Is Resource Abundance a Curse for Green Growth? Mitigating Role of Green Innovations and Environmental Regulations. Empirical Analysis in OECD Countries

By

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Abstract

The extraction of natural resources reduces bio-capacity and increases environmental pollution, highlighting the need for promoting green growth. Green growth (GG) is a nuanced concept that strives to balance economic growth with environmental sustainability. It ensures that we can continue to grow our economies while protecting and preserving the environment for future generations. Therefore, it is essential to examine the relationship between green growth and natural resource rents in OECD countries from 1996 to 2021. This study also explores the relevance of green growth with green innovations and environmental regulations in the form of environmental stringency index and environmental taxation in OECD, theses variables also appear as moderating in resource–growth nexus, along with research and development expenditure and fiscal policy as control variables. By applying the Common Correlated Effects Mean Group (CCEMG) estimator and the Augmented Mean Group (AMG) estimator, the Study reveals that there is a negative relationship between green growth and natural resource rent in OECD countries, hence proving the resource curse theory. Moreover, green innovations and environmental regulations also promote green growth in these countries. Regarding moderating roles of green innovations and environmental regulations, both mitigate the inhibiting influence of natural resource rent on green growth by promoting sustainable technologies and environmental protection regulations. To promote sustainable growth Government should increase the funding related to research and development in sustainable technologies and offer incentives for businesses to adopt eco-friendly practices. The government should increase the environmental taxes and environmental regulations that can discourage harmful activities and generate revenue for green projects, helping to shift the economy towards sustainability.

Keywords: Green Growth, Natural resource rents, Green Innovations, Environmental regulations, OECD, CCEMG, AMG

I. INTRODUCTION

Natural resources are best viewed as a double-edged sword, offering both positive economic benefits and negative institutional impacts on development performance. On the positive side, natural resources generate substantial economic rents that can be used for public goods provision and other productive purposes. For example, resource wealth can finance infrastructure projects, healthcare, and education, which in turn can spur economic growth. However, reliance on natural resources often leads to economic volatility due to fluctuating commodity prices. This volatility can undermine public finances and discourage long-term investment, potentially leading to a fiscal crisis (Ahakwa &Tackie, 2024) There is a crucial distinction between resource dependence, where a high proportion of GDP is derived from natural resources, and resource abundance, which refers to large natural resource endowments. Lashitew and Werker, (2020) findings indicate that resource dependence, rather than resource abundance, has a more detrimental effect on institutional quality and development outcomes. For instance, countries such as the Republic of Congo, which rely heavily on resources, encounter more significant institutional challenges compared to resource-abundant but economically diversified nations like Canada. Reliance on natural endowments can lead to deforestation, pollution, and environmental degradation by excessive extraction of natural resources that hampers sustainable growth. Adding on, Natural resource wealth can negatively affect institutional quality by fostering a rentier culture where governments rely on resource revenues instead of taxes (Cronin, 2009)

In OECD, a significant portion of greenhouse gas (GHG) emissions is directly or indirectly tied to how we manage materials depicted in figure 1. These emissions stem from various sources, including the burning of fossil fuels for energy, agriculture, manufacturing, and construction. As we extract and use more materials, GHG emissions rise globally, contributing to climate change.

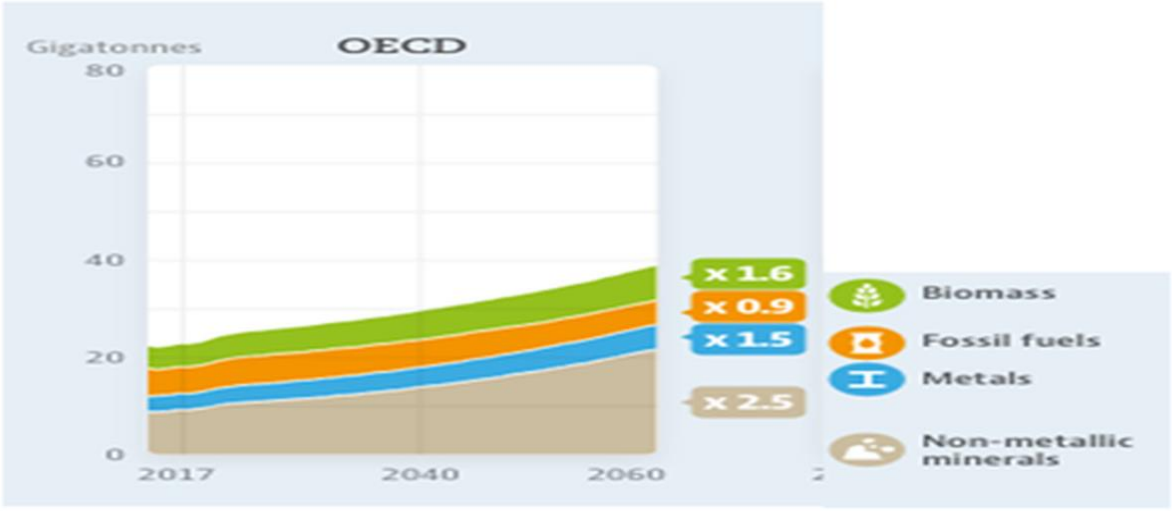


Fig. 1a. Natural resource in OECD


1812 - Adam Smith & David Ricardo
The belief in the positive impact of natural resources on economic development is long-standing, countries rich in resources such as oil and gas could leverage these assets to sustain and drive economic growth..
1988 - Gelb
The resource curse thesis was established. Oil rich countries experienced a marked decline in the efficiency of capital formation, and the benefits from oil windfalls frequently failed to translate into long-term economic gains.
1982 - Corden & Neary
The "Dutch disease" concept highlighted that resource-rich countries might face slower economic growth. This can happen due to currency appreciation, which makes other exports less competitive, along with increased economic volatility and challenges in governance.
1993 - Auty
The term "resource curse" was coined to describe the phenomenon where mineral-rich countries often experience lower economic growth. This is primarily due to the volatility of mineral revenues and the repatriation of earnings, which can destabilize the economy and hinder development.
1995 - Sachs & Warner
Research has shown that natural resource booms can have several significant effects on an economy. These booms often lead to currency appreciation, increased domestic income and demand, and inflation. As a result, the competitiveness of non-resource sectors can decline, making it harder for these industries to thrive.
2001 - Gylfason
It has been argued that resource-rich countries often save and invest less in other sectors, underinvest in human capital, and fail to diversify their economies. This lack of diversification makes them particularly vulnerable to fluctuations in resource prices. which can lead to economic instability.
2004-Michael L. Ross
Researchers have explored the political dimensions of the resource curse, suggesting that resource wealth often fosters authoritarianism, corruption, and conflict. Abundance of resources can create incentives for leaders to concentrate power, engage in corrupt practices exacerbate
2006-Halvor et al
It has been suggested that the quality of a country's institutions determines whether natural resources become a curse or a blessing. Strong, transparent, and effective institutions can ensure that resource wealth positively contributes to economic growth and development., while weak institutions can lead to mismanagement and negative outcomes.
2014-Samidi et al
Effective management of natural resource wealth and mitigation of the resource curse rely heavily on strong institutions and good governance practices.

(Fig. 1b. Evaluation of theory Natural Resource Curse theory)

Fig 1b describes the Contributions of Authors in evaluation of Natural Resource Curse theory.

In the literature, the negative impact of natural resource abundance on economic growth is often explained by the "natural resource curse hypothesis", also known as the paradox of plenty. The Dutch disease approach is a key concept used to explain the adverse effects of natural resource abundance on economic growth (Erdoğan et al., 2020). Above is a flow chart depicting the historical emergence of the natural resource curse theory

Green growth addresses this convergence, emphasizing the importance of seizing opportunities to achieve both goals simultaneously. It involves promoting economic growth and development in a way that ensures natural assets continue to provide the resources and environmental services essential for our well-being(OECD,2018). OECD green growth tools and indicators can enhance economic growth and job creation by promoting the sustainable use of natural resources, improving energy efficiency, and valuing ecosystem services.

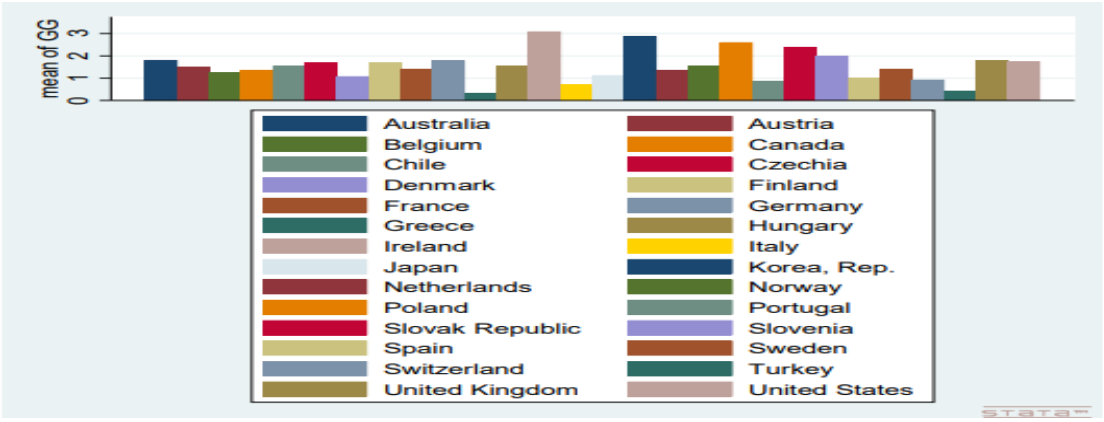


Fig. 2. Average green growth in OECD from 1996-2022

It is evident from the graph figure 2 that there is positive average green growth for OECD countries. The highest green growth is seen in Ireland while the lowest is in Greece.

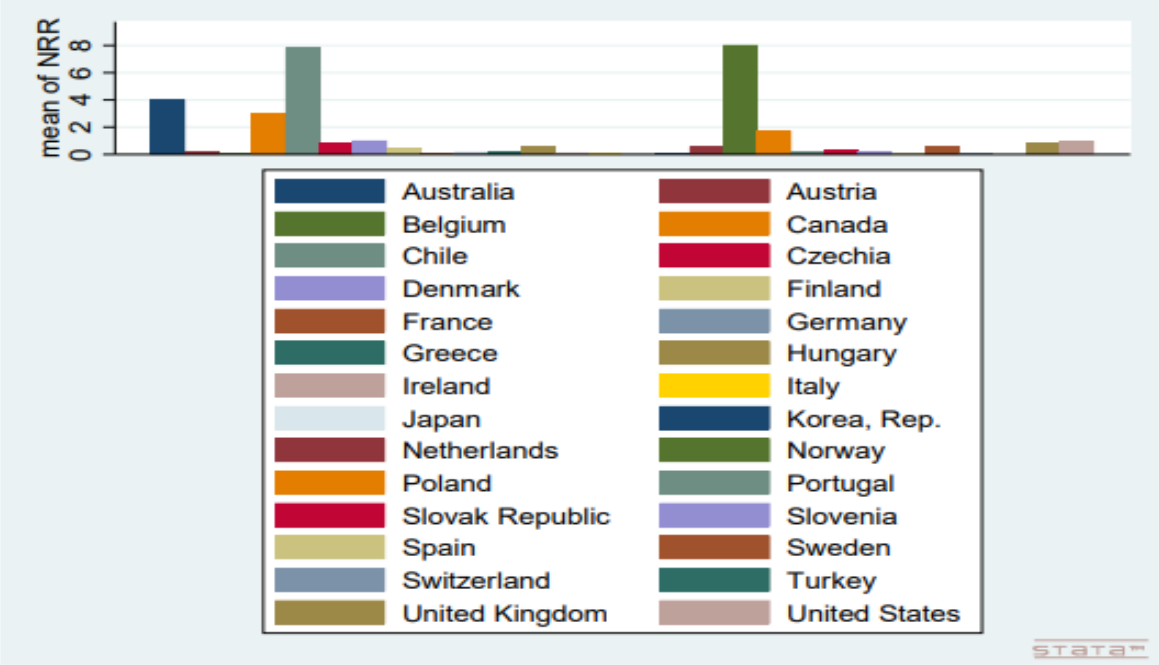


Fig. 3. Average Natural resource rent in OECD from 1996-2022

From Figure 3 it can be seen that the highest resource rent can be seen in Chile and Belgium.

There is no "one-size-fits-all" approach to fostering greener growth. The path to greening an economy depends on various factors, including policy and institutional frameworks, level of development, social structures, resource endowments, and specific environmental challenges. These objectives align with Sustainable Development Goals (SDGs), particularly SDG 13 (Climate Action) and SDG 7 (Affordable and Clean Energy).

Within the context of green growth, the quality of governance becomes critically important. It affects the adoption of environmentally sustainable practices, the allocation of resources to green investments, and the formulation of policies that promote long-term ecological balance (Ofori &Figari ,2023). The detrimental influence of institutional quality on development through natural resources is evident in the rent-seeking behavior of governments. Instead of relying on tax revenue from natural resources, this dependence reduces government accountability and undermines the development of robust political and governance institutions. Such institutional weakening can impede sustainable economic development in the long term (Lashitew & Werker, 2020).

Introducing green technologies also overcomes the issue of natural resource rent. Green innovation plays a crucial role in promoting sustainable growth. For example, feed-in tariffs ensure renewable energy producers receive a minimum price for their energy, providing them with financial stability. Additionally, government spending on subsidies for research and development supports the creation and implementation of new, environmentally friendly technologies (Dutz & Sharma, 2012). The economic benefits of green innovation include lower energy costs and more energy-

efficient production processes. More importantly, these innovations help reduce global warming and decrease the frequency and cost of climate disasters

There is no consensus in the literature regarding the association amid natural resource rent and green growth in high-income countries, with debates over whether there is a resource curse or a resource blessing. Empirical evidence is still needed to highlight the importance of the growth-resource nexus, particularly by incorporating the role of regulations and policies. The purpose of this research is to examine the dynamic link between green growth and natural resource rent in OECD countries from 1996 to 2021. This study differs from existing literature in several ways. First, we focus on OECD countries, which are high-income nations with abundant resources, whereas previous studies primarily examine low or middle-income countries. Second, we investigate how green innovation and environmental regulations influence the relationship between natural resources and green growth in OECD countries. Third, we will construct a green growth index to capture a longer time duration. While existing data on the green growth index covers from 2010 to 2020, we aim to extend this span from 1996 onwards. The study applies second-generation estimation methods such as the Common Correlated Effects Mean Group (CCEMG) estimator and the Augmented Mean Group (AMG) estimator. For robustness, we utilize the System GMM method in this study.

II. LITERATURE REVIEW

2.1 Green Growth and natural Resource Rent

Two decades after the initial Rio Summit, the world still faces a dual challenge: Creating economic opportunities for a growing global population is essential, It's about finding a balance between fostering economic growth and protecting our environment to ensure a sustainable future for everyone**.**Natural resources are vital to the economic growth and development of nations. They supply key materials for industries, create jobs, and support the well-being of communities. However, extracting and managing these resources can harm the environment, leading to pollution and loss of biodiversity. Balancing the benefits of natural resources with their environmental impact is crucial for sustainable development (Liang et al., 2024).

Scholars have identified at least three main channels in which natural resource rents might harm economic growth (Corden &Neary ; Van der Ploeg,2011). A very important channel is through rent-seeking theory, where political institutions play a very important role in all rent-seeking models of the resource curse. Rent-seeking refers to activities occurring to secure financial gains without increasing productivity, in which efforts are best put into manipulating political or economic environments (Deacon & Rode, 2015; Qiang &Jian,2020).

The second channel is the crowding-out theory, which postulates a dual impact of natural resource rents on the domestic economy: an increase in natural resource rents affects domestic income, which at the very least potentially stimulates domestic investment. However, this can raise

domestic prices, wages, and the real effective exchange rate, potentially causing Dutch disease (Abbas et al., 2022).

The third channel, Dutch disease: Such a theory postulates that a resource boom appreciates a country's exchange rate, thereby reducing competitiveness in the country's manufacturing exports or other traded goods through a theory known as Dutch disease. Proponents of the Dutch disease theory see the engine of growth in the manufacturing exports but not in the resource exports, which leads them to conclude that a resource boom, which crowds out manufacturing, will retard growth (Van der Ploeg & Venables,2013).

Du et al. (2020) In their 2020 study, explored how natural resources impact high-quality economic development across various provinces in China. They discovered that the "resource curse" phenomenon—where regions rich in natural resources tend to experience less economic growth compared to those with fewer resources—is indeed present at the provincial level in China. This means that instead of benefiting from their natural wealth, some provinces face challenges that hinder their overall economic progress. This finding highlights the complexities and potential pitfalls of relying heavily on natural resources for economic development.

He and Mou (2020) examined the effects of a thriving resource-based industry on different economic sectors in China. They found that while the booming resource industry can positively impact the service sector, it can also negatively affect the manufacturing sector. This phenomenon, known as the "Dutch disease," occurs when the growth of one industry, such as resources, leads to a decline in other sectors, like manufacturing.

OECD countries, which heavily rely on natural resources for economic growth, often engage in over-exploitation, leading to resource depletion. This not only strains their economies but also poses a serious threat of scarcity for future generations. This shows the presence of the resource curse hypothesis (Razzaq et al., 2021).

Finding that natural resources can be a blessing. However, this positive outcome is primarily achieved through the development of financial markets. We found strong evidence that financial institutions in these countries can suffer due to the abundance and use of natural resources. Despite this, our empirical results confirm that, overall, natural resources are effectively utilized to enhance financial development in the G7 countries. This indicates that with robust financial systems, natural resources can contribute positively to economic growth (Wei et al., 2020).

Based on the above literature, the following hypothesis can be developed

H_1= There is a negative relationship between green growth and natural resource rent in OECD countries.

2.2 Green Growth and Green Innovations

Green innovations encompass new or modified processes, techniques, practices, systems, and products designed to prevent or minimize environmental harm. These innovations may be created

with or without a specific focus on reducing environmental impact (Rennings, 2000 ; Rennings et al., 2004). Eco-innovation facilitates this progress by integrating both technological and non-technological changes, leading to significant environmental benefits. The ongoing economic crisis and climate change negotiations present a valuable opportunity to transition to a green economy by accelerating eco-innovation (Yu et al., 2023).

An increase in natural resources can negatively impact long-term economic development, there's a way to counteract this through green growth and innovation. By introducing green patents, regions can mitigate the adverse effects of resource dependence. These green patents, which cover innovations in environmentally friendly technologies, serve as indicators of regional technological and technical progress. By fostering such advancements, regions can reduce pollution and support sustainable economic growth (Li et al., 2023). Countries rich in natural resources are not inherently doomed to develop poor institutions. Instead, it is the presence of weak institutions that primarily causes slowdowns in growth and development (Kaznacheev, 2013).

Based on the above literature, the following hypothesis can be developed

H_2= There is a positive relationship between green growth and green innovations in OECD countries.

H_3=Green innovations moderates the relationship between green growth and natural resource rent in OECD countries.

2.3 Green Growth and Environmental Regulations

In a study by applying Q-ARDL, the author found that the resource-curse hypothesis holds for lower and medium quantiles of economic activity in China, but at higher quantiles, the resource-blessing hypothesis becomes evident. The study measured green growth using adjusted net savings, accounting for particulate emission damage as a percentage of GNI. This nuanced, asymmetric relationship across different economic levels indicates that natural resources, when managed with a strong institutional framework, regulatory control, and effective governance, can positively impact growth. This suggests that with the right policies in place, natural resources can indeed be a blessing rather than a curse (Yu et al., 2023).

The extraction of natural resources results in a decline in bio-capacity and increased environmental pollution. Stringent environmental policies and taxes are now emerging as effective tools for mitigating environmental degradation, alongside advancements in technology and green energy resources (Khan et al., 2022). Environmental regulations and pollution taxes are essential to reducing emissions. Additionally, measures such as subsidies, economic incentives, and facilities to develop efficient and effective environmentally friendly technologies are necessary (Cheng et al., 2017).

Researchers have pinpointed three main ways in which natural resources can negatively impact democratic governance. The first is the "taxation effect," where governments reduce or eliminate taxes due to resource income. This leads to citizens being less interested in holding the government accountable, weakening democracy. The second is the "spending effect," where governments use resource revenues to placate or buy off opposition groups, undermining democratic processes. Lastly, there's the "repression effect," where governments use resource wealth to suppress opposition, further eroding democratic principles. These channels illustrate how resource wealth can harm democratic governance (Ross, 2001; Avtac et al., 2016).

The abundance of natural resources can lead to a "curse" effect on green economic growth by encouraging the expansion of government expenditure and the size of government personnel. However, government institutional reform policies can effectively mitigate the "resource curse" phenomenon in various cities in China (Liu et al., 2023).

Green finance uses financial tools and strategies to promote the sustainable and responsible management of natural resources. In developing countries, the connection between natural resource rent and green finance is intricate and multi-dimensional. Revenue from natural resources can be crucial for funding green projects and sustainable practices. However, the success of this relationship hinges on factors like governance and legal frameworks (Liang et al.,2024).

Based on the above literature, the following hypothesis can be developed

H_4= There is a positive relationship between green growth and environmental regulations in OECD countries.

H_5=Environmental regulations moderate the relationship between green growth and natural resource rent in OECD countries.

III. MATERIALS&METHODS

3.1 Data

The present study utilizes panel data from 1996 to 2021, encompassing 28 OECD countries. The dependent variable in this study is green growth, which is constructed using a range of indicators. The main explanatory variables include green innovation and environmental regulations, with the Environmental Policy Stringency Index and environmental tax serving as components of the latter. Control variables include expenditure on research and development and fiscal policy. Table 1 provides the acronyms, measurement units, and sources for each variable. All estimation done by using Stata and R software.

Table 1. Variable description

Variable name	**Definition**	**Acronym**	**Sources**
Green Growth	Adjusted net saving*	GG	World Bank
Natural resource rent	Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents,% GDP	NRR	World Bank
Green Innovation	Development of environment-related technologies, % all technologies	INV	OECD
Environmental Policy Stringency index	The Environmental Policy Stringency Index is based on the stringency of 13 environmental policy instruments, primarily related to climate and air pollution. This index ranges from 0 (indicating no stringency) to 6 (indicating the highest degree of stringency).	ESPI	OECD
Environmental tax	Environmentally related taxes, % GDP	ET	OECD
Expenditure on research & development	Expenditure on research & development ,% GDP	R&D	World Bank
Fiscal policy	General government final consumption expenditure (% of GDP)	EXP	World Bank

*GG = GNS–DPC + CEE–RND–DCD/GNI

GNS = Gross National Saving

DPC =Depreciation of produced capital

CEE = Government expenditure on education

RND =rent from the natural resource depletion

DCD = damages from CO_2 emission

GNI = gross national income (Source: Miao et al.,2023).

3.2 Model

The first model is prepared to check the theoretical foundations of the resource curse hypothesis in OECD countries

$$\mathbf{GG_{it} = \alpha_0 + \beta_1 NRR_{it} + \beta_2 INV_{it} + \beta_3 ESPI_{it} + \beta_4 ET_{it} + \beta_5 E\&D_{it} + \beta_6 EXP_{it} + \varepsilon_{it}} \quad \textbf{(Model 1)}$$

To explore the role of green innovation in resource-growth nexus we introduce the interaction term NRR*INV in model 1 to capture the influence of natural resource rent on green growth in the presence of green innovation. This interaction term aims to determine whether INV modifies or enhance the relationship between resource and growth.

$$\mathbf{GG_{it} = \alpha_0 + \beta_1 NRR_{it} + \beta_2 INV_{it} + \beta_3 ESPI_{it} + \beta_4 ET_{it} + \beta_5 E\&D_{it} + \beta_6 EXP_{it} + \beta_7 NRR_{it}*INV_{it} + \varepsilon_{it}}$$

(Model 2)

$$\mathbf{GG_{it} == \alpha_0 + \beta_1 NRR_{it} + \beta_2 INV_{it} + \beta_3 ESPI_{it} + \beta_4 ET_{it} + \beta_5 E\&D_{it} + \beta_6 EXP_{it} + \beta_7 NRR_{it}*ESPI_{it} \beta_7 + \varepsilon_{it}}$$

(Model 3)

In model 3, environmental regulation in the form of a stringency index is introduced in the resource–growth nexus. In model 4, environmental tax another form of environmental regulation is introduced as a moderating variable resource-driven economy. The introduction of interaction terms with NRR is to confirm the institutional aspect of resource curse theory. This will help to understand how regulations and policies modify or enhance the impact of natural resource rent on green growth in OECD countries.

$$\mathbf{GG_{it} == \alpha_0 + \beta_1 NRR_{it} + \beta_2 INV_{it} + \beta_3 ESPI_{it} + \beta_4 ET_{it} + \beta_5 E\&D_{it} + \beta_6 EXP_{it} + \beta_7 NRR_{it}*ET_{it} \beta_7 + \varepsilon_{it}}$$

(Model 4)

3.3 Methodology

3.3.1 Cross-sectional dependence and slope heterogeneity tests

Seeing the closely related connection of OECD countries, which share strong economic ties and terrestrial closeness, it's crucial to recognize the likelihood of widespread cross-sectional

dependence (CSD) within the panel data. This interconnectedness means that what happens in one country can easily affect others, making it important to account for these influences in our analysis. Addressing cross-sectional dependence (CSD) is essential for several reasons. Firstly, it guarantees the correctness of our assessments. Secondly, understanding CSD allows us to detect common surprises and policy contagion impact among countries. Lastly, acknowledging CSD enables us to select the most appropriate econometric methods (Akyuz et al., 2023). Moreover, adding slope heterogeneity tests recognizes that the impacts of independent variables on the dependent variable can vary across diverse components in a panel.

3.3.2 Panel unit root

These tests help us spot non-stationarity in the data. When data isn't stationary, it can lead to misleading regression results, so it's important to identify and address this issue to ensure our analysis is accurate.

3.3.3 Panel long run test

The study applies common correlated effects (CCEMG) and augmented mean group (AMG).

The CCEMG method, known for its common structure and handling of complex processes, along with the AMG estimator established by Eberhardt and Bond (2009), tackles the problem of multifactor error structures. They do this by initially estimating regressions explicit to each group and then averaging the betas across all groups. Using the CCEMG and AMG estimators in panel data analysis helps to: Correct for cross-sectional dependence and unobserved common factors. Allow for heterogeneity in the relationships being modeled. Improve the robustness and reliability of the estimated coefficients. Address dynamic heterogeneity and structural breaks in the data

IV. RESULTS &DISCUSSIONS

In Table 2 descriptive statistics and correlation among variables are discussed. The highest variation is in INV and EEXP.INV and ESPI have 0 as minimum values which means either INV or ESPI is in the country or not. Highest maximum value observed in Govt expenditure. A higher correlation between GG and INV is observed from the correlation table.

Table 2. Descriptive Statistics

	Mean	Std. dev.	Min	Max
GG	1.52	2.00	-7.89	8.61
NRR	1.14	2.35	.0004	17.34
INV	9.56	4.09	0	4.22
ESPI	1.88	0.99	0	4.22
ET	2.48	0.81	0.33	5.36
R&D	0.046	0.041	0	0.27
EXP	18.93	3.95	9.66	30.32

Correlation Statistics

	GG	NRR	INV	ESPI	ET	R&D	EXP
GG	1.00						
NRR	-0.04	1.00					
INV	0.29	-0.04	1				
ESPI	0.24	0.08	0.44	1			
ET	0.08	0.04	0.34	0.20	1		
R&D	-0.04	0.07	0.21	0.26	-0.03	1	
EXP	-0.30	0.18	0.26	0.06	0.17	0.10	1

Table 3, displays the Pesaran cross-dependence test results, Since the p-value is close to zero, in the case of all variables it strongly suggests that the data are correlated across panel groups. In other words, there is significant cross-sectional dependence in all variables of interest

Table 3. Cross-sectional dependence test

	GG	NRR	INV	ESPI	ET	R&D	EXP
CD Test	40.06***	29.79***	47.84***	84.92***	11.33***	18.06***	28.25***

Note: *, **, ***mean significant at the 10%, 5%, and 1% level respectively

Table 4 displays the result of the slope heterogeneity test; the Null hypothesis is rejected at 10 % significance that homogenous qualities in data. This proves that there are statistically significant levels of heterogeneity present in the data.

Table 4. Slope heterogeneity test

	Delta	P-value
Slope Homogeneity	1.59	0.07*
Slope Homogeneity (Adjusted)	1.86	0.08*

Note: *, **, ***mean significant at the 10%, 5%, and 1% level respectively

4.1 Panel long-run analysis

Table 5 shows the results of the unit root test, It is evident that GG, NRR, R&D, EXP are stationary at their levels, meaning they do not require differencing to achieve stationarity. INV, ESPI, and ET are non-stationary at levels but become stationary after first differencing.

Table 5. Panel unit root tests

	I(0)	I(1)
GG	-8.62***	
NRR	-3.48***	
INV	-0.54	-3.07***
ESPI	8.10	-7.90***
ET	-0.67	-9.28***
R&D	-3.04***	
EXP	-2.83***	

Note: *, **, ***mean significant at the 10%, 5%, and 1% level respectively

The results of the panel long-run analysis are presented in Table 6. The long-run co-efficients of natural resource rent for the model 1 indicate that NRR is negatively related to green growth at 10% level of significance in both estimation techniques CCEMG &AMG. This advocates the resource curse theory in OECD countries. Excessive natural resource extraction not only leads to environmental degradation but also promotes the rent-seeking behavior that makes growth decline. Results are consistent with (Joshua et al., 2020; Lie et al., 2021; Miao et al.,2023). A resource-rich nation like those in the OECD often faces challenges with rent-seeking behaviors due to cheap labor and resource-focused exports. This can lead to underutilized resources and a decline in resource rents, ultimately hindering economic prosperity. Excessive exploration of resources by country makes sense because profits from natural resources can motivate continued exploration and use, even though it negatively impacts the ecosystem. One unit change in NRR leads to approx. 0.01-unit decline in GG in the CCEMG model and 0.03-unit decline in the AMG model. Incorporating the role of green innovation in the model with GG. In both estimation techniques, there is a positive association between green innovation and green growth. Green innovations encompass new or modified processes, techniques, practices, systems, and products designed to prevent or minimize environmental harm (Rennings, 2000; Rennings et al., 2004). Eco-innovation facilitates economic development by integrating both technological and non-technological changes, leading to significant environmental benefits (Yu et al., 2023). Figure 4. Shows the possible connection between natural resource rent and growth as discussed by the literature.

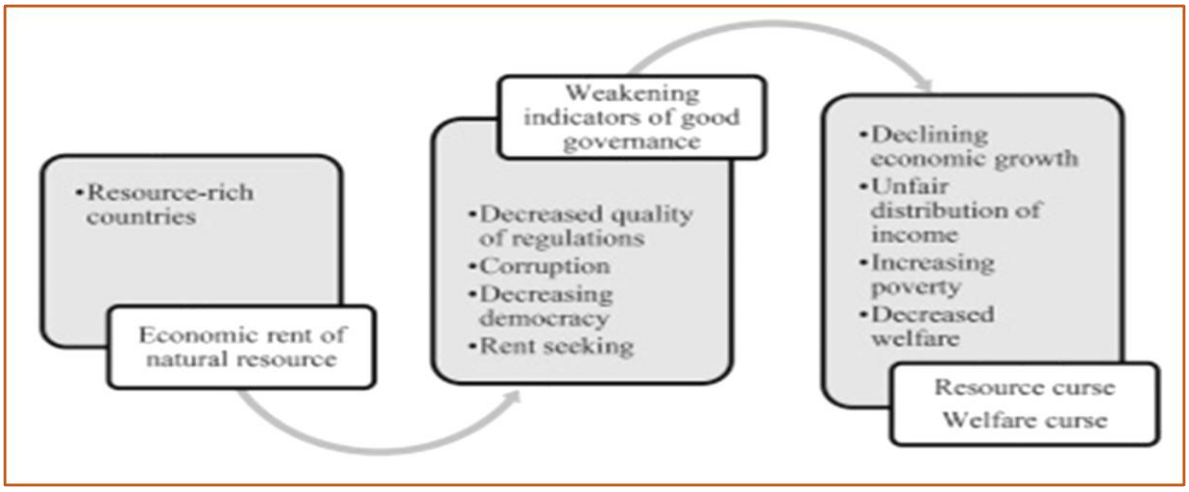


Fig. 4. Natural resource rent and Growth flow chart

Table 6. Panel long-term results tests.

	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
	CCEMG				AMG			
NRR	-0.03*(-1.97)	-0.01*(-1.81)	-0.01*(-1.82)	-0.02*(-1.90)	-0.03*(-1.93)	-0.01*(-1.81)	-0.07*(-1.62)	-0.08*(-1.75)
INV	0.09*(1.76)	0.21*((1.81)	0.03*(1.67)	0.001(1.32)	0.21*(1.86)	0.19*(1.91)	0.13*(1.77)	0.031*(1.69)
ESPI	0.05*(1.91)	0.03*(1.84)	0.02*(1.81)	0.038(1.87)	0.31*(1.71)	1.03(0.84)	0.02*(1.71)	0.037(0.87)
ET	0.32*(1.93)	0.42(1.32)	0.31*(1.87)	0.31*(1.90)	-0.72(-1.03)	0.22*(1.72)	0.01*(1.97)	0.11*(1.70)
R&D	0.12**(2.51)	0.14**(2.74)	0.11(1.54)	0.11*(1.85)	0.12*(1.71)	0.19(0.74)	0.17(1.04)	0.01*(1.65)
EXP	1.10*(1.68)	-1.30(-0.81)	1.11(1.32)	0.01*(1.65)	-0.09(-0.32)	-1.80(-0.31)	-1.11(-0.12)	0.11*(1.75)
NRR*INV		0.10*(2.00)				0.30**(2.37)		
NRR*ESPI			0.04**(2.31)				0.14*(1.99)	
NRR*ET				0.09**(2.37)				0.19***(3.37)

Note: *, **, ***mean significant at the 10%, 5%, and 1% level respectively. The numbers in parentheses are the t-statistics

The Environmental Policy Stringency Index is positively related to the green growth at a 10% level of significance.1 unit change in ESPI leads 0.05-unit increase in GG in CCEMG while 0.31-unit increase in GG under the AMG estimation technique. This confirms the presence of strong environmental regulation policies and regulations in the OECD. In previous literature such as Chien et al. (2022) environmental regulations promote the sustainable use of natural resources by promoting carbon pricing in case of environmental externality. There is a positive relationship between green growth and environmental regulations in the form of tax in the OECD. By taxing harmful activities like carbon emissions and pollution, we encourage businesses and individuals to adopt more sustainable practices. This shift helps reduce environmental damage and promotes a healthier ecosystem. The money collected from these taxes can then be reinvested into green projects, such as renewable energy and energy efficiency programs, further supporting sustainable

development (Okombi et al., 2024). Now introduce the moderating role of INV, ESPI, and ET in NRR and growth nexus to check either their synergies or antagonistic influence on green growth through NRR. Green innovation promotes the effective utilization of natural resources by introducing green technologies that make the extraction of natural resources minimal and promote the use of renewable energy resources. It is evident in model 2 in both CCEMG and AMG estimation techniques that NRR influences GG positively and increases the level of significance at 5 % in the presence of green innovation.

Now introducing the environmental regulations in the form of stringency index and environmental taxation. From model 3, it is evident that strict regulation improves the NRR-GG nexus relationship. Stricter regulations push companies to adopt cleaner technologies and practices, leading to more sustainable extraction and use of natural resources that promote sustainable growth. According to Caijuan et al. (2024), supportive environmental regulatory policies minimize the negative impact of resource rent on environmental sustainability.

Model 4, by adding environmental tax synergies the association between natural resource rent and green growth. NRR positively influences the GG in the presence of tax and the level of significance is also improved at 5% and 1% respectively.1 unit change in NRR in the presence of tax increases the GG by 0.09 and 0.19 units in both estimation procedures. Imposing taxes on the extraction of natural resources can lead to higher production costs and lower profits for industrialists. As a result, they need to adopt more environmentally friendly practices to conserve resources and reduce carbon emissions. This approach not only helps protect the environment but also promotes sustainable economic growth. The result is consistent with Dogan et al. (2022). Now incorporating the role of control variables it is evident in all cases that R&D and fiscal policy are positively associated with the green growth. Mostly impact of fiscal policy on green growth is insignificant, this can be justified that research & development expenditure already influence the GG. R&D is part of fiscal policy so, so that's why mostly it is insignificant.

4.2 Robustness Test

Using the Two-Step System Generalized Method of Moments (GMM) as a robustness estimation technique in our study is essential because it effectively addresses endogeneity concerns. This method ensures our results are more reliable and accurate. Table 7, depicts the results that the lag of GG is positively and significantly related to GG at a 10% level of significance. The results show that previous green growth (l.GG) positively and significantly influences current green growth in all models. Natural resource rents (NRR), on the other hand, generally have a negative impact on green growth in all models at a 10% level of significance advocates the presence of natural curse theory in OECD countries. Innovation (INV) mostly has a positive and significant effect, indicating that green technologies promote renewable resources and control the use of fossil fuels that make environmental pollutants important for green growth. Both the environmental stringency index (ESPI) and environmental taxes (ET) generally contribute positively to green growth. This promotes the idea that stringent regulations promote the use by taxing harmful activities like

carbon emissions and pollution, we encourage businesses and individuals to adopt more sustainable practices hence promoting a sustainable environment.

Table 7. Two-Step System GMM test

	Model 1	Model 2	Model 3	Model 4
l.GG	1.07*(1.90)	0.69*(1.86)	0.54*(1.85)	0.44*(1.68)
NRR	-1.01*(-1.84)	-1.60*(-1.73)	-0.30(-1.86)	-0.39*(-1.70)
INV	0.11**(2.08)	1.23*(2.00)	0.19*(1.64)	0.16(1.63)
ESPI	0.61*(1.67)	0.22*(1.70)	0.09*(1.99)	0.28*(1.92)
ET	0.36**(2.49)	1.95*(1.86)	0.13*(1.89)	0.04*(1.72)
R&D	0.17(1.16)	0.04**(2.10)	-15.12(-0.81)	0.08*(1.86)
EXP	0.51(0.03)	-0.86(-0.13)	-0.755(-0.03)	0.06*(1.69)
NRR*INV		3.63*(1.81)		
NRR*ESPI			1.09**(2.75)	
NRR*ET				0.60**(2.73)
AR(1)	0.01	0.03	0.02	0.01
AR(2)	0.71	0.67	0.91	0.77
Sargan test	0.32	0.33	0.78	0.99

Note: *, **, ***mean significant at the 10%, 5%, and 1% level respectively. The numbers in parentheses are the t-statistics.

In Model 2, the combination of natural resource rents (NRR) and innovation (INV) has a positive and significant effect on green growth, with a coefficient of 3.63* at a 10% level of significance. I1 unit change in NRR*INV promotes a 3.63-unit increase in green growth. This means that when natural resource rents are paired with green innovations, the overall impact on green growth turns positive. In Model 3, the interaction between NRR and environmental stringency index (ESPI) is also positive and highly significant, with a coefficient of 1.09** at a 5% level of significance. This indicates that stricter environmental policies can mitigate the negative effects of natural resource rents, resulting in positive green growth. In Model 4, the combination of NRR and environmental taxes (ET) has a positive and highly significant effect on green growth, with a coefficient of 0.60**. This shows that environmental taxes can offset the negative impacts of natural resource rents by reducing the use of natural resources hence, promoting green growth.

V. CONCLUSION & POLICY IMPLICATIONS

Using second-generation estimation techniques such as CCEMG and AMG, this study investigated the association-ship between green growth and natural resource rents in OECD countries from 1996 to 2021. The study also incorporates the moderating role of green innovation and environmental regulations in natural resource rent and green growth nexus. The study reveals that there is a negative relationship between green growth and natural resource rent in OECD countries,

hence proving the resource curse theory. Moreover, green innovations and environmental regulations also promote green growth in these countries. Regarding moderating roles of green innovations and environmental regulations in the form of environmental stringency index and environmental taxation hence mitigate the inhibiting influence of natural resource rent on green growth by promoting sustainable technologies and environmental protection regulations. All hypotheses such as from H_1 to H_5 are accepted in the case of OECD countries. Robustness test by using the system GMM also advocates the results mentioned above.

Governments should invest in and promote green innovation to counteract the negative impacts of natural resource rents. This means funding research and development in sustainable technologies and offering incentives for businesses to adopt eco-friendly practices. Stricter environmental regulations are needed to reduce the harmful effects of natural resource exploitation. These policies should aim to reduce pollution, promote renewable energy, and enforce environmental standards. Introducing or increasing environmental taxes can discourage harmful activities and generate revenue for green projects, helping to shift the economy towards sustainability.

Policies should also encourage the sustainable extraction and use of natural resources by adopting best practices in resource management and ensuring that resource rents fund sustainable development initiatives. Governments should monitor and prevent rent-seeking behavior to avoid the over-extraction of natural resources, ensuring that they are used responsibly and sustainably.

VI. LIMITATIONS OF THE STUDY

This study currently focuses on OECD countries, but it can be expanded to include additional countries and regions. A comparative analysis can then be conducted across different income levels. Furthermore, governance indicators can be introduced as moderating variables in the relationship between green growth and natural resource rents. Lastly, the study could benefit from utilizing various measures of green growth to provide a more comprehensive analysis.

CONFLICT OF INTEREST

"The authors declare no conflict of interest".

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