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Environmental Regulations and Sustainable Development: The Role of Fiscal Decentralization and Clean Energy

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Abstract

There is a growing recognition of the importance of sustainable development. Political economy factors and natural resources are considered important sources of economic prosperity. These are the fundamental primary resources utilized in the production process, which subsequently drives economic activities and results in sustained growth. Nevertheless, resource-rich countries often experience sustainability challenges. This study examines the impact of mineral resource rents on sustainable development in selected developed countries from a political economy perspective. Moreover, we include renewable energy deployment and fiscal decentralization as additional determinants of sustainable development. The study uses random-effects and fixed-effects estimation methods to estimate the model. The study also uses quantile regression econometric techniques. A sustainable development index (SDI), integrating economic, social and environmental dimensions, is constructed as the dependent variable. The results reveal that mineral resource rents and renewable energy electricity output negatively affect sustainable development. Nevertheless, environment-related taxes and fiscal decentralization positively affect sustainable development. These results provide valuable insights for academia, researchers and policy makers aiming to achieve environmental sustainability through institutional and fiscal reforms.

Keywords: Sustainable development, mineral resources, political economy, natural resources, developed countries

JEL Classification: Q58, Q32, H77, O44

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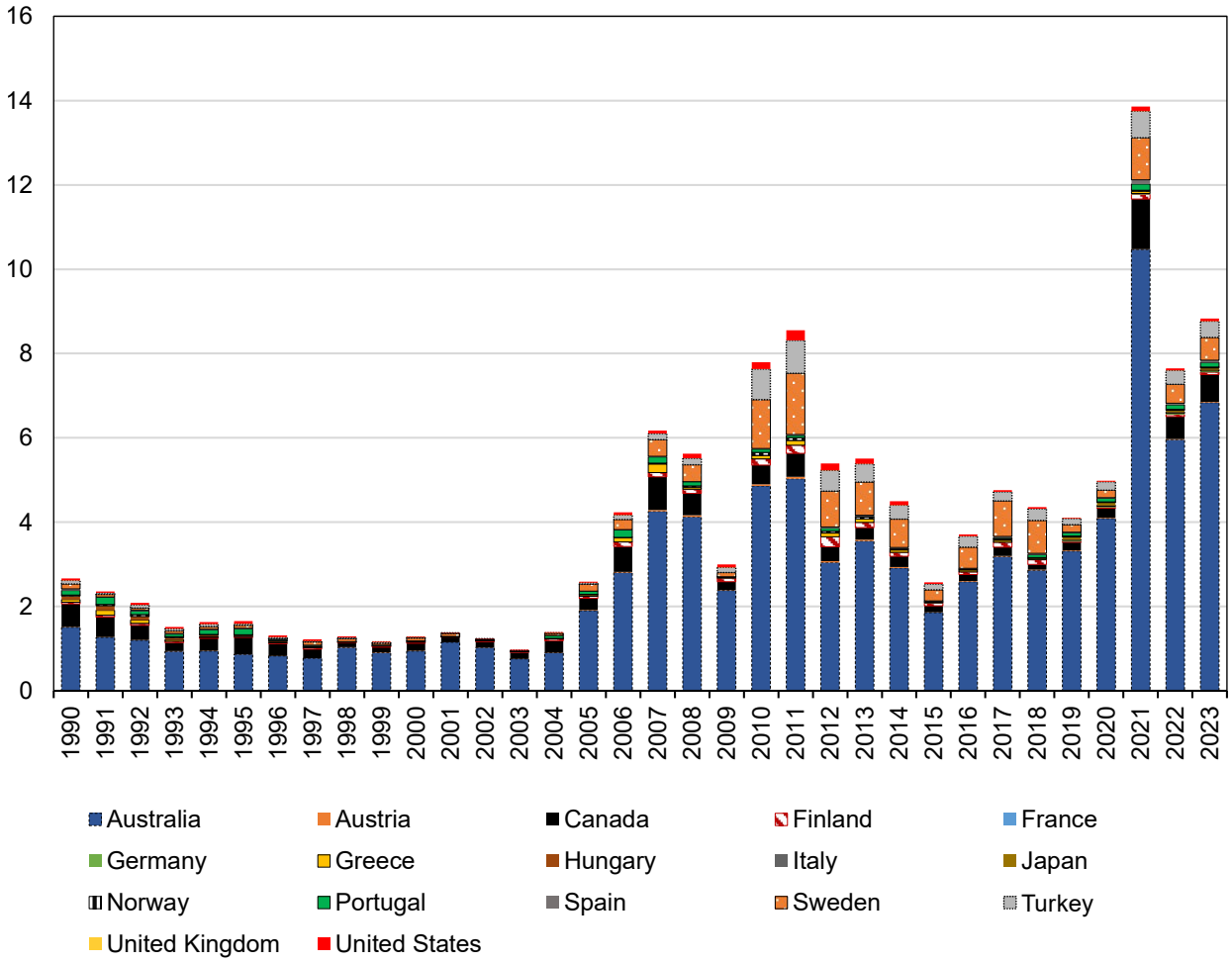
1. Introduction

The continuous increase in economic activity has deteriorated environmental quality and caused global warming, biodiversity loss and pollution. Therefore, countries are dealing with the daunting challenges of environmental sustainability. Environmental degradation poses a significant problem for all developed countries. The issue of environmental sustainability lies at the heart of political economy debates, particularly in developed countries where technological advancements often shape development outcomes. Despite rapid growth in technological advancements and consumerism, developed countries have not been successful in protecting themselves from the adverse effects of climate change. Environmental deterioration poses a significant threat to both ecosystems and biodiversity. Current economic growth significantly influences climate change by promoting energy-intensive activities, resulting in CO_2 emissions in the atmosphere and subsequently increasing global temperatures (Ali *et al*., 2021). To achieve a net zero carbon economy, developed countries are focusing on measures to abate rising CO_2 emissions. These measures include developing eco-friendly products and introducing carbon taxes. Through these measures, countries can improve their environmental quality over the years. However, developed countries have the capacity to contribute more to the global shift towards a more sustainable future. Therefore, achieving sustainable development is the top agenda of countries around the globe.

The main objective of sustainable development is to guarantee the availability of natural resources (NRs) to the existing generation without compromising the needs of future generations. Natural resources are considered important sources of economic prosperity. They are the essential raw materials used in the manufacturing process, which in turn stimulates economic activities and leads to long-term growth. Resource abundance may support the shift to renewable energy sources (Gylfason, 2001; Hassan *et al*., 2019). Aydoğan and Vardar (2020) claimed that the process of burning fossil fuels has the potential to stimulate economic expansion. Thus, the use of NRs is vital for safeguarding the world's welfare. Conversely, certain natural resources might be detrimental due to their substantial adverse effects on the economy and inadequate resource management. Resource-rich countries often experience sustainability challenges. The term "natural resource curse" is often used to describe the negative linkage between a country's abundant NRs and its growth (Gu *et al*., 2023). Sachs and Warner (1995) proposed that the prevailing explanation for this complex situation is its origin from the Dutch disease. This Dutch disease posits that the process of national integration of commodity rents gives rise to economic vulnerabilities, including adverse trade shocks and a decline in the proportion of non-mining commodities that contribute to national income. Nevertheless, if natural resources and their profits are effectively

controlled and utilized, it is feasible to decrease poverty rates and promote economic expansion and progress (Carmignani and Chowdhury, 2010; Chen and Chen, 2011; Erdogan *et al.*, 2020; Hacıimamoğlu and Cengiz, 2024).

Figure 1: Mineral resource rents in selected developed countries



Source: Authors' own elaboration

Figure 1 illustrates the trend in mineral resource rents for selected sample countries. Mineral resource rents (as a percentage of GDP) in several developed countries exhibit a combination of stability and fluctuations over time. Resource-rich countries, such as Australia, Canada and Norway, tend to exhibit greater mineral resource rents than resource-poor countries. Moreover, countries with stable and supportive regulatory environments tend to attract more investment in the mining sector, leading to greater mineral resource rent contributions. Some developed countries actively pursue economic diversification away from traditional mineral-dependent industries. These countries may experience a declining

trend in aggregate mineral resource rents (as a percentage of GDP) as they invest in alternative sectors. Countries such as Australia, Canada and Norway consistently display higher mineral resource rents due to their rich endowment with natural resources and strong mining sectors. These countries utilize resource extraction as a significant contributor to GDP, yet their sustainability outcomes vary based on governance and environmental policies.

There is a growing acknowledgment of the importance of sustainable development. Moreover, because of the need to transition towards cleaner and more inclusive growth models, the specific mechanisms and interactions among these variables remain inadequately understood in literature. The present study examines the impact of mineral resource rents on sustainable development in selected developed countries. Moreover, we include renewable energy deployment, fiscal decentralization and environment-related taxes as additional determinants of sustainable development.

The investigation of the dynamics of resource rents, fiscal reforms and environmental sustainability in the context of political economy debate is important. It is generally believed that abundance of natural resources is linked with environmental degradation. The relationship is deeply rooted in the political economic system particularly in developed countries, where technological advancements often shape development outcomes.

2. Literature Review

The topic of sustainability is well acknowledged in literature due to its important role in creating a prosperous world for current and future generations. Numerous studies have explored the factors responsible for environmental sustainability (Ali *et al*., 2021; Kirikkaleli *et al*., 2021; Safi *et al*., 2021; Qin *et al*., 2021; Chi *et al*., 2021; Wang *et al*., 2020; Ali *et al*., 2014). Rising economic activities, population and excessive energy use are acknowledged as the driving forces of environmental deterioration. Among others, human capital, institutional quality and utilization of renewable energy and environmentally sustainable inventions abate CO_2 emissions (Huang and Guo, 2022).

The relationship between NRs and output is well acknowledged in the literature (Adams *et al*., 2019; Alvarado *et al*., 2021; Amiri *et al*., 2019; Badeeb *et al*., 2020; Barma and Bashir, 2020; Brunnschweiler, 2008; Huang and Guo, 2022; Hussain, 2020; Janda and Quarshie, 2017). The literature in this regard can be divided into three schools of thought. The first school of thought argues that the abundance of NRs negatively affects economic performance because the process of rent accumulation gives rise to economic vulnerabilities, including adverse trade shocks and a decline in the proportion of non-mining commod-

ities that contribute to national income. The second school of thought argues that the exploitation of natural resources is associated with poverty reduction. They are the vital elements of the manufacturing process that are responsible for shedding light on the economic activities that are necessary for sustained growth. Burning of fossil fuels has the potential to stimulate economic expansion (Aydoğan and Vardar, 2020). Gu *et al*. (2023) argued that the main objective of sustainable development (SD) is to safeguard the current generation without compromising the needs of future generations. NRs are considered important sources of economic wellbeing.

However, resource-rich countries often experience sustainability challenges. Thus, there are opposing outcomes for the impact of NRs on SD. However, these studies were concentrated on specific regional blocks, such as BRICS, G7 and G8. The countries in these blocks are considered highly progressive (Huang, 2022). Furthermore, the utilization of different econometric techniques has produced different outcomes. Therefore, results on the relationship between the resource rents and SD are vague. For example, some studies support the pollutant-inducing impacts of resource rents (Nwani and Adams, 2021; Shabbir *et al*., 2020; Shao *et al*., 2014; Shen *et al*., 2021; Song *et al*., 2018; Zallé, 2019; Zameer *et al*., 2020, *etc*.). In contrast, other studies support the pollutant-reducing impact of resource rents (Sachs and Warner, 2001; Kongbuamai *et al*., 2020; Loganathan *et al*., 2020; Muhanji *et al*., 2019, *etc*.). Nevertheless, some studies have found no linkage between NRs and sustainability (Topcu *et al*., 2020; Tufail *et al*., 2021; Usman *et al*., 2021). Thus, there is no general consensus regarding the linkage between NRs and sustainable development, which is the basic motivation for this study.

The impact of renewable energy sources on long-term SD has attracted increasing attention in the current academic literature (Agboola *et al*., 2021; Ahmed *et al*., 2020; Joshua and Bekun, 2020; Quan *et al*., 2021; Safi *et al*., 2021; Balsalobre-Lorente *et al*., 2018; Ulucak *et al*., 2020; Zia *et al*., 2021). Research typically underscores the vital role of alternative energy sources in attaining the SDGs. Alternative energy technologies are helpful for achieving sustainable development objectives. Several studies have found a positive influence of renewable energy sources on environmental sustainability (Ali *et al*., 2021; Ulucak *et al*., 2020; Kirikkaleli *et al*., 2021; Ahmed *et al*., 2020; Joshua and Bekun, 2020; Zia *et al*., 2021). Ulucak *et al*. (2020) found that renewable energy sources play an important role in mitigating CO_2 emissions. Furthermore, the transformation of the industrial sector to renewable energy sources is vital for reducing greenhouse gas emissions. Ali *et al*. (2021) argued that renewable energy sources improve the standard of living by providing electricity for rural and isolated areas. Consequently, renewable energy sources are linked with improved standard of living.

The literature on the role of fiscal decentralization (FISDS) in influencing environmental performance and sustainable development is rich (Ji *et al*., 2020; Mu, 2018; Feng *et al*., 2020). A substantial association exists between a limited level of fiscal decentralization and a more powerful central administration, indicating that the central administration exercises greater authority over fiscal and monetary policies. In the literature, it is generally acknowledged that an increased degree of fiscal decentralization is linked with low pollution levels. Greater fiscal decentralization is beneficial for achieving effective pollution control and reducing CO_2 emissions. Mu (2018) argued that fiscal decentralization offers local governments several advantages, such as improved allocation of resources. Under decentralization, local governments endorse environmental policies that are allied with the structures of their own regions. Moreover, local governments are anticipated to achieve economic development. Thus, fiscal decentralization affects the carbon footprint through different channels.

Feng *et al*. (2020) found that eco-innovation and fiscal decentralization transformed environmental costs into benefits in highly decentralized economies. The authors argued that devolving the financial decision-making authority to lower levels of government is considered important in affecting environmental performance. Fiscal decentralization fosters innovation, ultimately resulting in the development of policies that progressively encourage environmental sustainability. Khan *et al*. (2021) argued that the presence of natural resource markets significantly contributes to the advancement of environmental sustainability by creating economic incentives for the preservation of resources and their sustainable exploitation. With decentralized testing, it is significantly easier to uncover efficient methodologies, share information and enhance successful initiatives. Fiscal decentralization fosters innovation, ultimately resulting in development of policies that progressively encourage environmental sustainability. The presence of natural resource markets significantly contributes to advancement of environmental sustainability by creating economic incentives for preservation of resources and their sustainable exploitation.

In summary, the literature has explored the effects of NRs, alternative energy outputs and fiscal decentralization on environmental performance. However, the combined role of these factors in affecting SD has not been investigated before. This study examines the impact of mineral resource rents, renewable energy sources, environmental taxes and fiscal decentralization on the SD of selected developed countries. The main question that we seek to answer is whether mineral resource rents, along with these factors, affect the SD in developed countries. Some researchers have argued that the specific type of natural resource is the determining factor for economic growth rather than the mere presence of a variety of NRs that are necessarily linked to growth. Consequently, the research is concentrated

on the mineral industry. The main objective of this research is to ascertain the degree to which sustainable development relies on the abundance of minerals. We hypothesize that sustainable development is affected by mineral resource rents, renewable energy sources and fiscal decentralization. Previous studies have investigated the economic, environmental and social consequences of resource rents. However, despite the extensive studies conducted in these fields, certain gaps remain. There is a need for a greater number of studies that explore the impact of these factors in different geographical areas. Moreover, this study contributes to the literature by constructing a sustainable development index (SDI), which comprises education, health, income, the carbon footprint and the material footprint.

3. Methodology

3.1 Theoretical framework

This study examines the impact of mineral resource rents, renewable electricity, environmental taxes and fiscal decentralization on SD in developed countries. SD highlights the importance of safeguarding the current generation without compromising the needs of future generations. As a theoretical framework, this study uses the resource curse hypothesis, which states that countries with rich natural resources may experience adverse development consequences. The evidence of resource curse can be seen in countries such as Venezuela and Nigeria, where abundant oil resources have not translated into sustainable development. Due to corruption and rent-seeking behaviour, the other productive sectors in these countries have been ignored. In contrast, countries such as Norway and Denmark have managed to avoid the resource curse through strong institutions and prudent fiscal reforms. According to the theoretical framework, resource rents influence sustainable development through several channels. The process of national integration of commodity rents gives rise to economic vulnerabilities, including adverse trade shocks and a decline in the proportion of non-mining commodities that contribute to national income. The prevailing explanation for this complex situation is its origin from the Dutch disease (Sachs and Warner, 1995). Nevertheless, if natural resources and their rents are well managed and utilized, it is feasible to decrease poverty rates and promote economic growth and progress (Hacıimamoğlu and Cengiz, 2024). Thus, this study empirically examines how resource abundance, when combined with governance mechanisms such as fiscal decentralization and environmental taxation, influences sustainable development outcomes in developed countries.

This study uses renewable energy electricity output in the SD model. Renewable energy output decreases the ecological footprint and is therefore important for sustainable development. This is vital for addressing environmental concerns and adhering to sustainability goals. Moreover, renewable energy electricity output can lead to more efficient resource use, increased productivity and the development of green industries, which in turn promote sustainable development. We use fiscal decentralization in the sustainable development model. Fiscal decentralization decreases the ecological footprint and is therefore important for sustainable development. Fiscal decentralization is vital for addressing environmental concerns and adhering to sustainability goals because devolving the financial decision-making authority to lower levels of government is considered important for affecting carbon emissions. Moreover, efficient allocation of resources through an increasing degree of decentralization is related to development with fewer carbon emissions.

3.2 Model specification

We specify the following model:

$$SDI_{i,t} = \lambda_0 + \lambda_1 MRR_{i,t} + \lambda_2 ERT_{i,t} + \lambda_3 RELO_{i,t} + \lambda_3 FISDS_{i,t} + \varepsilon_{i,t} \quad (1)$$

where *SDI* is the sustainable development index from Hickel (2020). *MRR* is the mineral resource rents as a percentage of GDP. *ERT* is the environment-related tax from the OECD. *RELO* is the renewable energy electricity output. The *MRR* and *RELO* data are taken from the WB (2022). *FISDS* is the fiscal decentralization index.

The empirical model of this study also incorporates environment-related taxes (*ERT*). We argue that *ERT* positively affect sustainable development. Improving *SDI* is one of the main goals of developed countries. To successfully implement strategies to improve environmental performance, countries need to levy environmental taxes. Without environmental taxes, shifting the industrial structure from non-renewable to environmentally friendly energy is in jeopardy. The empirical model of this study also incorporates renewable energy electricity output (*RELO*). We argue that *RELO* abates greenhouse gas emissions. *RELO* such as rooftop solar panels, renewable hydrogen and geothermal energy are important for reducing GHG emissions. The empirical model of this study also incorporates fiscal decentralization (*FISDS*).

Table 1: Variables, units and sources

Variable	Description	Units	Sources
SDI	Sustainable development index	Broad measure for sustainable development by taking into account material wellbeing and ecological footprints	Hickel (2020)
FISDS	Fiscal decentralization	Ratio of own revenues/expenditures to general government revenues/expenditures	IMF (2022)
ERT	Environment-related tax	% of GDP	WB (2022)
RELO	Renewable energy electricity output	% of total electricity production	WB (2022)
MRR	Mineral resource rents	Total mineral resource rents as a percentage of GDP	WB (2022)

Source: Authors' own elaboration

We contend that fiscal decentralization abates greenhouse gas emissions. Fiscal decentralization is always linked to efficient economic activities, which in turn results in reduced energy demand and consumption, which could be one reason for the positive influence of *FISDS* on *SDI*. Table 2 provides the key descriptions of the variables.

Table 2: Descriptive statistics

	SDI	***MRR***	***RELO***	***FISDS***	***ERT***
Mean	0.474344	0.227234	1.335552	1.679224	0.394653
Median	0.484000	0.017046	1.358980	0.811168	0.385048
Maximum	0.808000	10.46578	4.304670	13.36583	7.598250
Minimum	0.151167	5.59E-08	−0.237988	2.41E-06	−0.143271
Std. dev.	0.191052	0.815226	0.499130	2.352948	0.514958
Skewness	−0.046414	6.894786	0.083802	2.244395	9.911919
Kurtosis	1.705385	63.91551	7.193074	8.223560	119.4659
Jarque–Bera	40.57189	93945.52	424.1065	1142.388	336138.2
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	578	578	578	578	578

Source: Authors' own calculations

3.3 Econometric methods

Based on the econometric techniques listed, this study employs a diverse array of methodologies to analyse the relationships among mineral resource rents, fiscal decentralization, renewable energy electricity output and sustainable development. Cross-sectional dependence (CSD) and slope heterogeneity (SH) are the two greatest potential issues in panel data (Ali and Malik, 2020). To check the CSD, this study uses Pesaran's (2015) CSD test. Accounting for cross-sectional dependence helps ensure the validity of the results. The test statistics are given as follows:

$$CSD_{TN} = \left[\frac{TN(N-1)}{2}\right]^{1/2} \hat{\bar{\rho}}_N \tag{2}$$

where $\hat{\bar{\rho}}_N$ is the pairwise correlation coefficient. To check the SH, we employ the P&Y test. This technique examines whether the associations among variables change across different segments of the data. The significance test statistics of the SH test imply that the impacts of mineral resource rents, fiscal decentralization, environment-related taxes and renewable energy outputs on sustainable development can differ across different segments of the data. The SH equations are as follows:

$$\tilde{\Delta}_{SH} = (N)^{\frac{1}{2}}(2k)^{-\frac{1}{2}}\left(\frac{1}{N}\tilde{S} - k\right) \tag{3}$$

$$\tilde{\Delta}_{ASH} = (N)^{\frac{1}{2}}\left(\frac{2k(T-k-1}{T+1}\right)^{-\frac{1}{2}}\left(\frac{1}{N}\tilde{S} - 2k\right) \tag{4}$$

To observe the stationarity of the variables, we employ the CIPS unit root test. Ensuring that the variables are stationary is essential for accurate estimation of the model. The equation for the CIPS test is as follows:

$$\Delta W_{i,t} = \varphi_i + \varphi_i Z_{i,t-1} + \varphi_i \overline{W}_{t-1} + \sum_{l=0}^{p} \varphi_{il} \Delta \overline{W_{t-l}} + \sum_{l=1}^{p} \varphi_{il} \Delta W_{i,t-l} + \mu_{it} \tag{5}$$

where:

$$W^{i,t} = \varphi^1 \overline{MRR}^{i,t} + \varphi^2 \overline{ERT}^{i,t} + \varphi^3 \overline{RELO}^{i,t} + \varphi^4 \overline{FISDS}^{i,t} \tag{6}$$

The test statistic is:

$$\widehat{CIPS} = N^{-1} \sum_{i=1}^{n} CDF_i \tag{7}$$

This study uses the Westerlund test to assess the cointegration of sustainable development with mineral resource rents, fiscal decentralization and renewable energy electricity output. The group (G) and panel (P) test statistics are given in Equations (8) to (11):

$$G_t = \frac{1}{N}\sum_{i-1}^{N}\frac{\acute{\alpha}_i}{SE(\acute{\alpha}_i)} \tag{8}$$

$$G_a = \frac{1}{N}\sum_{i-1}^{N}\frac{\mathrm{T}\acute{\alpha}_i}{\acute{\alpha}_i(1)} \tag{9}$$

$$P_t = \frac{\acute{\alpha}}{SE(\acute{\alpha})} \tag{10}$$

$$P_a = T\acute{\alpha} \tag{11}$$

This study employs both random-effects and fixed-effects models. The main justification for using these tests is that there are certain features of countries that do not change over time and can affect the relationships between variables. Thus, these models take into account the impact of these features. The fixed-effects model is given as follows:

$$SDI_{i,t} = \lambda_0 + \lambda_1 MRR_{i,t} + \lambda_2 X_{i,t} + \lambda_3 RELO_{i,t} + \lambda_3 FISDS_{i,t} + Country_i + Year_t + \varepsilon_{i,t} \tag{12}$$

where $Country_i$ represents the country fixed effect and $Year_t$ represents the year fixed effect. The random-effects model is written as follows:

$$SDI_{i,t} = \lambda_i + \lambda_1 MRR_{i,t} + \lambda_2 ERT_{i,t} + \lambda_3 RELO_{i,t} + \lambda_3 FISDS_{i,t} + \varepsilon_{i,t} \tag{13}$$

$$\lambda_i = \lambda_1 + \varepsilon_i \tag{14}$$

To assess the level of suitability of the model, we use the Hausman test. This test enables us to compare the two models. It is possible that the random effects are associated with regressors, indicating that the random-effects model is not appropriate. This conclusion is obtained when the null hypothesis is disproven.

For a robustness check, this study employs the PCSE and quantile regression (QR) econometric techniques. The PCSE technique is employed to correct standard errors in panel data analysis. PCSEs can be used to generate efficient and unbiased estimates in the presence of autocorrelations. Moreover, we employ the quantile regression (QR) method, which estimates variables across varying quantiles of the distribution (median in our case). The equation for quantile regression is given as:

$$SDI_{i,t}\left(\tau I\gamma_i, \delta_t, X_{i,t}\right) = \varphi_i + \lambda_{1,\tau} MRR_{i,t} + \lambda_{2,\tau} ERT_{i,t} + \lambda_{3,\tau} RELO_{i,t} + \lambda_{4,\tau} FISDS_{i,t} + \\ + \lambda_{4,\tau} RE_{i,t} + \upsilon_{\tau,i,t} \tag{15}$$

The median quantiles are given as:

$$Q_{0.5}(SDI_{i,t}) = \beta_{0.5} + \beta_{1,0.5}MRR_{i,t} + \beta_{2,0.5}ERT_{i,t} + \beta_{3,0.5}RELO_{i,t} + \beta_{4,0.5}FISDS_{i,t} + \upsilon_{0.5,i,t} \quad (16)$$

Quantile regression is employed to estimate the coefficients at different quantiles. We estimate the equation at the median quantile only.

4. Results and Discussion

Tables 3 and 4 present the results of the SH and CSD tests, respectively. It is obvious that all the variables suffer from CSD. Any change in the *SDI*, *MRNT*, *ERT*, *RELO* or *FISDS* in one of the developed countries has an effect on the other developed country. This indicates that developed countries have close ties with each other. The results of the SH test show that the model suffers from SH.

Table 3: Slope heterogeneity

Delta	Statistics
Delta ($\tilde{\Delta}$)	24.573***
Adj. delta ($\tilde{\Delta}_{adjusted}$)	27.078***

Source: Authors' own calculations

Table 4: Cross-sectional dependence

Variable	CD-Test
SDI	35.977***
MRR	19.878***
ERT	13.762***
RELO	30.668***
FISDS	–2.699***

Source: Authors' own calculations

The results of the CIPS unit root test indicate that all the variables are stationary at first difference. The results of Table 5 suggest that there is a long-term relationship between *SDI* and its determinants. The results show that mineral resource rents, fiscal decentralization, environmental taxes and renewable energy electricity output are cointegrated with *SDI*.

Table 5: Unit root test – CIPS

Variable	I(0)	I(1)
SDI	–1.744	–4.915***
MRR	–2.620	–5.859***
ERT	–1.700	–4.924***
RELO	–2.587	–5.874***
FISDS	–2.117	–4.292***

Source: Authors' own calculations

Table 6: Cointegration test

	Westerlund test		
Statistic	**Value**	***Z*-value**	***p*-value**
G_t	–4.997***	–12.102	0.000
G_a	–22.312***	–7.208	0.001
P_t	–20.543***	–10.954	0.000
P_a	–23.613***	–9.869	0.000

Source: Authors' own calculations

Table 7 presents the results of the fixed-effects (FE) and random-effects (RE) methods. The results of the RE and FE models suggest that higher levels of mineral resource rents and renewable energy electricity output are linked with lower levels of SD. A negative coefficient of mineral resource rents (*MRR*) indicates that high mineral resource rents lead to more CO_2 emissions and lower SDs, which supports the findings of Nwani and Adams (2021), Shabbir *et al*. (2020), Shao *et al*. (2014), Shen *et al*. (2021), Song *et al*. (2018), Zallé (2019) and Zameer *et al*. (2020). Given the carbon-intensive nature of these activities, it can be concluded

that mineral extraction industries contribute significantly to the carbon footprint. Examples of such industries include mining and mineral extraction. Thus, mineral extraction can result in higher carbon emissions due to activities such as deforestation and alterations in land utilization. There is a general consensus that mineral resources contribute to both economic growth and carbon emissions. The process of national integration of commodity rents gives rise to economic vulnerabilities, including adverse trade shocks and a decline in the proportion of non-mining commodities that contribute to national income. In contrast, other studies support the pollutant-reducing impact of resource rents (Sachs and Warner, 2001; Kongbuamai *et al*., 2020; Lampert, 2019; Li and Xiao, 2019; Loganathan *et al*., 2020; Muhanji *et al*., 2019, *etc*.). We support the pollutant-inducing impacts of resource rents.

The positive coefficient of fiscal decentralization (*FISDS*) implies that *FISDS* promotes sustainable development in developed countries. Greater fiscal decentralization is beneficial for achieving effective pollution control and reducing CO_2 emissions. Under decentralization, local governments are expected to improve environmental quality. These results confirm the findings of Ji *et al*. (2020), Mu (2018) and Feng *et al*. (2020). Devolving the financial decision-making authority to lower levels of government is considered important in affecting environmental performance. Under decentralization, local governments endorse environmental policies that are allied with the structures of their own regions. Moreover, local governments are anticipated to achieve economic development. Thus, fiscal decentralization affects the carbon footprint through different channels. Fiscal decentralization fosters innovation, ultimately resulting in the development of policies that progressively encourage environmental sustainability. The presence of natural resource markets significantly contributes to the advancement of environmental sustainability by creating economic incentives for the preservation of resources and their sustainable exploitation. Countries with strong decentralization structures, such as Germany and Switzerland, actively implement renewable energy initiatives and local environmental regulations, contributing to the countries' leadership in renewable energy adoption and emission reduction. On the contrary, countries with weak decentralization structures often face challenges in aligning national environmental goals with local implementation. Therefore, these countries are not able to invest in sustainable development initiatives aligned with their unique environmental and socio-economic contexts. Thus, fiscal decentralization in combination with institutional quality can significantly enhance sustainable development.

The results show that environment-related taxes (*ERT*) positively affect sustainable development. Developed countries are levying environment-related taxes to abate rising CO_2 emissions and achieve sustainable development. By levying high taxes on carbon-intensive

industries, developed industries have been successful in abating CO_2 emissions. Thus, countries with greater degrees of *ERT* experience highly sustainable development. These results confirm the findings of Song *et al*. (2018) and Zameer *et al*. (2020).

The negative coefficient of renewable energy electricity output (*RELO*) challenges the widely held assumption that renewable energy inherently promotes sustainable development. This implies that *RELO* hampers sustainable development in developed countries. In many developed countries such as Germany, Sweden, Hungary, Greece and Spain, the initial phases of renewable energy transition involve significant infrastructure development and high capital costs that can temporarily increase the ecological footprint. For instance, large-scale solar and wind farms may lead to deforestation, habitat loss and resource-intensive manufacturing of photovoltaic panels and turbines, offsetting environmental gains in the short term. Thus, environmental benefits of renewables may materialize only after overcoming initial infrastructural and technological challenges. These results do not support the findings of Agboola *et al*. (2021), Ahmed *et al*. (2020) and Zia *et al*. (2021). Moving to renewable energies is vital for reducing emissions. Renewable infrastructure is helpful in achieving the SDGs. These transformations prevent environmental harm associated with the exploitation and burning of fossil fuels.

A key contribution of this study lies in constructing a comprehensive sustainable development index (*SDI*), which uniquely integrates economic, social and environmental dimensions. The results of this study offer unique contributions to the existing body of research on sustainable development. Unlike prior studies that focus solely on ecological indicators or economic growth, the present study combines *SDI* with fiscal decentralization and environmental taxation. A particularly novel finding is the negative impact of *RELO* on *SDI*, which contrasts with much of the existing literature, which assumes that renewables inherently enhance sustainability. Another distinctive aspect of this study is the positive and significant role of *FISDS* and *ERT* in promoting sustainable development.

For a robustness check, this study utilizes QR and PCSE techniques. The results of the PCSE method show that mineral resource rents (*MRR*), environment-related taxes (*ERT*) and fiscal decentralization (*FISDS*) positively contribute to sustainable development. However, the coefficient of *RELO* is negative and significant, which implies that *RELO* negatively contributes to sustainable development. These results support the findings of fixed-effects and random-effects approaches. However, by using the QR technique, we find that the coefficient of mineral resource rents (*MRR*) is negative, which is not consistent with the results of the PCSE, fixed-effects and random-effects approaches.

Table 7: Random-effects and fixed-effects estimates

	Random-effects estimates	Fixed-effects estimates	Difference	χ^2
MRR	−0.0499*** [0.0148]	−0.0471*** [0.0145]	−0.0027	−2.73
ERT	0.1080*** [0.0207]	0.1063*** [0.0229]	0.0017	
RELO	−0.1548*** [0.0336]	−0.1557*** [0.0332]	0.0009	
FISDS	0.0090* [0.0355]	0.0087** [0.0042]	0.0003	
Constant	0.6346** [0.1819]	0.6364*** [0.0526]	–	

Source: Authors' own calculations

Table 8: Robustness check

	PCSE estimates	Non-parametric QR estimates (median)
MRR	0.1189*** [0.01342]	−0.1181*** [0.0134]
ERT	0.1726*** [0.0202]	0.1740*** [0.0288]
RELO	−0.1332*** [0.0126]	−0.1296*** [0.0135]
FISDS	0.0128*** [0.0017]	0.0135*** [0.0034]
Constant	0.5895*** [0.0134]	0.0199*** [0.0034]

Note: PCSEs refer to panel-corrected standard errors. QR refers to quantile regression.
Source: Authors' own calculations

5. Conclusion and Policy Recommendations

The main objective of sustainable development is to guarantee provision of natural resources for the existing generation without compromising the needs of future generations. Natural resources are considered important sources of economic prosperity. They are the es-

sential raw materials used in the manufacturing process, which in turn stimulates economic activities and leads to long-term growth. Resource-rich countries often experience sustainability challenges. Despite rapid growth in technological advancements and consumerism, developed countries have not been successful in protecting themselves from the adverse effects of climate change. Environmental deterioration poses a significant threat to both ecosystems and biodiversity. Current economic growth significantly influences climate change by promoting energy-intensive activities, resulting in increased levels of carbon dioxide in the atmosphere and subsequently increasing global temperatures. This study examined the impact of mineral resource rents on sustainable development in selected developed countries. Moreover, we included renewable energy deployment and fiscal decentralization as additional determinants of sustainable development.

This study used renewable energy electricity output, fiscal decentralization and environment-related taxes in the sustainable development model. Using different econometric approaches, we found that mineral resource rents and renewable energy electricity output hamper sustainable development. Due to its carbon-intensive nature, the exploration of mineral resources results in rising CO_2 emissions. Based on this research, the utilization of mineral resources for economic purposes can result in higher levels of CO_2 emissions. The extraction of mineral resources can lead to immediate economic benefits, but it also raises environmental issues that must be addressed by implementing effective strategies that foster sustainable development. We found that environment-related taxes are associated with highly sustainable development. This conclusion suggests that developed countries may levy environment-related taxes on carbon-intensive industries to decarbonize their economies. We found that countries' fiscal decentralization positively affects sustainable development. Devolving the financial decision-making authority to lower levels of government is considered important in affecting environmental performance. The decentralization system enables local governments to endorse environmental policies that are aligned with the unique features of their own regions. These policies may include sustainable land-use planning, waste management and other initiatives to foster the adoption of renewable energy. Thus, fiscal decentralization affects carbon emissions through different channels. We found that the adoption of renewable energy technologies, such as solar, wind, hydropower and biomass, is helpful for sustainable development objectives. These transformations prevent environmental harm associated with the exploitation and burning of fossil fuels. Thus, advancement of renewable energy implementation is crucial for attaining sustainable development objectives.

This study suggests that advanced countries promote the establishment of renewable energy infrastructure by offering incentives, subsidies and support mechanisms. This will help accelerate the shift away from fossil fuels. Based on the findings, this study proposes that developed countries take this action. Additionally, it is necessary to establish rules that would facilitate the incorporation of renewable energy sources into the power system. These policies should encompass grid modernization, energy storage options and advanced grid technologies. Based on the findings, it is suggested that resource-rich countries prioritize economic diversification strategies to reduce dependency on extractive industries, investing in knowledge-based and green sectors that generate sustainable long-term growth. Moreover, strengthening fiscal decentralization frameworks is crucial. Countries can incentivize local-level renewable energy projects, land-use planning and conservation programmes, promoting bottom-up approaches to sustainability.

Moreover, we suggest that the sample countries need to actively pursue economic diversification away from traditional mineral-dependent industries. These countries should focus on the provision of supportive regulatory environments, which may attract more investment in the mining sector, leading to greater mineral resource rent contributions. Furthermore, we suggest that governments enhance regulatory frameworks for mineral extraction to mitigate adverse environmental impacts. To support the promotion of local development priorities and the improvement of service delivery, it is imperative to grant subnational governments the power to make decisions and independence to manage their own budgets. Policymakers should promote a shift towards development paths that are more inclusive, resilient and sustainable by creating and implementing a range of initiatives and policies. This transition can facilitate the attainment of equilibrium among economic affluence, ecological preservation and societal equity in industrialized economies. The results suggest that renewable energy electricity output hampers sustainable development in developed countries. This means that large-scale renewable energy deployment, particularly in developed countries, may initially increase environmental pressures. Thus, policy makers need to focus on minimizing the environmental and social costs associated with renewable energy infrastructure development.

5.1 Limitations and future research

This study examined the impact of mineral resource rents on sustainable development in selected developed countries from a political economy perspective. The study included renewable energy deployment and fiscal decentralization as additional determinants of sustainable development. The study was limited to a selected group of developed countries, which may limit the generalizability of the findings to developing or resource-constrained

countries. In future, research may be carried out to test the results in other groups of countries such as Next Eleven (N11), developing and oil rich countries. Secondly, the renewable energy variable captured aggregate electricity output, without differentiating between types of renewables (solar, wind, hydro or biomass). In future, research may be carried out to investigate the environmental and economic impacts of each of the renewables.

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