2024). At the same time, concerns are increasing about the negative environmental consequences of rapid economic growth. Accelerated development requires greater resource consumption, which leads to severe environmental damage, including pollution and climate change (Merko et al., 2019). Environmental degradation, in turn, affects the global economy and slows economic growth, making sustainable development a top priority worldwide (Wada et al., 2021). Between 2030 and 2050, climate change is expected to cause approximately 250,000 additional deaths per year. Similarly, from 1980 to 2023, weather- and climate-related events caused over EUR 738 billion in losses in the European Union. More than EUR 162 billion of these losses occurred in the last three years, placing them among the top five years with the highest annual economic losses (European Environment Agency, 2025). To address this global challenge, the world economy is increasingly moving toward green growth.

The synthesis of the existing literature allowed to conclude, that recent studies have explored green growth from different perspectives. For instance, some research has focused on the impact of natural resource rents on green growth, the determinants of green growth in developed and developing countries, as well as the effects of green technology on green growth (Danish & Ulucak, 2020; Qian & Chen, 2025; Tawiah et al., 2021). However, to the best of our knowledge, the combined impact of green technology, green energy, and control variables (resource rents and economic growth) has been scarcely investigated. To fill this gap, the present research jointly examines the impact of green technology, green energy, and control variables (resource rents and economic growth) on green growth in the European Union. As a robustness test, this research also measures green growth by dividing GDP per capita by CO_2 emissions. Although the European Union faces significant economic damage and losses caused by climate-related events, limited evidence is available to guide stakeholders and drive investment in adaptation strategies. Therefore, the ultimate goal of this research is to provide empirical evidence to stakeholders for to develop policies that improve living standards while also enhancing environmental quality.

Research Methodology: This research investigates how green technology, green energy, and control variables (resource rents and economic growth) influence green growth in the European Union over the period 2000 to 2025. The main dependent variable of this study is green growth. It is measured using two proxies: (1) adjusted net savings, excluding particulate emission damage

(% of GNI), and (2) GDP per capita divided by carbon emissions. Two recent studies in European regions have used these proxies to measure green growth (Eltayeb, 2025; Lu et al., 2025). The main independent variables are green technology (environment-related technology), green energy (renewable electricity output), and control variables, including resource rents (total natural resource rents) and economic growth (GDP at constant prices). The data are collected from the World Development Indicators (WDI), Our World in Data (OWID), and the Organisation for Economic Co-operation and Development (OECD). This study employs the Autoregressive Distributed Lag (ARDL) econometric technique to examine the long-run and short-run impacts of green technology, green energy, and control variables (resource rents and economic growth) on green growth in the European Union. To investigate the long-run and short-run relationships among the variables, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests, as well as the ARDL bounds cointegration test, are conducted. In addition, various diagnostic tests are performed to ensure the reliability and robustness of the research outcomes.

Results: The results show that green growth, green technology, green energy, and the control variables (resource rents and economic growth) are all stationary at the first difference. Afterward, the ARDL bounds test was performed. The outcomes indicate that the variables are cointegrated and that a long-run relationship exists, as the F-statistic value (12.61) is higher than both the upper and lower critical bounds. These findings confirm that the ARDL model is appropriate for further investigation. The results from the ARDL econometric approach indicate that green technology, green energy, and economic growth have a positive impact on green growth in both the long run and the short run. In contrast, resource rents have a negative impact on green growth in both the long run and the short run. As a robustness test, green growth is also measured by dividing GDP per capita by CO_2 emissions per capita and replacing it as the dependent variable. Green technology, green energy, and economic growth have a positive impact on green growth in both the long run and the short run, while resource rents have a negative impact on green growth in both the long run and the short run. Overall, both green growth proxies show consistent relationships with the explanatory variables. Moreover, the diagnostic tests confirm that the research model is stable. The CUSUM and CUSUMQ test results show no structural instability. The VIF results indicate no multicollinearity, as all VIF values are below 10. According to general guidelines, a VIF value above 10 suggests multicollinearity issues. In addition, the Breusch-Godfrey Serial Correlation LM test confirms the absence of serial correlation. Similarly, the Breusch-Pagan-Godfrey test results indicate that there is no heteroscedasticity in the model.

Research Implications: This research provides significant empirical evidence based on the findings, showing that green technology, green energy, and economic growth enhance the level of green growth in the European Union, while resource rents negatively affect green growth. These results suggest that stakeholders should revise policies related to resource rents and better integrate them with other indicators that can help transform resource rents into drivers of green growth. The findings assist policymakers and stakeholders in designing effective policies to promote green growth in the region. As the European Union has a global influence, its policies can serve as a model for other regions. From an academic perspective, this research opens avenues for future

studies to examine green growth with different enablers in other regions and contributes to the environmental economics literature.

Research Limitations and Future Research Directions: This research examines the impact of green technology, green energy, and control variables (resource rents and economic growth) on green growth in the European Union. However, it has some limitations. A significant challenge is the availability of data, which may limit the depth and accuracy of the findings. In addition, this study focuses exclusively on the European Union; therefore, the policy implications and recommendations may not be directly applicable to other countries due to differences in economic structures and institutional characteristics. While this research concentrates on green technology, green energy, and control variables (resource rents and economic growth), future studies could incorporate additional enablers to better understand their impact on green growth. These may include green innovation, green finance, artificial intelligence, and the role of renewable and non-renewable energy sources. Future research could also examine other regions, such as BRICS, G7, G20, and Asian economies, where environmental sustainability poses serious challenges. Moreover, future studies may employ alternative econometric techniques and additional robustness tests to further ensure the validity and reliability of the findings.

Key words: Green Growth, Green Technology, Green Energy, Resource Rent and Economic Growth

Jel Classification: F43, F63, O32, Q42, Q32 and O44

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