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The Effect of Green Bonds on Natural Capital Protection: Worldwide Evidence

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Abstract: The continued destruction of nature, including the degradation of natural capital and biodiversity, threatens ecosystem services and human well-being. Natural capital is crucial for providing the conditions necessary for human survival and ecosystem services. Without protecting natural capital, this degradation will have lasting effects on current and future generations. Existing studies increasingly show that Green Bonds can finance environmental projects effectively, but few have examined their impact on natural capital protection. This study investigates the effect of Green Bonds on natural capital protection globally, using IMF Climate Data and World Bank data from 2019 to 2022. By applying the Green Investment theory and quantile-panel regression analysis, the results show that Green Bonds significantly enhance natural capital protection at the 25th and 50th percentiles. This indicates that countries can improve their natural capital protection through the issuance of Green Bonds. Moreover, the study finds that renewable energy positively correlates with natural capital protection, while population growth and total natural resource rents have negative impacts. Hence, this study recommends that governments prioritize the issuance of Green Bonds to fund environmental initiatives.

Keywords: Green Bonds; Green Growth Index; Natural Capital Protection
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Introduction

Natural capital includes resources used in manufacturing and ecosystem services provided by nature. The depletion of natural resources and environmental degradation have become significant concerns, leading to biodiversity loss and socioeconomic liabilities. Despite global initiatives like the 2030 Agenda and the Global Biodiversity Strategy, the situation has not improved, with biodiversity loss continuing to worsen. Financial innovation, particularly green bonds, has impacted various societal aspects, but its influence on natural capital is not fully understood.

This study highlights the necessity for further research to investigate how financial innovation, such as green bonds, can contribute to the safeguarding and restoration of natural resources. Green bonds present investment opportunities that have a positive environmental impact and help raise awareness about the significance of natural capital. However,

existing research primarily focuses on market pricing for municipal securities, leaving a notable gap in understanding the environmental performance and engagement of green bond issuers. Moreover, there are only limited literature that specifically examines the effects of green bonds on the protection of natural capital. Therefore, this research intends to empirically investigate the effects of green bonds on natural capital protection.

This study used a panel data analysis from the selected 74 countries in the world from the year 2019-2022, with controlled variables such as real GDP per capita, population growth, total natural resource rents, renewable energy consumption and country income class as the dummy variable. The primary theoretical framework guiding this study is the Green Investment theory proposed by David Pearce, Edward Barbier, and Alan Markandya in 1990. They argued that green investments could be both profitable and environmentally friendly. Green investment refers to investors choosing projects that have economic, social, and environmental benefits (Lin et al., 2022). This includes investing in Natural Capital Protection such as renewable energy, biofuels, forests, and bio food (Doval & Negulescu, 2014). Green bonds are a financial tool that emerged from the practical application of Green Investment theory. They are issued by governments, international banks, or companies to raise funds for projects that support a low-carbon, climate-resilient economy (Della Croce et al., 2011). Today, Green Bonds dominate the global green finance market and are viewed as a way to distribute the costs of environmental protection between current and future generations (Chang et al., 2022). This theory underpins the research hypotheses by suggesting that countries issuing green bonds for green project investments can yield positive performance in protecting their natural capital. The study is also complemented by other theories such as the Malthusian theory and the Environmental Kuznets curve to explain controlled variables. Based on the trends of green bonds and natural capital protection in the selected countries from the year 2019-2022, it reveals a growing emphasis on sustainable finance, particularly in low-middle-income countries with limited natural capital protection and green bond issuance. This underscores the importance of further research and policy development to promote sustainable development and safeguard natural resources through the effective utilization of green bonds and other eco-friendly financing mechanisms.

The empirical literature on natural capital protection and green bonds encompasses a wide range of studies that highlight the intricate relationship between economic development, environmental quality, and the impact of various factors such as population growth, renewable energy consumption, and natural resource rent. Several empirical studies have demonstrated that regions with higher levels of green bond development tend to exhibit better environmental quality, even at similar levels of economic development. For instance, Zhou et al. (2020) examined the effect of green finance on economic growth and environmental quality. This suggests that the development of green bonds can play a crucial role in achieving a harmonious balance between economic progress and environmental improvement. Additionally, the impact of population growth on natural capital has been the subject of extensive research, with findings consistently indicating that rapid population growth can have detrimental effects on the environment, particularly in terms of CO2 emissions and environmental degradation.

The study by Aladejare (2022), where he investigated the impact of total natural resource rents, globalization, and urbanization on environmental degradation in African economies, highlights the significant contribution of natural resources to economic growth and development. Furthermore, the transition to renewable energy consumption has been identified as a pivotal factor in promoting environmental sustainability. According to Ali et al. (2022), Wang et al. (2022), and Acaroğlu and Güllü (2022) as stated in Zhao et.al., (2023) study, results have shown that renewable energy consumption can significantly reduce CO2 emissions and enhance overall environmental quality. Additionally, the empirical literature has explored the relationship between GDP per capita and environmental quality indicators, revealing that as economies develop, there is a shift towards cleaner and more sustainable energy options, leading to the adoption of laws and technologies aimed at enhancing efficiency and lowering emissions. Moreover, the relationship between population growth and environmental quality has been extensively explored by researchers such as Merchant (2022), and a study of Salman et.al., (2019) wherein they cited Al Mamun et al. (2014), and Rahman (2017) study, all of whom have highlighted the detrimental impact of population growth on environmental pollution.

Research Method

To investigate the effect of green bonds on natural capital, this study incorporated the quantile panel data regression analysis, which enables the investigation of how green bonds affect natural capital protection in 74 selected countries worldwide. The four-year time frame encapsulates the years 2019 to 2022. Utilizing panel data, which involves observing data across multiple entities over time, allows for a comprehensive assessment of the relationship between green bond issuance and the enhancement or conservation of natural capital.

This study utilized an empirical model to investigate the relationship between the dependent variable Natural Capital Protection (NCP) and various independent variables Green Bonds (GB), Total Natural Resource Rents (TNRR), Population Growth (POPG), Renewable Energy Consumption (REC), Real GDP per capita (RGDPPC), and Country Income Class as the dummy variable. Before conducting the analysis, pre-estimation tests were performed to assess the model's accuracy. The study employed pooled OLS regression to assess whether the error terms were independent and identically distributed and to detect the presence of unobservable entity-specific effects. Correlation tests were also conducted to see which independent variables are correlated with one another. The researchers also conducted the Jarque-Bera normality test to see if the data was normally distributed. Moreover, scatter plots were conducted in order to assess the linearity of the model. Visualizing the data points through plotting allows for the detection of non-linear patterns or trends, guaranteeing that the relationships being studied are modelled appropriately. Additionally, this study examined the Variance Inflation Factor (VIF) values for the independent variables to check for multicollinearity concerns. The study proceeded to evaluate heteroskedasticity, multicollinearity, and non-autocorrelation. Heteroskedasticity was assessed to confirm unequal variance of

residuals, respectively. Ramsey RESET test was employed to see if there was an omission of the relevant variables.

Quantile panel regression is a statistical technique that examines the association between variables in a dataset, taking into account various quantiles of the distribution of the dependent variable. By using quantile panel regression, this study assessed whether the effects of these independent variables on Natural Capital Protection (NCP) differ across different quantiles of NCP, specifically the the lower quartile (25th percentile), median (50th percentile), upper quartile (75th percentile). This approach provides a more comprehensive view of how the independent variables Green Bonds (GB), Total Natural Resource Rents (TNRR), Population Growth (POPG), Renewable Energy Consumption (REC), Real GDP per capita (RGDPPC), and Country Income Class, a secondary data which was derived from the World Bank, impact the dependent variable Natural Capital Protection (NCP), as it accounts for potential variations in the relationship at different levels of Natural Capital (NCP). The study also tested the robustness of the quantile model to compare which of the quantile regressions had better results. Furthermore, this study used secondary data from the World Bank and Green Growth Index to conduct quantile panel data regression analysis of the influence of green bonds on natural resources and ecosystems.

The dependent variable used in this study is the natural capital protection which is one of the four green growth dimensions of the Green Growth Index. Natural capital protection has four indicator pillars namely environmental quality, greenhouse gas emissions reductions, biodiversity and ecosystem protection, and cultural and social value. The Green Growth Index scores range from 1 to 100, with 100 representing the highest performance and 1 representing the lowest performance. The Sustainable Development Goals (SDGs), the Paris Climate Agreement, and the Aichi Biodiversity Targets are among the sustainability goals that are measured by the Green Growth Index (Green Growth Index, 2022). Moreover, the independent variable is the green bonds which by definition are any type of bond instrument where the proceeds will be exclusively applied to finance or refinance, in part or in full, new and/or existing eligible Green Projects. The data utilized for this variable are from the International Monetary Fund (IMF).

This study was also conducted with controlled variables such as total natural resource rent which refers to the profit or extra value gained from extracting or harvesting resources like oil, minerals, or timber (Hamilton & Clemens, 1999). Next is renewable energy consumption which is the share of renewable energy in total final energy consumption (World Bank, 2023). In addition to the list is population growth wherein it is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship (World Bank, 2023). The real GDP per capita is a measure of a country's economic well-being. It is the total value of all final goods and services produced within a country in a given year, adjusted for inflation, and divided by the same year's average population (World Bank, 2023). Last but not least is the country income class as the dummy variable, where high-income countries take on the value of 1 and 0 for the low- and middle-income countries, all of which are measured quantitatively.

To construct the study's model, the authors have carefully considered previous empirical studies that have explored similar relationships. A total of three models were derived to know the effect of green bonds along with the following controlled variables. The baseline model attempts to capture the effect between the controlled variables and natural capital protection. The second baseline model involves the independent variable "green bonds" which also aims to capture its effect towards natural capital protection. To investigate the impact of green bonds and controlled variables on natural capital protection across different quantiles, the final empirical model employs quantile panel regression. Only the final model was subjected to pre-estimation, diagnostic tests and quantile panel regression.

Result and Discussion

Descriptive Statistics

Table 1 presents descriptive statistics for a consolidated dataset of high and low-middle income countries. Key variables include the dependent variable, independent variable, control variables, and dummy variables. The dataset comprises 284 observations for Natural Capital Protection, 211 for Green Bonds, 218 for Total Net Resource Rent, 296 for Population Growth and Country Income Class, 158 for Renewable Energy Consumption, and 288 for Real GDP. The average Natural Capital Protection score is 68.38 points, and the average Green Bond issuance is 7.84 billion USD, indicating a wide range of Green Bond issuance and moderate natural capital protection globally. Mean values are 2.00% for Total Net Resource Rent, 0.53% for Population Growth, 22.35% for Renewable Energy Consumption, and 26,330.43 USD for Real GDP. Additionally, 61% of the total observations of country income class are from high-income countries. Standard deviations show high variability for Natural Capital Protection, Green Bonds, and Renewable Energy Consumption, indicating significant dispersion in these variables. In contrast, Population Growth, Real GDP, and Country Income Class exhibit lower standard deviations, suggesting less variation and more clustering around their means.

Table 1 Summary of Descriptive Statistics

Variables	OBS	Mean	Std. Dev	Min	Max
Natural Capital Protection	284	68.38	11.76	1	87.09
Green Bonds (GB)	211	7.84	14.69	0	99.43
Total Net Resource Rent (TNRR)	218	2.00	3.40	0	18.51
Population Growth (POPG)	296	0.53	1.25	-14.19	3.31
Renewable Energy Consumption (REC)	158	22.35	17.54	0	82.79
Real Gross Domestic Product (RGDP)	288	26330.43	24456	0	107792.2
Country Income Class	296	0.61	0.49	0	1

Data Analysis Results

Pre-Estimation and Diagnostic Tests

The Breusch-Pagan/Cook-Weisberg test revealed heteroskedasticity in the pooled OLS regression, which was evidenced by a statistically significant p-value of 0.0027. The Variance Inflation Factor (VIF) test confirmed no significant multicollinearity issue in the model. The overall mean VIF was 1.60, which was well below the commonly accepted threshold of 10. The Ramsey RESET test results (No omitted variables (Prob > F = 0.0960)) showed that there are no omitted variables in the model. The Jarque-Bera normality test (0.1913) showed that the data is normally distributed with a chi(2) greater than 0.05. The Hausman test was employed in the panel regression of the final model to see whether it should be specified as Fixed-Effects or Random-Effects model. The results indicated a probability chi-squared value of 0.0021 which suggests that the fixed-effects model is more appropriate to apply in the final model. The modified Wald test for groupwise heteroskedasticity in the fixed effects regression model was employed to see if it suffers from heteroskedasticity. The results revealed that it does suffer from heteroskedasticity, which is consistent with the Breusch-Pagan/Cook-Weisberg test from the pooled OLS regression.

Quantile Panel Regression Results

Table 2 Pooled OLS (Robust) and Quantile Panel Regression Results (Robust)

Variables	Pooled OLS Regression	Panel Regression	0.25th Quantile	0.50th Quantile	0.75th Quantile
GB	0.323***	0.194	0.361**	0.227***	0.040
	(0.007)	(0.106)	(0.019)	(0.005)	(0.394)
POPG	-4.476*	-0.900	-3.878**	-2.260	-2.367***
	(0.057)	(0.663)	(0.032)	(0.173)	(0.000)
lRGDPPC	-6.207	-1.347	-3.860	-6.447*	0.895
	(0.100)	(0.729)	(0.381)	(0.066)	(0.528)
TNRR	-0.719*	-0.298	-0.970***	-1.228***	-1.746***
	(0.067)	(0.373)	(0.004)	(0.000)	(0.000)
REC	0.125	-0.016	0.160	0.146**	0.033
	(0.179)	(0.882)	(0.190)	(0.044)	(0.161)
RGDPPC2	1.46e-09	9.97e-11	-8.93e-11	7.78e-10	-2.07e-10
	(0.185)	(0.932)	(0.953)	(0.535)	(0.580)
INCOMESTAT	7.634	3.253	13.422**	12.387**	-1.655
	(0.185)	(0.580)	(0.044)	(0.017)	(0.545)
R-squared	0.2366				
Prob>chi2:		0.2563			
Prob > F	-				

Note: *** significance at 1% level, ** significance at 5% level, *10% significance at 10% level

Table 2 compares the results among pooled OLS regression, panel regression, and quantile panel regression. This is to see if the independent variables incorporated in the model significantly affect the dependent variable. The results of the pooled OLS

regression unravelled the explanatory effects of green bonds (GB), population growth (POPG), and total natural resource rents (TNRR), which match up to their respective expected outcomes. However, the rest of the independent variables do not exhibit any significant or explanatory effect. The same is true for the panel regression results, wherein all the independent variables do not significantly affect natural capital protection (NCP). Thus, this study used bootstrapped quantile regression, a method well-suited for small datasets because it doesn't require data to follow a normal distribution (unlike traditional methods). This makes it a robust choice for analyzing real-world data, which often deviates from perfect normality.

The results show that Green bonds (GB) positively and significantly affect the 25th and 50th quantiles of natural capital protection, which are significant at 5% and 1%, respectively. This implies that a 1 billion increase in the issuance of green bonds would increase the score of natural capital protection by 0.361 points and 0.227 points in their respective quantiles. The results indicate that the performance of countries in terms of the protection of natural capital can be influenced and improved through the issuance of green bonds. However, green bonds no longer affect the higher quantile of natural capital protection as it no longer displays any significant value, limiting the extent of the effect of green bonds. The results suggest the issuance of green bonds can significantly enhance environmental quality, reduce greenhouse gas emissions, protect biodiversity and ecosystems, and foster cultural and social value, all of which are crucial indicators of natural capital protection. This also implies that green bonds play a pivotal role in enabling countries to achieve sustainability goals by providing financing and facilitating investments in environmentally responsible projects (Ning et.al., 2022). This means that the development of green finance which includes green bonds can help to synchronize economic development and environmental improvement at a lower level of economic development (Zhou et al., 2020).

Population growth (POPG) negatively and significantly affects the 25th and 75th quantiles of natural capital protection, which are significant at 5% and 1% significance levels. This implies that a 1% increase in population growth decreases the score of NCP by 3.878 points and 2.367 points in their respective quantiles. The results indicate that the performance of countries in terms of protecting natural capital will fall if there is an increase in the growth of the population specifically at the lower and higher end of the quantile distribution. Al Mamun et.al., (2014) supports these results as they state that population growth is a long-term contributor to environmental pollution. Moreover, Rahman et.al., (2017), have indicated that population growth indeed has a negative impact on environmental quality in their study.

On the other hand, total natural resources rents (TNRR) negatively and significantly affect all quantiles of natural capital protection, which are significant at the 1% level. This implies that a 1% increase in the total natural resources rents decreases the score of NCP by 0.970 points, 1.228 points, and 1.746 points in all quantile levels, foregoing a country's capability to protect its natural capital. The result is supported by the study of Aladejare (2022) wherein according to him, natural resource rents, are crucial to a nation's growth, especially for emerging economies aiming to become an advanced one. Such emerging

economies depend extensively on natural resource exploitation to significantly increase their national income. Additionally, the researcher stated that it is important to manage these rents wisely to avoid the negative consequences of overexploitation leading to environmental degradation.

Meanwhile, Gyamfi et al., (2021) suggests that revenue from the exploitation of raw materials and processing degrades environmental quality among the G7 member states. This result is consistent with earlier claims that income from natural resources is mostly used to fund further opportunities for productivity that could increase the depreciation of the natural environment. The negative results of both population growth and total natural resources rents coincide with the study of Ohlan (2015), wherein the increasing population tends to use more natural resources for power generation, industry, and transportation which leads to higher fossil fuel consumption and CO2 emissions. Also, uncontrolled population growth can lead to resource scarcity and environmental degradation (Ohlan, 2015).

Renewable energy consumption (REC) shows a positive and significant impact only the 50th quantile of NCP at the 5% significance level. This indicates that a 1% increase in renewable energy consumption will increase the score of NCP by 0.146 points. The result indicates that REC only has a limited yet significant effect on improving a country's performance in the protection of natural capital. This suggests that the consumption of renewable energy can mitigate the problem of carbon emissions, which enhances the quality of the environment and helps in mitigating climate change leading to better environmental sustainability. This result is consistent with the study of Chen et al., (2023) wherein they stated that the use of renewable energy has a significant impact on mitigating climate change, as evidenced by the declining annual average temperature.

The variables log of real gross domestic product per capita (RGDPC) exhibits a negative yet significant effect on the 50th quantile of natural capital protection, while the square of real gross domestic product per capita does not show any significant effect on all the quantiles of natural capital protection. This forfeits the validity that the Environmental Kuznets curve exists in the selected countries. According to Zhu et al., (2016), the results they found show that the association involving economic growth (represented by the change in GDP) and carbon emissions (which is the dependent variable) in the ASEAN 5 countries is monotonic, implying that the environmental Kuznets curve is not applicable to the nations they studied. One probable explanation is that the ASEAN countries studied were unable to attain the necessary level of wealth at the point of development according to the study of Zhu et.al., 2016 where they cited Narayan & Narayan, (2010) and Chandran & Tang, (2013).

Lastly, the country income class positively and significantly affects the 25th and 50th quantiles of natural capital protection with a significance level of 5%. This implies that a thousand-dollar increase in the income of high-income countries increases the score of NCP by 13.422 points and 12.387 points in their respective quantiles. The result indicates that countries with high income levels are willing to practice environmental protection which results in the improvement of a country's performance in terms of natural capital

protection. Nobody ever focuses only on their financial success, and as people's standard of living rises, they are able to give the environment more importance without compromising their fundamental needs (Jayachandran, 2021). The results are also supported by the study of Shao et.al., (2018).

Conclusion

In conclusion, the positive link between green bonds (GB) and natural capital protection (NCP) emphasizes how green bond issuance can play an important part in promoting the preservation and improvement of ecosystems and natural resources of a country. It is marketed as a viable choice for commercial debt financing of climate resilience-related initiatives, such as adaptation. Therefore, the government is encouraged to prioritize the procurement of green bonds as a primary means of funding environmental initiatives. Ranging from putting up conferences or giving tax incentives, and encouraging government bodies to become involved in the matter. These initiatives may also focus on energy efficiency, sustainable agriculture, green transportation, renewable energy, or biodiversity preservation, among other things.

Lastly, future researchers are encouraged to explore further studies where indicators of environmental degradation can be included in the model. Prioritizing green bonds as a primary funding mechanism for environmental initiatives, coupled with concerted efforts to integrate family planning goals into sustainable development agenda, can significantly enhance natural capital protection and advance the transition towards a more sustainable and resilient future.

Appendix

In our unending effort to pursue understanding and academic excellence, we express our deepest appreciation to the Almighty God, the source of wisdom and guidance that has guided our path throughout this study's journey. His grace has been a constant companion, bringing the strength and inspiration needed to overcome the inevitable difficulties of our academic pursuits. To our loving parents and family members as well as our friends, we are deeply grateful for their constant support, understanding, and motivation. Lastly, to Mindanao State University, Iligan Institute of Technology, Philippines for their unwavering support that has served as powerful catalysts in our research journey.

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