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Research article

Relating fiscal decentralization and financial inclusion to environmental sustainability: Criticality of natural resources

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ABSTRACT

This study deals with a novel perspective on how natural resource dependence (NRD) and natural resource abundance (NRA) moderate the effects of fiscal decentralization and financial inclusion on energy and carbon intensity. Our work develops on the Stochastic Impacts by Regression on Population, Affluence, and Technology framework, considering the selected seven Organization for Economic Co-operation and Development members as the investigative laboratory from 1995 through 2018. Employing a panel Method of Moments Quantile Regression with fixed effects, we find that fiscal decentralization is beneficial for environmental sustainability, especially across the countries with a higher level of energy and carbon intensity; however, enhanced financial inclusivity is detrimental to the environmental quality, with more visible effects in more energy-efficient economies. As per the direct effects, NRD and NRA mitigate energy and carbon efficiency, with more substantial contributions in less energy- and carbon-intensive countries. Concerning the indirect effects, NRD and NRA positively moderate the influence of fiscal decentralization and financial inclusion on energy and carbon intensities, displaying more substantial effects in more energy-efficient economies. Among other control variables, environmental innovation, renewable electricity, employment to population ratio, and economic progress enhance environmental sustainability. We suggest fiscal decentralization should be built on a more transparent and accountable subnational governmental setup to prevent rent-seeking and fragile environmental protection. We also recommend inclusive finance should enhance the access to and affordability of financial services to economic agents for green consumption and investment ventures to achieve environmental sustainability, among other Sustainable Development Goals.

1. Introduction

Climate change is a multifaceted concern caused by greenhouse gas (GHG) emissions driven by energy-intensive and carbon-intensive industrial development for economic growth motives. Though tenacious global efforts have been made, including the most recent *COP26*, the *2030 Sustainable Development Agenda, 2015 Paris Climate Change Agreement*, zero net carbon emissions and carbon neutrality goals remain a dream far from actualization (Schoenmaker, 2021) amidst the global crises, particularly COVID-19 pandemic which is far from over. As the fundamental culprit of climatic adversities, environmental degradation has primarily been measured by indicators involving GHG emissions (Abul and Satrovic, 2021; Sovacool et al., 2022), water-based emissions (Wong and Lewis, 2013), particulate matter (Shen et al., 2018), ecological footprint consumption (Yang et al., 2021), and energy consumption (Ahmad et al., 2021; Mujtaba et al., 2022; Satrovic et al., 2022). However, those indicators only captured the environmental aspect and failed to incorporate the economic activity dimension of sustainability. On the contrary, energy intensity – the cost of converting each unit of energy for some incremental units of gross domestic product (GDP) – has been considered the yardstick to gauge the energy efficiency of an economy in that lower energy intensity means higher energy efficiency and vice versa, capturing the holistic environmental sustainability. Carbon intensity – the amount of carbon produced per unit of

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GDP – may also help determine the environmental sustainability regarding carbon efficiency being the economy-inclusive indicator. Modern literature claims that macroeconomic factors such as governmental structure, financial institutions, and natural resources are central to economic and environmental sustainability worldwide.

Fiscal decentralization – the devolution of power in terms of transferring expenditure and revenue responsibilities to the lower governmental levels – has been known to have the primary policy objective of fostering economic growth. From one perspective, fiscal decentralization might corroborate an effective tool for ameliorating public spending efficiency along with macroeconomic stability at the subnational levels (Martinez-Vazquez and McNab, 2003). Also, domestic energy regulatory performance standards may prove crucial tools to encourage businesses to adopt renewable energy for sustainable environments (Drago and Gatto, 2022). The contradictory argument is that fiscally decentralized economies could face the so-called horizontal fiscal imbalance – when local governments face regional disparity in tax collection and service provision – emerging because of the different budgetary capacities of various subnational governments, adversely impacting regional economic development (Fritz and Feld, 2020). Two styles elucidate the environmental influence of fiscal decentralization: *first*, fiscally decentralized nations following the "*race to the top*" style would likely advance ecological quality through the effective provision of public goods, such as an improved environment at the subnational levels (Shan et al., 2021). Such nations might put climate change mitigation plans at the forefront of public policy, bringing structural transformation to the energy sector through innovation or invention. For instance, Aldieri et al. (2022) unfolded that innovation in renewable energy improves the efficiency of both carbon emissions and particulate matter in 148 developing and transition economies. Besides, Sadik-Zada and Gatto (2022) found that civic engagement positively contributes to the energy transition from fossil-fueled to renewable energy in the Nordic-Baltic Sea Region. It highlights the criticalness of polycentric governance involving various sub-national governing bodies to interact and design comprehensive energy transitions for apt environmental management policies. *Second*, decentralized governments involved in the "*race to the bottom*" style would be highly likely to fall into the pitfalls of poor environmental quality since they exercise weak ecological protection policies to attract domestic and international investments for regional growth (Kassouri, 2022) and thus allow polluting industries to exploit the local environmental quality. While the eventual environmental impact of a fiscally decentralized setup remains inconclusive, the development of financial systems is inevitable for the efficacy and efficiency of economic investments at any governmental level.

Financial inclusion – referring to the process of providing access and affordability of formal financial services, including but not limited to the credit, loans, insurance, remittance, and savings facilities to all – is not only an essential growth driver but also a convincingly critical role player in environmental sustainability (Shahbaz et al., 2018). Financial inclusivity promotes economic growth through increased savings (Allen et al., 2016), employment creation (Marcelin et al., 2021), and domestic production (Nawaz et al., 2019). In this way, financial inclusion mitigates income inequality (Burgess and Pande, 2005) and information asymmetry (Stiglitz and Weiss, 1981), promoting informed lending. Conversely, developing countries might undermine the economic payoffs of inclusive finance because of the fragile institutional structure (Rajan and Zingales, 2003), inflationary pressures, and less competitiveness (Rousseau and Wachtel, 2002). Regarding its environmental outcomes, financial inclusion makes the financial decision convenient and affordable, inducing the economic agents (firms and households) to utilize financial resources effectively. Easy and low-interest rate loans might incentivize the firms to expand their investments, driving either horizontal or vertical industrialization. Through horizontal one, firms would increase the production units, enhancing the energy intensity and deteriorating the environmental quality. While vertical industrialization might involve the transformation of existing industries into energy-efficient and technology-intensive structures, allowing ecological performance improvement (Ahmad and Wu, 2022a). Moreover, easy credits would motivate households to purchase big-ticket items, including electronic appliances, responsible for high energy demand and escalated environmental degradation (Shahbaz et al., 2018). However, households could also use those credits to buy renewable energy products such as solar photovoltaic and biogas plants (Jabeen et al., 2021), indirectly contributing to environmental sustainability. Additionally, green microfinance enables vulnerable groups, women, and the energy poor to access affordable, clean, and sustainable energy, contributing to the 7th Sustainable Development Goal (Gatto and Drago, 2021). In light of these mechanisms, the ultimate influence of financial inclusion on economic and ecological performance remains without consensus.

Despite the persistent interest of past studies, the combined influence of fiscal decentralization, financial inclusion, and natural resources on environmental sustainability met scarce consideration. The pioneering works of Sachs and Warner (1995, 2001, 1997) empirically culminated that natural resource-rich economies tended to have sluggish growth than resource-scarce ones; nevertheless, they found it conceptually puzzling to determine why natural resource abundance (NRA) engendered slow growth and hence named it a '*resource curse puzzle*' (RCP). Political economists like Gelb (1988) and Auty (1990) argued that natural resources-led economic growth malfunction was attributable to diversified political and economic factors such as institutional quality, financial development, and governance structure. On the one hand, the mainstream resources-environmental nexus supports the notion that resources-driven RCP gives rise to poor economic performance, bringing about poor availability of public goods, including environmental protection policies (Majeed et al., 2021). In this regard, Sadik-Zada and Gatto (2021) viewed that fossil-fuel abundance instigates carbon-intensive oil extraction power generation, offering a hike in atmospheric pollution. On the other hand, RCP opponents suggest that NRA could help economies capitalize on the beneficial environmental outcomes of properly managed natural resources (Atil et al., 2020). Furthermore, from one perspective, natural resource dependence (NRD) could drive remarkable economic growth, possibly keeping climate change mitigation plans at the forefront (Balsalobre-Lorente et al., 2021). From another standpoint, over-reliance on natural resources, particularly coal and oil, could produce environmental emissions (Song et al., 2020), starkly enhancing ecological deterioration and biodiversity losses. In this vein, Nawaz et al. (2020) examined and found positive contemporaneous and negative one-period lag effects, ultimately broadcasting a positive impact of natural resources on energy use in Pakistan's economy.

The existing literature overlooked the role of natural resources in moderating the impacts of fiscal decentralization and financial inclusion on environmental sustainability. Herein, we offer novel moderation pathways of natural resources: *first*, decentralized government structure in economies with resource bonanza might induce equitable resource distribution responsible for inclusive economic growth, eventually contributing to environmental quality. However, since the politics of resource wealth could instigate rent-seeking behavior, the resource-rich subnational levels would face a growth slowdown due to the so-called RCP, preventing the local governments from prioritizing environmental protection. *Second*, resource-dependent and fiscally decentralized nations, in one way, may seek energy transformative policies and strategies to improve energy efficiency and environmental quality. Nevertheless, fiscally decentralized economies with non-robust and fragile institutions would prioritize rent-seeking over the provision of public goods such as a quality environment. *Third*, NRA engages all factors of production in the resource sector, restricting the economic output of other economic sectors and thus impeding economic growth and environmental quality. *Fourth*, countries with resource windfall may export natural resources, appreciating local currency responsible for mitigating inflation and interest rates and supporting households to borrow credits for adopting green products. In the same vein, investors may also borrow more to expand their green businesses, improving environmental conditions. However, these mechanisms would reverse the environmental impacts, given households and firms do not choose green products and investments. *Finally*, NRA may lead to more imports, depreciating domestic currency, upscaling both inflation and interest rates, curtailing consumers' green purchases and investors' green investment financing, and inevitably declining environmental sustainability. Contrariwise, if the consumers and investors reduce spending on non-green products and investments, it would have an ecological improvement effect.

We investigate the role of twin facets of natural resources (i.e., NRD and NRA) in moderating the influence of fiscal decentralization and financial inclusion on environmental sustainability, controlling the confounders, including environmental innovation, employment to population ratio, and GDP. We offer the following multifaceted contributions to the existing knowledge. *First*, we estimate the indirect (moderation) impacts of NRD and NRA on fiscal decentralization-environment as well as financial inclusion-environment linkages, which is new to the literature. This contribution would deepen the understanding of governments and environmental and economic policy-makers since the interactions between governance structure and resource bonanza are crucial for the environmental implications; thereby, NRA and NRD could inevitably set the tone of public policies. Moreover, inclusive finance under a resource windfall situation would significantly impact households and businesses, percolating environmental consequences. *Second*, from theoretical frontiers, we modify the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) framework by incorporating fiscal decentralization, financial inclusion, and natural resources as affluence factors. This is relevant since decentralized governments enhance affluence through regional economic growth driven by competition among the local governments. Similarly, financial inclusivity integrates each economic agent into economic activities, strengthening the affluence of the economy. And, akin to the dominant notion of RCP, natural resources lead to growth slowdown, adversely contributing to affluence. *Third*, on empirical grounds, the previous works on fiscal decentralization-environment, financial inclusion-environment, and natural resources-environment nexuses opted for the mean effects estimators, overlooking the distributional heterogeneities of effects across varying quantiles of environmental sustainability indicators. To address this, we employ the novel panel data Method of Moments Quantile Regression (MMQR) with fixed effects permitting the parameter estimates of our regressors at heterogeneous conditional quantiles of energy intensity and carbon intensity variables. *In closing*, we consider the selected seven Organization for Economic Co-operation and Development (OECD) member countries as the investigative laboratory for the following motivations: (i) OECD members states were the world leaders in adopting the Green Growth Approach in 2011, immediately after the origination of *Green Growth* notion by the *United Nations Economic and Social Commission for Asia and the Pacific* (UNESCAP) (OECD, 2019). Given the abovementioned initiatives, OECD states have been reported to enhance their energy efficiency over time (Aldieri et al., 2021). (ii) *Financial Supervisory Authority* (FSA) of OECD members led the *Network for Greening the Financial System* (NGFS), involving 89 central banks globally, launched during the 2017 Paris One Planet Summit to promote a climate-inclusive financial system. The FSA also plays a leading role in the *International Organization of Securities Commissions* (IOSCO), fostering sustainable finance (OECD, 2021a). (iii) OECD members are high-income economies, and the selected seven countries (Austria, Germany, Netherlands, Norway, Spain, Sweden, and the United Kingdom) are among the top-ranked economies in terms of energy technology research and development and demonstration budget per GDP (OECD, 2021b; Verbič et al., 2021).

The remaining study is structured as follows: Section 2 explains the data, theoretical modeling, and methods. Section 3 is based on results and discussions. Finally, Section 4 describes the core conclusion points and policy suggestions originating from the central findings of this study.

2. Data, model, and econometric methods

2.1. Data

The data of selected seven OECD member countries (Austria, Germany, Netherlands, Norway, Spain, Sweden, and the United Kingdom) are compiled to evaluate the relationships among the variables under analysis. These countries secured a high rank in terms of energy technology research development and demonstration budget per gross domestic product (GDP) as per 2018 statistics that ranged from 0.852 to 0.084 (highest - Norway to lowest - Spain). In doing so, balanced panel data are taken on an annual basis from 1995 to 2018. Table 1 tabulates the data descriptions, sources, and measurement units of variables.

The data on real GDP per capita, employment to population ratio, and natural resources rents are obtained from the WB (2021) indicators database. Energy intensity, carbon intensity, renewable electricity and R&D budget data are sourced from the OECD (2020) database. Data on fiscal decentralization and financial inclusion are retrieved from the IMF (2020, 2018) data bank. The selection of the period was motivated by the availability of fiscal decentralization data (1995–2018). Table 2 documents the summary statistics of the study variables.

From Table 2, the results demonstrate that all variables had positive average values. NRA showed the highest mean value with a minimum (i. e., 2.00×10^{08}) reported for Austria in 1998, and a maximum value (i.e., 5.70×10^{10}) for Norway reported in 2008. Considering the energy intensity, Spain had the minimum value (i.e., 2.44) in 2014, whereas Norway disclosed the maximum value (i.e., 6.73) in 2008. Besides, the Netherlands expressed the maximum carbon intensity value (i.e., 11.13), while Sweden ranked last in terms of carbon intensity. The average value of real GDP per capita was 48147.65 (constant 2010 US$). On average, the environment-related government R&D budget was 2.36% for the sample of seven OECD countries; renewable electricity was 39.81%; employment to population ratio was reported to be 56.75%; fiscal decentralization was equal to 35.86%, whereas the average value of financial inclusion was documented to be 73.33%. Finally, skewness and kurtosis statistics strictly reject the proposition of data normality for all variables.

Table 3 documents the correlation matrix among the study variables.

Table 1
Data description and source.

Indicator name and measurement	Abbreviation	Sources
Economic progress – gross domestic product (GDP) per capita (constant 2010 US$)	GDP	WB (2021)
Environmental innovation – environmentally related government R&D budget, % total government R&D	RDENV	OECD (2020)
Renewable electricity, % total electricity generation	REW	OECD (2020)
Population - Employment to population ratio, 15+, total (%)	EMPO	WB (2021)
Expenditure decentralization (percentage of own spending to general government spending, subnational)	FDEX	IMF (2018)
Financial inclusion - financial development index	FDIN	IMF (2020)
Natural resource dependence – total natural resources rents (% of GDP)	NRD	WB (2021)
Natural resource abundance – total natural resources rents (% of GDP) * GDP (current US$)	NRA	(WB, 2021); authors' calculations
Energy intensity, total primary energy supply (TPES) per capita	ENIN	OECD (2020)
Carbon intensity - production-based carbon dioxide (CO_2) intensity, energy-related CO_2 per capita	COIN	OECD (2020)

Table 2
Summary statistics.

Country	Stat.	ENIN	GDP	RDENV	REW	EMPO	FDEX	FDIN	NRD	NRA	COIN
Austria	Mean	3.79	44689.46	1.58	70.54	56.25	30.89	61.33	0.17	5.80×10^{08}	7.86
	SD	0.20	3999.17	0.54	5.34	1.00	0.70	7.28	0.05	3.00×10^{08}	0.63
	Skewness	−0.299	−0.658	−0.241	0.274	−0.771	−0.573	−0.588	0.548	0.544	0.377
	Kurtosis	2.256	2.214	2.281	2.293	3.398	4.591	3.375	2.260	2.072	2.222
	Min.	3.36	36538	0.65	60.68	53.50	28.81	45.16	0.09	2.00×10^{08}	6.91
	Max.	4.10	50051.8	2.46	81.45	57.79	32.16	74.06	0.27	1.20×10^{09}	9.02
Germany	Mean	4.04	40686.50	3.12	15.25	54.63	38.26	72.48	0.12	3.83×10^{09}	9.61
	SD	0.20	3880.27	0.32	10.04	2.26	1.43	5.35	0.06	2.45×10^{09}	0.66
	Skewness	−0.548	0.155	0.279	0.605	0.406	−1.814	−2.455	1.125	1.271	0.060
	Kurtosis	1.975	1.800	1.795	2.040	1.755	8.226	9.906	4.032	4.309	2.147
	Min.	3.63	34786.7	2.70	4.21	51.41	33.08	52.20	0.05	1.00×10^{09}	8.37
	Max.	4.28	47313.8	3.74	35.29	58.77	40.11	77.91	0.30	1.10×10^{10}	10.91
Netherlands	Mean	4.67	48524.83	1.71	7.72	60.08	32.64	76.75	0.59	4.38×10^{09}	9.94
	SD	0.24	4393.47	1.35	4.46	2.14	2.00	5.54	0.32	3.17×10^{09}	0.62
	Skewness	−0.605	−0.778	0.549	0.230	−1.321	1.469	−0.560	0.403	0.666	−0.191
	Kurtosis	2.246	2.734	1.817	1.839	4.256	7.208	2.452	2.128	2.135	2.068
	Min.	4.21	38676.1	0.05	1.73	54.25	29.41	63.22	0.09	4.20×10^{08}	8.84
	Max.	4.98	54894.1	4.36	16.50	62.56	39.57	83.94	1.19	1.00×10^{10}	11.13
Norway	Mean	5.81	85506.24	2.52	98.58	63.04	33.91	64.05	8.20	2.78×10^{10}	7.43
	SD	0.41	5947.18	0.35	1.20	1.50	2.42	7.99	2.69	1.59×10^{10}	0.40
	Skewness	0.786	−1.066	−0.725	−0.847	−0.583	0.142	−0.597	−0.579	0.286	0.368
	Kurtosis	2.915	3.194	2.656	2.522	3.191	2.192	3.120	2.700	2.017	2.841
	Min.	5.19	70409.7	1.79	95.74	59.14	30.16	43.79	1.67	2.60×10^{09}	6.72
	Max.	6.73	91964.3	3.02	99.72	65.70	38.63	76.49	12.30	5.70×10^{10}	8.32
Spain	Mean	2.81	29473.24	3.65	24.74	46.51	43.25	80.88	0.05	5.83×10^{08}	6.15
	SD	0.26	2553.25	1.05	9.02	4.05	5.05	10.42	0.01	2.62×10^{08}	0.86
	Skewness	0.268	−0.898	−0.131	0.443	−0.232	−0.541	−2.013	0.119	0.440	0.271
	Kurtosis	1.641	2.924	2.327	1.784	2.441	2.338	5.967	1.981	1.864	1.621
	Min.	2.44	23737.5	1.73	13.23	38.66	32.70	50.09	0.04	2.50×10^{08}	4.96
	Max.	3.21	32949.1	5.52	40.11	53.32	49.76	90.07	0.07	1.10×10^{09}	7.58
Sweden	Mean	5.38	49575.65	1.64	52.39	58.69	45.16	72.83	0.40	1.76×10^{09}	5.15
	SD	0.37	6200.38	0.41	5.72	0.94	3.83	8.21	0.15	1.03×10^{09}	1.05
	Skewness	−0.561	−0.525	−0.117	−0.449	−0.294	−0.325	−1.471	1.367	1.092	−0.005
	Kurtosis	2.229	2.075	2.466	2.945	2.481	2.292	4.199	3.783	3.401	1.766
	Min.	4.55	37870.9	0.85	38.40	56.57	37.19	50.59	0.24	7.40×10^{08}	3.46
	Max.	5.85	57911.2	2.34	63.27	60.29	51.03	79.61	0.78	4.50×10^{09}	7.05
United Kingdom	Mean	3.35	38577.62	2.30	9.44	58.01	26.88	84.95	0.74	1.76×10^{10}	7.81
	SD	0.45	3649.78	0.43	9.73	1.17	1.88	6.68	0.28	8.60×10^{09}	1.32
	Skewness	−0.422	−0.815	0.229	1.296	−0.211	−0.618	−1.324	−0.261	0.389	−0.731
	Kurtosis	1.558	2.625	1.965	3.302	2.611	2.154	4.009	2.570	2.702	2.049
	Min.	2.61	30596.4	1.60	1.63	55.54	23.12	67.50	0.16	2.60×10^{09}	5.25
	Max.	3.88	43246.2	3.02	33.49	60.24	29.23	94.59	1.31	3.80×10^{10}	9.19
Cumulative	Mean	4.27	48147.65	2.36	39.81	56.75	35.86	73.33	1.47	8.07×10^{09}	7.71
	SD	1.05	17138.25	1.03	33.23	5.31	6.78	10.82	2.95	1.19×10^{10}	1.80
	Skewness	0.191	1.335	0.321	0.550	−1.187	0.480	−0.481	2.392	2.097	−0.246
	Kurtosis	2.149	3.973	3.183	1.934	4.495	2.366	2.715	7.291	7.088	2.318
	Min.	2.44	23737.5	0.05	1.63	38.66	23.12	43.79	0.04	2.00×10^{08}	3.46
	Max.	6.73	91964.3	5.52	99.72	65.70	51.03	94.59	12.30	5.70×10^{10}	11.13

The correlation matrix indicates a statistically significant positive linkage between GDP, renewable electricity, employment to population ratio, and natural resources in relation to energy intensity. This table also highlights a statistically significant negative correlation between R&D budget and financial inclusion with energy intensity. Besides, the findings also outline the statistically significant positive correlation between employment to population and carbon intensity. Also, the correlation matrix visualizes the statistically significant negative correlation between renewable electricity and fiscal decentralization with respect to carbon intensity. The scatter matrix plot among the core variables of interest is displayed in Fig. 1, providing correlation results consistent with those recorded in Table 3. Besides, the histograms on the x-axis and y-axis of Fig. 1 proved the non-normality of all the variables, demanding the panel data strategy robust to non-normal data.

2.2. Developing theoretical model

Considering the benchmark framework Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT), originally postulated by Dietz and Rosa (1997), we build theoretical connections of our potential predictors with environmental sustainability. To begin with, we consider the mainstream expression as follows:

$$I_{it} = \alpha_{it} P_{it}^{\beta 1} A_{it}^{\beta 2} T_{it}^{\beta 3} \varepsilon_{it} \tag{1}$$

Based on Eq. (1), I illustrates the environmental externalities (both positive and negative), which are affected by population P, the level of economic progress A, and the efficiency of technology pointed by T. The inspected countries are denoted by i, whereas the time dimension is represented by t; $i = 1, \ldots, N$, $t = 1, \ldots, T$. The individual effect is captured by α; error-term by ε_{it}. Also, the coefficients of P, A, and T, respectively, are denoted by β_1, β_2, and β_3. These variables are transformed into natural logarithms. Herein, the log-linear form of equation (1) is written as per the following (Eq. (2)):

$$LI_{it} = \alpha_{it} + \beta_1 LP_{it} + \beta_2 LA_{it} + \beta_3 LT_{it} + \varepsilon_{it} \tag{2}$$

where L signifies the operator of the natural logarithm. We augment Eq. (2) by introducing fiscal decentralization, financial inclusion, NRD and NRA as affluence (A) factors. Environmental innovation and renewable

Table 3
Correlation matrix.

Var.	ENIN	GDP	RDENV	REW	EMPO	FDEX	FDIN	NRD	NRA	COIN
ENIN	1									
GDP	0.768a (0.000)	1								
RDENV	−0.310a (0.000)	−0.231a (0.003)	1							
REW	0.504a (0.000)	0.748a (0.000)	−0.191b (0.013)	1						
EMPO	0.721a (0.000)	0.743a (0.000)	−0.445a (0.000)	0.386a (0.000)	1					
FDEX	0.110 (0.156)	−0.112 (0.148)	0.308a (0.000)	0.043 (0.582)	−0.293a (0.000)	1				
FDIN	−0.354a (0.000)	−0.310a (0.000)	0.216a (0.005)	−0.561a (0.000)	−0.128c (0.099)	0.133c (0.087)	1			
NRD	0.603a (0.000)	0.868a (0.000)	−0.002 (0.981)	0.656a (0.000)	0.519a (0.000)	−0.167b (0.030)	−0.252a (0.001)	1		
NRA	0.358a (0.000)	0.651a (0.000)	−0.026 (0.737)	0.326a (0.000)	0.484a (0.000)	−0.373a (0.000)	0.092 (0.237)	0.795a (0.000)	1	
COIN	0.056 (0.470)	−0.065 (0.401)	0.032 (0.682)	−0.422a (0.000)	0.174b (0.024)	−0.461a (0.000)	−0.070 (0.365)	−0.048 (0.535)	0.020 (0.795)	1

Note: p values in parentheses, a ($p < 0.01$), b ($p < 0.05$), c ($p < 0.10$).

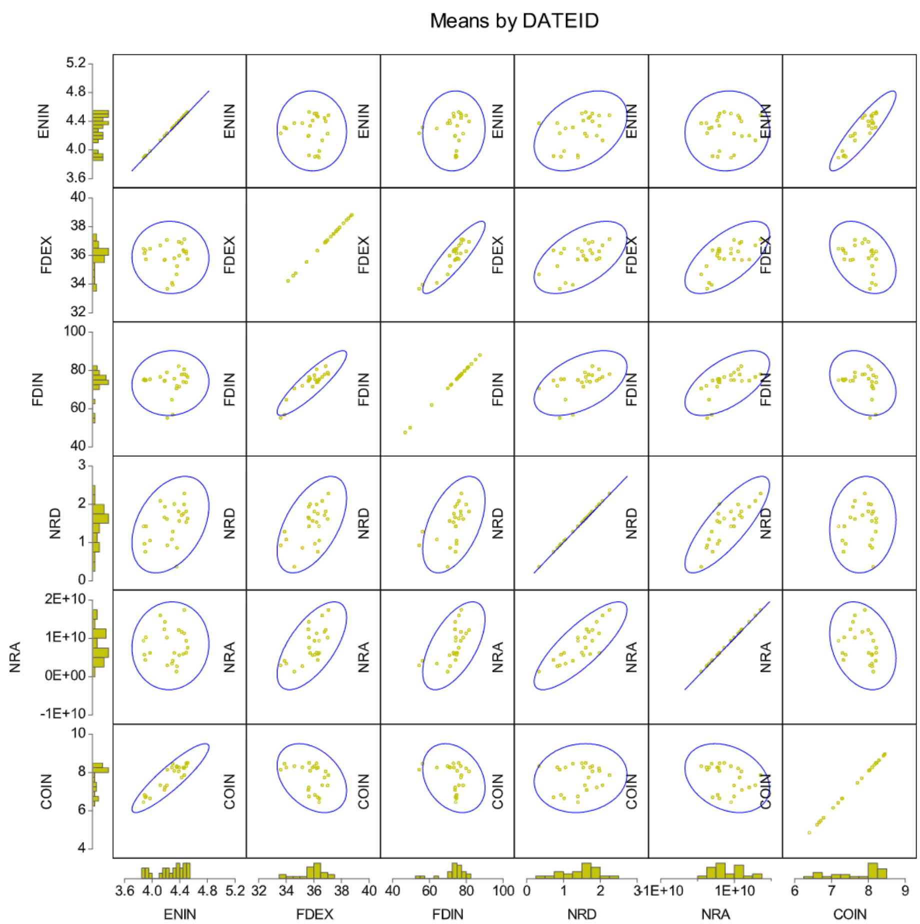


Fig. 1. Scatter matrix diagram for core variables of interest.
Source: Authors' estimations.

electricity capture the environment-related efficiency of technology (T). The real GDP per capita is also embraced as the conventional determinant of affluence, whereas the employment to population ratio is the population (*P*) factor. The subsequent equation for the current analysis is formalized as (Eq. (3)):

$$LES = \alpha_{it} + \beta_1 LGDP_{it} + \beta_2 LRDENV_{it} + \beta_3 LREW_{it} + \beta_4 LEMPO_{it} + \beta_5 LFDEX_{it} + \beta_6 LFDIN_{it} + \beta_7 LNR_{it} + \varepsilon_{it} \quad (3)$$

where ES signifies the environmental sustainability proxies, namely energy intensity and carbon intensity, GDP is the real GDP per capita, RDENV is environmentally related government R&D budget proxy for environmental innovation, REW represents the renewable electricity, EMPO is a pointer of employment to population ratio, FDEX demonstrates fiscal decentralization, FDIN is financial development index, and NR captures the NRD and NRA facets.

From the theoretical frontiers, we introduce several modifications to the conventional STIRPAT model detailed below: the *first modification* is based on the choice of environmental sustainability measure. Mainstream studies mostly opted for the environmental indicators spotlighting the only environmental perspective; however, since economic activities are highly correlated with environmental impacts (Adedoyin et al., 2021; Satrovic et al., 2021), a holistic measure is needed to capture the environmental sustainability impacts. Against this background, departing from the traditional measures, we adopt energy intensity and carbon intensity as comprehensive measures to incorporate the environmental sustainability effects of our model. The *second modification* includes fiscal decentralization as a factor of affluence (*A*). In this context, two opinions are existent. The '*race to the top*' proclaims that fiscal decentralization could allow the governments to opt for innovation activities, promoting policy competitiveness and making the public goods, including environmental quality, more of a governance concern (Shan et al., 2021). On the contrary, fiscally decentralized governments would likely favor the '*race to the bottom*' to create attractive economic conditions for foreign firms' investments by offering less stringent environmental regulations and thus compromising ecological quality (Kassouri, 2022). Thus, fiscal decentralization may either improve or deteriorate environmental sustainability (i.e., $\frac{\partial ES_{i,t}}{\partial FDEX_{i,t}} > 0$ or < 0).

Our *third modification* involves plugging in financial inclusion also as the affluence factor. Since access to and affordability of well-established and feasible financial services could enable individuals to integrate into the economies (Imboden, 2005), it might contribute to economic growth and environmental sustainability. It has been viewed that the availability of financial facilities incentivizes firms to spur innovation, product diversification, and employment generation, consequently proliferating economic growth (Marcelin et al., 2021). Economic agents (firms and households) might increase their spending provided enhanced access to financial facilities. From one standpoint, firms might expand production through horizontal industrialization (Ahmad and Wu, 2022b), promoting the use of energy-intensive production facilities and thus adding to environmental sustainability deterioration. Also, households with improved financial access might consume more big-ticket items demanding more energy and uplifting the overall residential energy consumption (Shahbaz et al., 2018), indirectly growing carbon emissions. From another stance, better financial inclusivity would lead the firms to induce vertical industrialization through investing in energy-efficient and economical innovation ventures (Le et al., 2020), cultivating the technology-intensive production units and thus improving energy efficiency. In the same vein, households with easy access to financial services would be more inclined to adopt renewable energy solutions involving high capital costs but the inexpensive operating cost (Jabeen et al., 2021), contributing to better environmental sustainability. Hence, financial inclusion may either manifest beneficial or detrimental environmental impacts (i.e., $\frac{\partial ES_{i,t}}{\partial FDIN_{i,t}} > 0$ or < 0).

Our *fourth modification* is the incorporation of natural resources' two facets (i.e., NRD and NRA) also as affluence factors. On the one hand, NRD has been argued to dampen economic progress since over-reliance on natural resources might involve decreasing returns to scales (Ginsburg, 1957). Additionally, sluggish economies tend not to devote resources to environmental protection (Li et al., 2019). Contrastingly, the favorable opinion is that more extraction and consumption of natural resources would earn rents and increase production scales (Brückner, 2010). Thus, economies with resource-driven high growth rates would be incentivized to spend on environmental goods. Moreover, the phenomenon that resource windfall impedes the economic growth of economies with rich natural resources has been popularized as RCP. The proponents of RCP argue that natural resource richness induces the human and material capital lock-in influence, inhibiting economic efficiency (Ding and Field, 2005). Thus, NRA might stimulate countries to consume more natural resources, causing natural resource depletion and environmental unsustainability through increased emissions and energy intensity (Xiaoman et al., 2021). However, opponents of RCP substantiate the argument that, if properly managed, natural resource richness could be converted into growth miracles in the presence of efficient institutional structure and technological advancement (Gradstein and Klemp, 2020), having potentially favorable environmental impacts. Herein, natural resources might either foster or hamper environmental sustainability (i.e., $\frac{\partial ES_{i,t}}{\partial NR_{i,t}} > 0$ or < 0).

Among the mainstream covariates of the STIRPAT model, real GDP per capita is used as the affluence factor, analogous to several past studies (Li et al., 2015; Poumanyvong and Kaneko, 2010). As suggested by the Environmental Kuznets Curve (EKC) theory, the linear term of GDP has been known to induce environmental deterioration impact (Grossman and Krueger, 1991). However, some empirical works favoring the reverse impacts are also existential (Ahmad et al., 2022; Satrovic et al., 2021). Thus, real GDP per capita may either reinforce or hamper environmental sustainability (i.e., $\frac{\partial ES_{i,t}}{\partial GDP_{i,t}} > 0$ or < 0). Next, environmental innovations as a determinant of technology (*T*) factor could mitigate emissions through energy-efficiency enhancement (Mao et al., 2021). However, it has also been argued that improved energy efficiency might upsurge the firms' demand for energy-efficient products, known as the energy rebound impact of environmental innovation (Liu et al., 2020), increasing the overall energy consumption and intensifying the environmental deterioration. Therefore, environmental innovation may either reduce or increase environmental sustainability (i.e., $\frac{\partial ES_{i,t}}{\partial RDENV_{i,t}} > 0$ or < 0). After that, renewable electricity, also a contributor to technological factor, is considered superior to nonrenewable energy for producing relatively low levels of hazardous emissions without harming economic growth (Bhattacharya et al., 2020; Satrovic and Adedoyin, 2022). Herein, it is expected to improve the environmental sustainability (i.e., $\frac{\partial ES_{i,t}}{\partial REW_{i,t}} > 0$). Eventually, the employment to population ratio is taken as the population (*P*) factor since, being an economically active population, it would explain the contributions to environmental sustainability more effectively. Thereby, employment to population ratio is likely to mitigate the environmental sustainability (i.e., $\frac{\partial ES_{i,t}}{\partial EMPO_{i,t}} < 0$), following the argument presented by (Antal et al., 2020).

Our *fifth modification* involves the integration of moderating role of NRD and NRA in modifying the environmental sustainability impact of fiscal decentralization within the augmented STIRPAT framework. The extended version of the model takes the following form (Eq. (4)):

$$LES = \alpha_{it} + \beta_1 LGDP_{it} + \beta_2 LRDENV_{it} + \beta_3 LREW_{it} + \beta_4 LEMPO_{it} + \beta_5 LFDEX_{it} + \beta_6 LFDIN_{it} + \beta_7 L(NR_{it} * FDEX_{it}) + \varepsilon_{it} \quad (4)$$

where $NR_{it} * FDEX_{it}$ indicates the interaction term of natural resources with fiscal decentralization to capture the moderation impacts of both NRD and NRA. The political economics literature has shed light on how natural resource richness and dependency have been correlated with the fiscal setup (Brückner, 2010). From one perspective, corrupt governments are likely to be involved in rent-seeking while extracting and utilizing natural resources, leading to the RCP (Sachs and Warner, 1995, 1997). On the flip side, governments with decision-making processes under strict checks and balances and transparency are expected to effectively use the abundant natural resource wealth to drive economic progress (Robinson et al., 2006). We introduce two novel channels to explain how natural resources moderate the influence of fiscal decentralization on environmental sustainability. (i) Fiscally decentralized governments of resource-rich and resource-dependent nations may bring about natural resource distribution equity, leading to more inclusive regional growth, strengthening the regional environmental policies driven by competition among the local governments and thus improving the environmental sustainability. (ii) However, the politics of natural resources are highly vulnerable to the rent-seeking phenomenon, leading to RCP and translating the sluggish growth into poor environmental sustainability effects. Particularly, geographical differences in NRA among the states of a country may incentivize the local governments to either consider the resource richness a window of opportunity to outperform other governments or involve in the rent-seeking and corruption of resource bonanza. With more fiscal decentralization, the former situation may improve resource-rich countries' economic and environmental sustainability. In comparison, the latter case may be detrimental to both the economic and environmental conditions of more fiscally decentralized resource-rich nations. Concerning the NRD, on the one hand, fiscally decentralized governments may formulate competitive energy transformation policies, departing from fossil-based resources to clean energy resources to some degree and improving environmental sustainability. On the other hand, under corrupt leadership and weak institutions, local governments may benefit more from resource dependency through the rent-seeking phenomenon. Given this narrative, which channel would dominate is totally or partially reliant on the degree of political structure's robustness in terms of the transparency of decision-making and accountability of the states of a country. In light of these theoretical underpinnings, the NRD and NRA are likely to either improve or deter environmental sustainability (i.e., $\frac{\partial ES_{i,t}}{\partial (NR_{it} * FDEX_{it})} > 0$ or < 0).

Our *final modification* is incorporating the interaction of natural resources with financial inclusion (i.e., $NR_{it} * FDIN_{it}$) to capture the moderation effects of NRD and NRA on financial inclusion-environmental sustainability linkage. The modified empirical model is expressed as (Eq. (5)):

$$LES = \alpha_{it} + \beta_1 LGDP_{it} + \beta_2 LRDENV_{it} + \beta_3 LREW_{it} + \beta_4 LEMPO_{it} + \beta_5 LFDEX_{it} + \beta_6 LFDIN_{it} + \beta_7 L(NR_{it} * FDIN_{it}) + \varepsilon_{it} \quad (5)$$

Natural resources are known to interact with financial inclusion through different pathways. For instance, natural resource richness may impede the financial sector development through rent-seeking and poor institutional quality. Under such a scenario, the governments do not attribute importance to institutional development since it would prevent them from ren-seeking (Krugman, 1987). The RCP has been considered an institutional curse in that weak institutions support the financial curse of natural resources (Khan et al., 2020); conversely, robust institutions would help reap the financial blessings of natural resource rents. We postulate three principal channels through which natural resources moderate the influence of financial inclusion on environmental sustainability. (a) Natural resource-rich economies' factors of production shift from other sectors to the resources sector, reducing the portfolio investments and diversification of other financial endeavors, decelerating economic growth and subsequently cultivating environmental deterioration. (b) NRA-driven exportation of natural resources may increase the foreign currency reserves of a resource-abundant economy, appreciating the domestic currency. Appreciated currency may usually reduce inflation since imports become less expensive than domestic substitutes, leading to reduced prices and low inflation, causing low interest rates (i.e., borrowing constraints) and encourage consumers to purchase green products through credit borrowing. In parallel, investors may decide to borrow more for green investments, advancing environmental sustainability. But this pathway may turn to adverse environmental impact if households and firms do not select the green products and investment ventures. (c) Natural resource dependency may enhance the importation of natural resources, depreciate the domestic currency, increase the inflation rate and interest rate, and discourage consumers from buying green products through credit borrowing, adversely contributing to environmental quality. Inversely, if the households and investors cut non-green products and investment expenditures, it may have environmental enhancement impact. Along these lines, the NRD and NRA are expected to either promote or hamper environmental sustainability (i.e., $\frac{\partial ES_{i,t}}{\partial (NR_{it} * FDIN_{it})} > 0$ or < 0). Eventually, for all the models, production-based carbon dioxide (CO_2) intensity is taken as an alternate proxy to capture the environmental sustainability impacts.

2.3. Econometric method

The empirical analysis of the current study consists of three steps. First, to know whether the data is cross-sectional dependent; second, to perform unit root tests; third, to evaluate the nature of the relationship between the outlined variables by relying on panel quantile regression. Since cross-sectional dependence can give unreliable results, the current study utilizes three tests which are Pesaran's (2004) cross-sectional dependence (CD) test, Pesaran's (2015) scaled Lagrange multiplier (LM) test, and Breusch and Pagan's (1980) LM test, that will help decide whether the cross-sectional dependence issue occurs. The Breusch-Pagan LM test is formalized as (Eq. (6)):

$$CD = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \quad (6)$$

Pesaran's (2004) CD test is shown in Eq. (7) as:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \rho_{ij} \quad (7)$$

Based on Eqs. (6) and (7), ρ_{ij} signifies the correlation coefficient; T is the time dimension, and N stands for countries.

Recalling the CD issue, the current study uses the second-generation Im et al.'s (2003) cross-sectionally augmented (CIPS) panel unit. The test statistics of CIPS are computed from the Cross-sectional augmented Dickey-Fuller (CADF) regression and can be expressed as (Eq. (8)):

$$CIPS = N^{-1} \sum_{i=1}^{n} CADF \quad (8)$$

Lastly, the current study employs the panel Method of Moments Quantile Regression (MMQR) with fixed effects proposed by Machado and Silva (2019) to explore the dynamic impacts of fiscal decentralization, financial inclusion, natural resources, environmental innovation, renewable electricity, employment to population ratio, and GDP on environmental sustainability for the selected OECD countries. Most importantly, MMQR provides efficient and unbiased estimates for non-normal data, which conventional estimators fail to do. Another vital property is that it works well in panel data surrounded by individual fixed effects. Besides, this model is suitable for endogenous regressors (Gimenes and Guerre, 2022). It is worth mentioning that MMQR calculates results at each quantile and remains robust in the case of outliers. The panel MMQR with fixed effects equation signifies the following functional form (Eq. (9)):

$$Q_{Y_{i,t}}(\tau|X_{it}) = \alpha(\tau)' X_{it} + \beta_i, i = 1, \ldots, N, t = 1, \ldots, T \quad (9)$$

Y_{it} signify dependent variables ($LENIN|LCOIN$), X_{it} outlines the explanatory variables , $a(\tau)$ denotes the unknown coefficients, β_i stands for the unobserved individual effects. The subsequent equations for the current empirical analysis are given below (Models 1 and 7 – Eq. (10); Models 2 and 8 – Eq. (11); Models 3 and 9 – Eq. (12); Models 4 and 10 – Eq. (13); Models 5 and 11 – Eq. (14); Models 7 and 12 – Eq. (15)):

$$Q_{LENIN|LCOIN}(\tau|X_{it}) = a_{1\tau} LGDP_{it} + a_{2\tau} LRDENV_{it} + a_{3\tau} LREW_{it} + a_{4\tau} LEMPO_{it} + a_{5\tau} LFDEX_{it} + a_{6\tau} LFDIN_{it} + a_{7\tau} LNRD_{it} + \beta_i \quad (10)$$

$$Q_{LENIN|LCOIN}(\tau|X_{it}) = a_{1\tau}LGDP_{it} + a_{2\tau}LRDENV_{it} + a_{3\tau}LREW_{it} + a_{4\tau}LEMPO_{it} + a_{5\tau}LFDEX_{it} + a_{6\tau}LFDIN_{it} + a_{7\tau}Mod\ 1_{it} + \beta_i \quad (11)$$

$$Q_{LENIN|LCOIN}(\tau|X_{it}) = a_{1\tau}LGDP_{it} + a_{2\tau}LRDENV_{it} + a_{3\tau}LREW_{it} + a_{4\tau}LEMPO_{it} + a_{5\tau}LFDEX_{it} + a_{6\tau}LFDIN_{it} + a_{7\tau}Mod\ 2_{it} + \beta_i \quad (12)$$

$$Q_{LENIN|LCOIN}(\tau|X_{it}) = a_{1\tau}LGDP_{it} + a_{2\tau}LRDENV_{it} + a_{3\tau}LREW_{it} + a_{4\tau}LEMPO_{it} + a_{5\tau}LFDEX_{it} + a_{6\tau}LFDIN_{it} + a_{7\tau}LNRA_{it} + \beta_i \quad (13)$$

$$Q_{LENIN|LCOIN}(\tau|X_{it}) = a_{1\tau}LGDP_{it} + a_{2\tau}LRDENV_{it} + a_{3\tau}LREW_{it} + a_{4\tau}LEMPO_{it} + a_{5\tau}LFDEX_{it} + a_{6\tau}LFDIN_{it} + a_{7\tau}Mod\ 3_{it} + \beta_i \quad (14)$$

$$Q_{LENIN|LCOIN}(\tau|X_{it}) = a_{1\tau}LGDP_{it} + a_{2\tau}LRDENV_{it} + a_{3\tau}LREW_{it} + a_{4\tau}LEMPO_{it} + a_{5\tau}LFDEX_{it} + a_{6\tau}LFDIN_{it} + a_{7\tau}Mod\ 4_{it} + \beta_i \quad (15)$$

From Eq. (10) through (15), Mod1 = NRD*FDEX, Mod2 = NRD*FDIN, Mod3 = NRA*FDEX, Mod4 = NRA*FDIN. Whereas, COIN indicates carbon intensity.

3. Results and discussion

3.1. Pre-estimation diagnostics

When observing the economies experiencing an ever-increasing environmental, financial and economic integration, the data are likely to exhibit cross-sectional dependence in the errors, which may yield misleading estimates if not dealt with. Table 4 reveals the CD results.

The outcomes shown in Table 4 approve the persistence of the cross-sectional dependence. The significance of the test statistics across the twelve specifications confirms cross-section dependence in the errors. In other words, all the CD tests reject the null hypothesis of cross-section independence across inspected OECD economies. This finding reaffirms that from 1995 through 2018, international trade and investment flows have thrived, boosting interdependence between OECD countries. The unobserved common factors in fiscal decentralization, financial inclusion, natural resources, employment to population ratio, renewable electricity, and economic progress in one OECD economy can spill over to other member nations. This study utilizes techniques that account for cross-sectional dependence to avoid unreliable outcomes.

Having established the presence of cross-sectional dependence, first-generation unit root methods may generate unreliable results. Therefore, this study employs the second-generation CIPS panel unit test proposed by Pesaran (2007). Table 5 demonstrates the outcome of the CIPS test.

As a further step, we examine the integration level of variables. It can be claimed that the test statistics appeared insignificant for five variables (LENIN, LGDP, LRDENV, LEMPO, and LCOIN) at their levels, indicating that the null hypothesis on unit root could not be rejected, including constant only. Dealing specifically with cross-sectional dependence, Table 5 shows that four (LENIN, LGDP, LRDENV, and LEMPO) out of fourteen variables exhibit non-stationary processes at levels with both constant and a trend. As far as the first differences are considered, Table 5 demonstrates that all the variables are stationary at the first difference using both specifications: (i) constant only; (ii) constant and trend. CIPS test results reaffirm that the variables have the same order of integration. In other words, the outcome presented in Table 5 claims that the variables are integrated of order one, i.e., $I(1)$.

3.2. Main estimation results and robustness check

The results of normality tests (Table 2) show that all inspected variables are non-normally distributed, which reaffirms the use of panel quantile regression (Kazemzadeh et al., 2021). Thus, employing a novel panel data MMQR with fixed effects, Table 6 reports the results reported at odd quantiles of energy intensity (the dependent variable). Moreover, for visual inspection, the impacts of regressors on energy intensity at the even quantiles are shown in Fig. 2.

Our *first finding* is that expenditure decentralization negatively affects energy intensity in all models (Table 6), manifesting that fiscal decentralization positively drives environmental sustainability. A statistically significant increasing trend has been observed for models 1, 3, 4, and 6 from quantiles 40th to 90th, displaying that fiscal decentralization is beneficial for environmental sustainability, especially across the OECD members with higher levels of energy and carbon intensity. Thus, for countries with poor environmental sustainability, a higher degree of fiscal decentralization could prove the window of opportunity to achieve more substantial energy efficiency and emissions reductions. These empirics elicit that the sampled OECD countries do not choose the *"race to the bottom"* style, indicating that they do not offer lax local environmental regulations to attract foreign investments to drive enhanced economic progress. More viable reasoning for this finding is that fiscal decentralization could maintain the budgetary balance, providing leveling fields for local governments to compete for environmental protection. Such competition among local governments is believed to induce the federal governments to follow the market-oriented development path, beneficial to advancing the efficacy and effectiveness of environmentally favorable public goods (Kassouri, 2022). In this regard, Cai and Treisman (2006) credited China's economic miracle to the Chinese style of fiscal decentralization accompanied by public finance, encouraging local policy reform experimentation and allowing new ideas to infiltrate from the grassroots levels. On the contrary, centralization might engender fiscal imbalance (Musgrave,

Table 4
Cross-sectional dependence.

Model/Test	Breusch-Pagan LM	Pesaran scaled LM	Pesaran CD	Model/Test	Breusch-Pagan LM	Pesaran scaled LM	Pesaran CD
LENIN = f(LGDP, LRDENV, LREW, LEMPO, LFDEX, LFDIN, LNRD)	104.97a (0.000)	11.88a (0.000)	7.62a (0.000)	LCOIN = f(LGDP, LRDENV, LREW, LEMPO, LFDEX, LFDIN, LNRD)	164.07a (0.000)	21.00a (0.000)	11.07a (0.000)
LENIN = f(LGDP, LRDENV, LREW, LEMPO, LFDEX, LFDIN, Mod1)	104.97a (0.000)	11.88a (0.000)	7.62a (0.000)	LCOIN = f(LGDP, LRDENV, LREW, LEMPO, LFDEX, LFDIN, Mod1)	164.07a (0.000)	21.00a (0.000)	11.07a (0.000)
LENIN = f(LGDP, LRDENV, LREW, LEMPO, LFDEX, LFDIN, Mod2)	104.97a (0.000)	11.88a (0.000)	7.62a (0.000)	LCOIN = f(LGDP, LRDENV, LREW, LEMPO, LFDEX, LFDIN, Mod2)	164.07a (0.000)	21.00a (0.000)	11.07a (0.000)
LENIN = f(LGDP, LRDENV, LREW, LEMPO, LFDEX, LFDIN, LNRA)	163.65a (0.000)	20.93a (0.000)	11.30a (0.000)	LCOIN = f(LGDP, LRDENV, LREW, LEMPO, LFDEX, LFDIN, LNRA)	134.67a (0.000)	16.46a (0.000)	8.23a (0.000)
LENIN = f(LGDP, LRDENV, LREW, LEMPO, LFDEX, LFDIN, Mod3)	163.65a (0.000)	20.93a (0.000)	11.30a (0.000)	LCOIN = f(LGDP, LRDENV, LREW, LEMPO, LFDEX, LFDIN, Mod3)	134.67a (0.000)	16.46a (0.000)	8.23a (0.000)
LENIN = f(LGDP, LRDENV, LREW, LEMPO, LFDEX, LFDIN, Mod4)	163.65a (0.000)	20.93a (0.000)	11.30a (0.000)	LCOIN = f(LGDP, LRDENV, LREW, LEMPO, LFDEX, LFDIN, Mod4)	134.67a (0.000)	16.46a (0.000)	8.23a (0.000)

Note: p values in parentheses, a ($p < 0.01$), b ($p < 0.05$), c ($p < 0.10$), Mod1 = NRD*FDEX, Mod2 = NRD*FDIN, Mod3 = NRA*FDEX, Mod4 = NRA*FDIN.

Table 5
CIPS unit root test results.

Variables	Levels		1st Diff		Variables	Levels		1st Diff	
	No trend	With trend	No trend	With trend		No trend	With trend	No trend	With trend
LENIN	−1.42	−2.23	−4.72a	−4.68a	LNRD	−3.44a	−3.52a	−5.89a	−6.01a
LGDP	−1.68	−1.78	−2.80a	−2.74c	LNRA	−3.17a	−3.59a	−5.98a	−5.94a
LRDENV	−1.75	−1.71	−4.00a	−3.94a	Mod1	−3.54a	−3.92a	−5.99a	−6.06a
LREW	−2.27c	−3.16a	−5.25a	−5.29a	Mod2	−3.44a	−3.69a	−5.93a	−6.09a
LEMPO	−1.18	2.06	−3.08a	−2.94b	Mod3	−3.06a	−3.80a	−5.97a	−5.98a
LFDEX	−2.28c	−3.56a	−5.08a	−5.49a	Mod4	−3.16a	−3.93a	−5.99a	−5.94a
LFDIN	−2.64a	−3.06b	−4.97a	−4.96a	LCOIN	−2.20	−3.16a	−4.84a	−4.86a

Note: a ($p < 0.01$), b ($p < 0.05$), c ($p < 0.10$), Mod1 = NRD*FDEX, Mod2 = NRD*FDIN, Mod3 = NRA*FDEX, Mod4 = NRA*FDIN.

Table 6
Estimation results from panel quantile regression model (ENIN - dependent variable).

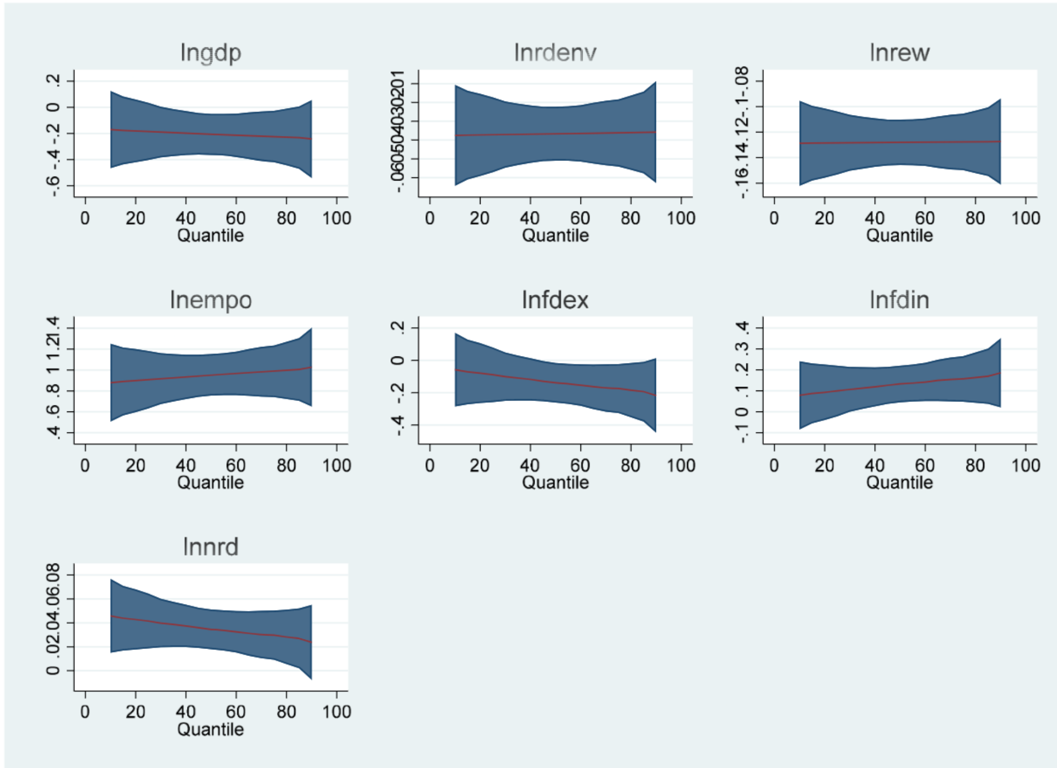
Model	Var./QR	.1 QR		.3 QR		.5 QR		.7 QR		.9 QR	
		Coef.	P > z	Coef.	P > z	Coef.	P > z	Coef.	P > z	Coef.	P > z
1	LGDP	−0.170	0.256	−0.190c	0.054	−0.207b	0.010	−0.221b	0.022	−0.242	0.111
	LRDENV	−0.038a	0.006	−0.037a	0.000	−0.037a	0.000	−0.036a	0.000	−0.036b	0.010
	LREW	−0.129a	0.000	−0.128a	0.000	−0.128a	0.000	−0.128a	0.000	−0.127a	0.000
	LEMPO	0.878a	0.000	0.918a	0.000	0.954a	0.000	0.983a	0.000	1.026a	0.000
	LFDEX	−0.058	0.619	−0.101	0.186	−0.139b	0.026	−0.171b	0.022	−0.218c	0.064
	LFDIN	0.079	0.344	0.108b	0.049	0.133a	0.003	0.154a	0.004	0.186b	0.027
	LNRD	0.046a	0.004	0.040a	0.000	0.035a	0.000	0.030a	0.003	0.024	0.137
2	LGDP	−0.170	0.256	−0.190c	0.054	−0.207b	0.010	−0.221b	0.022	−0.242	0.111
	LRDENV	−0.038a	0.006	−0.037a	0.000	−0.037a	0.000	−0.036a	0.000	−0.036b	0.010
	LREW	−0.129a	0.000	−0.128a	0.000	−0.128a	0.000	−0.128a	0.000	−0.127a	0.000
	LEMPO	0.878a	0.000	0.918a	0.000	0.954a	0.000	0.983a	0.000	1.026a	0.000
	LFDEX	−0.104	0.377	−0.141c	0.068	−0.174a	0.006	−0.201a	0.008	−0.242b	0.042
	LFDIN	0.079	0.344	0.108b	0.049	0.133a	0.003	0.154a	0.004	0.186b	0.027
	LMod1	0.046a	0.004	0.040a	0.000	0.035a	0.000	0.030a	0.003	0.024	0.137
3	LGDP	−0.170	0.256	−0.190c	0.054	−0.207b	0.010	−0.221b	0.022	−0.242	0.111
	LRDENV	−0.038a	0.006	−0.037a	0.000	−0.037a	0.000	−0.036a	0.000	−0.036b	0.010
	LREW	−0.129a	0.000	−0.128a	0.000	−0.128a	0.000	−0.128a	0.000	−0.127a	0.000
	LEMPO	0.878a	0.000	0.918a	0.000	0.954a	0.000	0.983a	0.000	1.026a	0.000
	LFDEX	−0.058	0.619	−0.101	0.186	−0.139b	0.026	−0.171b	0.022	−0.218c	0.064
	LFDIN	0.033	0.700	0.068	0.225	0.099b	0.031	0.124b	0.023	0.162c	0.059
	LMod2	0.046a	0.004	0.040a	0.000	0.035a	0.000	0.030a	0.003	0.024	0.137
4	LGDP	−0.272c	0.081	−0.285a	0.005	−0.294a	0.000	−0.304a	0.002	−0.318b	0.044
	LRDENV	−0.037a	0.007	−0.037a	0.000	−0.038a	0.000	−0.038a	0.000	−0.039a	0.005
	LREW	−0.132a	0.000	−0.130a	0.000	−0.128a	0.000	−0.127a	0.000	−0.125a	0.000
	LEMPO	0.934a	0.000	0.955a	0.000	0.970a	0.000	0.986a	0.000	1.007a	0.000
	LFDEX	−0.076	0.499	−0.110	0.134	−0.134b	0.029	−0.159b	0.030	−0.194c	0.092
	LFDIN	0.078	0.338	0.110b	0.037	0.133a	0.003	0.158a	0.003	0.192b	0.021
	LNRA	0.038a	0.002	0.034a	0.000	0.031a	0.000	0.028a	0.001	0.024c	0.059
5	LGDP	−0.272c	0.081	−0.285a	0.005	−0.294a	0.000	−0.304a	0.002	−0.318b	0.044
	LRDENV	−0.037a	0.007	−0.037a	0.000	−0.038a	0.000	−0.038a	0.000	−0.039a	0.005
	LREW	−0.132a	0.000	−0.130a	0.000	−0.128a	0.000	−0.127a	0.000	−0.125a	0.000
	LEMPO	0.934a	0.000	0.955a	0.000	0.970a	0.000	0.986a	0.000	1.007a	0.000
	LFDEX	−0.114	0.316	−0.144c	0.052	−0.165a	0.008	−0.187b	0.011	−0.218c	0.060
	LFDIN	0.078	0.338	0.110b	0.037	0.133a	0.003	0.158a	0.003	0.192b	0.021
	LMod3	0.038a	0.002	0.034a	0.000	0.031a	0.000	0.028a	0.001	0.024c	0.059
6	LGDP	−0.272c	0.081	−0.285a	0.005	−0.294a	0.000	−0.304a	0.002	−0.318b	0.044
	LRDENV	−0.037a	0.007	−0.037a	0.000	−0.038a	0.000	−0.038a	0.000	−0.039a	0.005
	LREW	−0.132a	0.000	−0.130a	0.000	−0.128a	0.000	−0.127a	0.000	−0.125a	0.000
	LEMPO	0.934a	0.000	0.955a	0.000	0.970a	0.000	0.986a	0.000	1.007a	0.000
	LFDEX	−0.076	0.499	−0.110	0.134	−0.134b	0.029	−0.159b	0.030	−0.194c	0.092
	LFDIN	0.040	0.628	0.076	0.154	0.102b	0.022	0.129b	0.015	0.168b	0.045
	LMod4	0.038a	0.002	0.034a	0.000	0.031a	0.000	0.028a	0.001	0.024c	0.059

Note: a ($p < 0.01$), b ($p < 0.05$), c ($p < 0.10$), Mod1 = NRD*FDEX, Mod2 = NRD*FDIN, Mod3 = NRA*FDEX, Mod4 = NRA*FDIN, QR = Quantile regression.

1959), upscaling the possibility of rent-seeking for the local governments with relatively unfair distribution of public revenues and expenditures and disincentivizing them to spend on ecological protection (Lin and Zhou, 2021). Overall, our finding is consistent with Khan et al. (2021) and Sun and Razzaq (2022) in the OECD context and Cheng et al. (2021) in the Chinese perspective since they observed the carbon emissions mitigation impact of fiscal decentralization; however, they overlooked considering this linkage across heterogeneous quantiles of countries.

Our *second finding* is that financial inclusion positively affects the energy intensity across the observed quantiles and for all the models. The effects of higher financial inclusivity on the energy intensity are positive and statistically significant for the 30th-90th quantiles in models 1, 2, 4, and 5. However, models 3 and 6 display statistically significant positive impacts for 40th-90th quantiles. Models 1 through 6 exhibit increasing degrees of influence from lower to upper quantiles, suggesting that enhanced financial inclusion would be detrimental to energy efficiency, especially across the OECD member states with high energy intensity. The justification of this finding is that financial inclusivity might allow economic agents (consumers and producers)

(a) Model 1



(b) Model 2

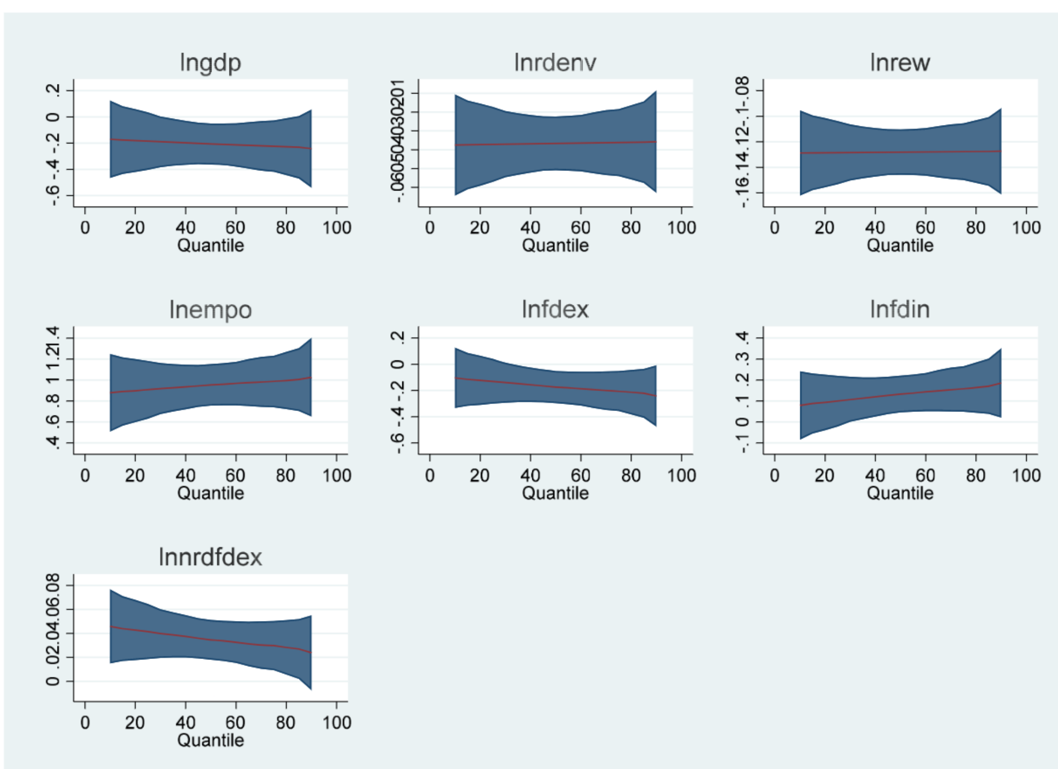
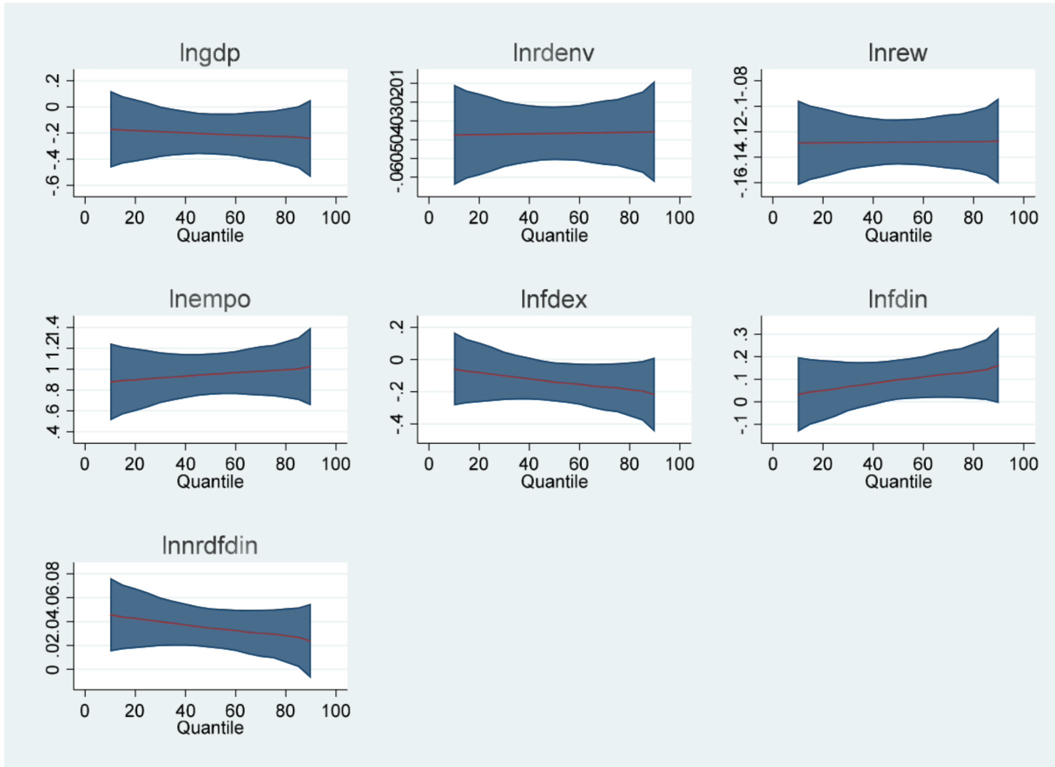


Fig. 2. Plotting coefficients of quantile regression (ENIN - dependent variable). **Note:** lngdp = LGDP, lnrdenv = LRDENV, lnrew = LREW, lnempo = LEMPO, lnfdex = LFDEX, lnfdin = LFDIN, lnnrd = LNRD, lnnra = LNRA, lnnrdfdex = LMod1, lnnrdfdin = LMod2, lnnrafdex = LMod3, lnnrafdin = LMod4.

(c) Model 3



(d) Model 4

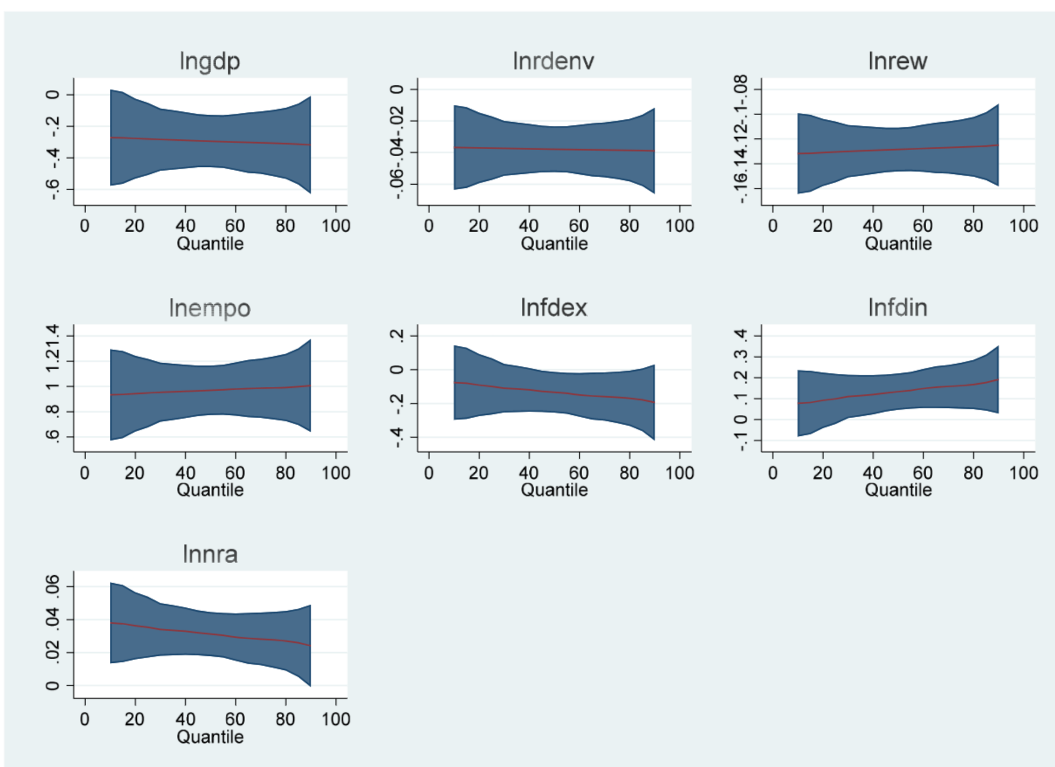
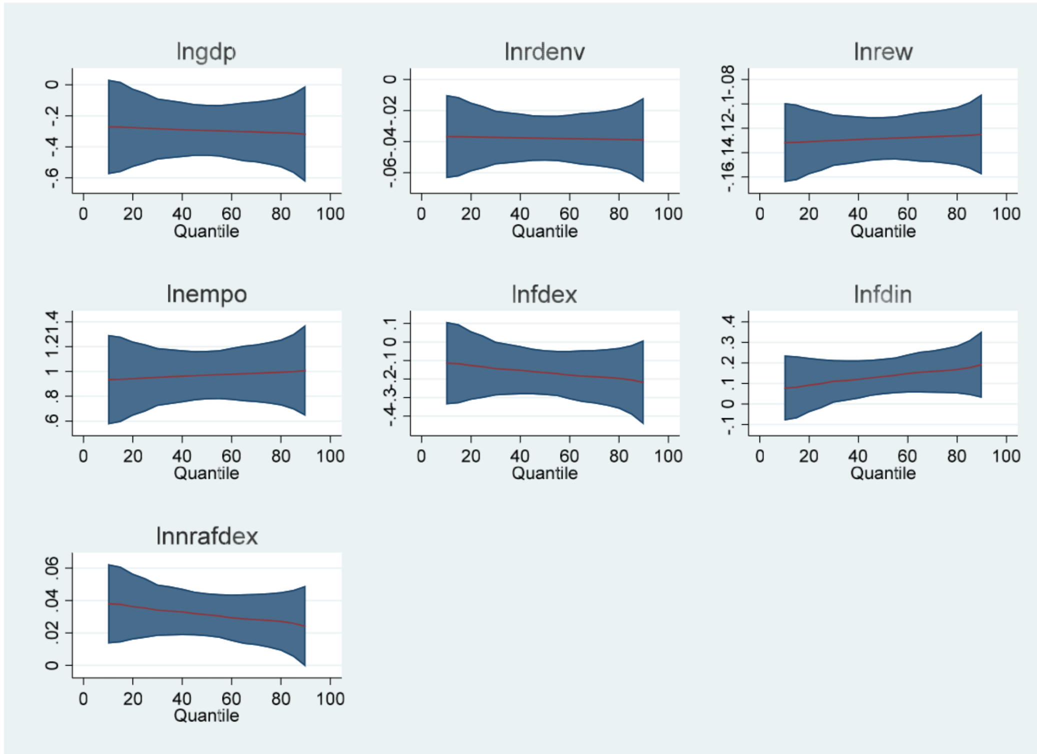


Fig. 2. (*continued*).

access to useful and affordable financial products and services (Shahbaz et al., 2018), possibly inducing consumers to purchase big-ticket items and producers to expand businesses, consequently uplifting residential and industrial energy demand and mitigating energy efficiency (Ahmad and Wu, 2022b; Seles et al., 2019). This finding lends credence to Le et al. (2020) as they communicated the environmental deterioration impact of financial inclusion in the sample of Asian economies. They posited that such linkage was attributable to a lack of policy synergies

(e) Model 5



(f) Model 6

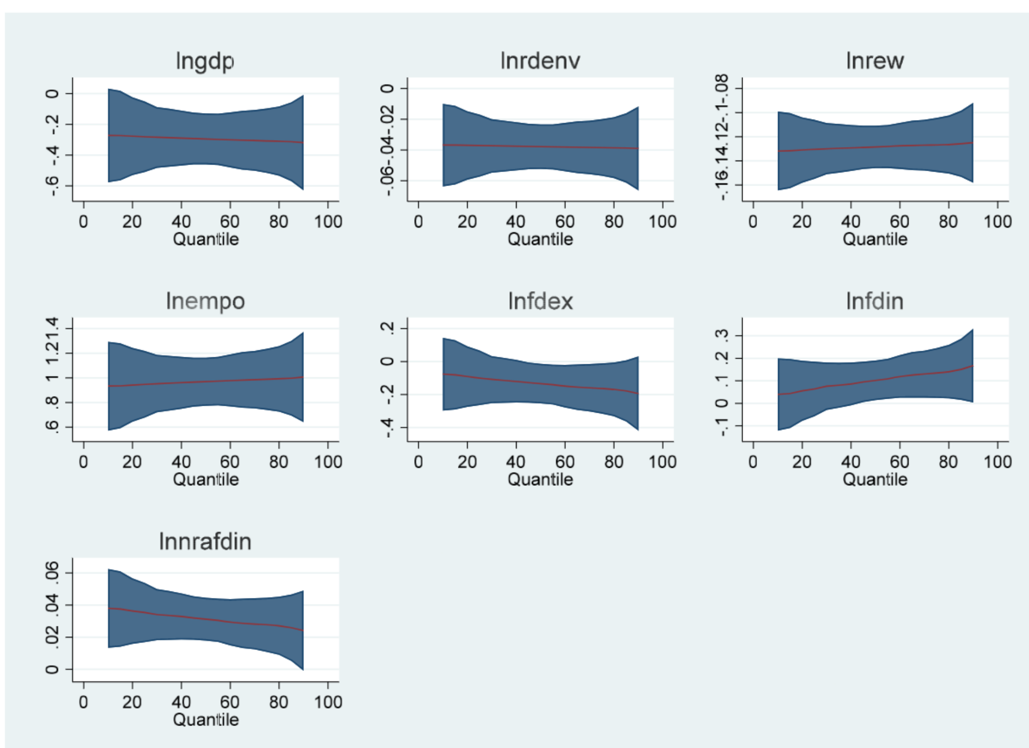


Fig. 2. (*continued*).

between emissions mitigation plans and financial development. Our finding contradicts Qin et al. (2021) and Shahbaz et al. (2022) since they observed the emissions curtailment impact of financial inclusion in the E7 countries and Chinese provinces, respectively.

Our *third finding* exhibits that NRD and NRA add to energy intensity, deterring the environmental sustainability of the OECD region (see models 1 and 4). As regards the role of NRD, it can be justified that the over-reliance of economies on natural resources keeps both physical and human capital occupied by the resource industry, which inhibits the industrial transition to an energy-efficient structure, thereby restricting the improvements in environmental sustainability (Li et al., 2019). In model 1, the impact of NRD on energy intensity is significant for the 10th-80th quantiles; nevertheless, an insignificant effect of the same appears for the 90th quantile. Additionally, the contributions of NRD to energy intensity decrease with ascending quantile levels. Concerning the involvement of NRA, resource-rich economies tend to over-rely on resource-intensive technologies and industrial structures, which boosts energy intensity and limits environmental sustainability. Another possible explanation is that the richness in natural resources increments the demand for extraction and consumption of such resources as oil and coal, skyrocketing the anthropogenic emissions (Pata et al., 2021). This finding supports Langnel et al. (2021) as they spotted environmental degradation in response to NRA in ECOWAS countries involving Cameroon and Nigeria. In model 4, the contribution of NRA to energy intensity displays a decreasing trend across all quantiles, affirming that the environmental sustainability of more energy-efficient OECD countries is more sensitive to changes in NRD. Our finding contrasts with Xiaoman et al. (2021), revealing the environmentally favorable influence of natural resources on GHG emissions, attributing it to clean technologies used to extract natural resources in the MENA region.

Our *fourth finding* explains the cruciality of the twin facets of natural resources (i.e., NRD and NRA) in positively moderating the influence of fiscal decentralization and financial inclusion on energy intensity (see models 2, 3, 5, 6). Concerning interaction with fiscal decentralization, both NRD and NRA positively moderate the impacts of fiscal decentralization (models 2 and 5) on energy intensity, suggesting that an enhanced fiscal decentralization deteriorates environmental sustainability for a high level of NRD and NRA. It is noteworthy that the signs of the estimated coefficients of the LMod1 and LMod 3 are in the opposite direction of the main effect of fiscal decentralization. By introducing the interaction terms, the environmental impacts of fiscal decentralization are conditional on NRD and NRA in that natural resource dependency reverses the beneficial environmental sustainability effects of fiscal decentralization into detrimental ones. The possible explanation is that natural resource richness and dependency allow the local governments to exploit those resources through rent-seeking, decelerating economic performance and disincentivizing environmental protection. However, the channel of resource distribution equity postulated by this study is empirically not supported in the case of selected OECD countries. The coefficients of LMod1 and LMod3 follow a declining pattern and are significant for all levels except quantile 90th in model 2. It means that for more energy-intensive countries, the detrimental moderation effects of NRD and NRA are relatively less substantial and vice versa. Regarding their interaction with financial inclusion, NRD and NRA positively and significantly moderate the influence of financial inclusion on energy intensity (see models 3 and 6). Though the signs of the main effects of financial inclusion and the moderation effects are consistent, the magnitudes of influence are reduced for the moderators, meaning that NRD and NRA weaken the adverse environmental impacts of financial inclusion. The possible explanation is that, on the one hand, NRA appreciates the domestic currency of resource-rich nations through the exportation of natural resources, reducing the inflation and interest rates and increasing the access to easy credits for households and firms, uplifting the energy-intensive industrial expansions and driving the energy demand and anthropogenic emissions from the producer's perspective. While from the consumer perspective, access to financial services may upsurge the consumption of big-ticket items, increasing energy use and deteriorating environmental sustainability. Besides, the coefficients of LMod2 and LMod4 follow a descending pattern for all levels except quantile 90th in model 3. It means that for more energy-intensive countries, the detrimental moderation effects of NRD and NRA are relatively less substantial and vice versa. It has been reported that OECD countries rely on natural resource sectors to provide employment. Since natural resources extraction inevitably imposes environmental damage, the positive coefficients of the effects of NRD and NRA, as well as the positive moderating effects of both factors, signal that the selected OECD countries do not use clean technologies to extract natural resources; thereby, the exploitation of natural resources amplifies environmental unsustainability. Even though the selected OECD countries are resource-rich, NRA is unsustainable due to the industrialization process, accelerating the extraction of natural resources and dependence on fossil fuels, clearly indicating that natural resources do not make a beneficial environmental impact in the inspected OECD member countries.

Among other control variables, environmental innovation depicts a heterogeneous but negative effect on energy intensity across different models and diversified quantiles (Table 6). For models with NRD, a higher level of environmental innovation can reduce energy intensity and improve energy efficiency more in relatively less energy-intensive countries. For models 1–3, in the 10th quantile, its coefficient is 0.038, which gets smaller in the 90th quantile, displaying a declining pattern of impact of environmental innovation across the quantiles. However, the reverse situation is observed for models 4–6, presenting a declining trend of coefficients across the quantiles of energy intensity. Despite this, the overall finding confirms that in countries that are functional enough, the increase in the environmental innovation budget might be advantageous to them in terms of energy efficiency and environmental sustainability. In the same vein, an inverse linkage has been revealed between renewable electricity and energy intensity. A possible justification is that the OECD members are known to develop less carbon-intensive energy solutions, particularly focusing on renewable energy resources, since they are considered superior to fossil fuels to produce relatively low GHG emissions without jeopardizing the growth process. Besides, the impact of renewable electricity on climate change has been uncovered to be more cost-effective than nonrenewable energy (Chen et al., 2019), constituting around 26.2 percent of global electricity generation in 2018 (REPN, 2019). The significance of this finding could be traced to Wang et al. (2021) since they observed that renewable energy's carbon emissions reduction impact was more substantial than that brought about by technological advancements. Contrastingly, Dong et al. (2020) marked an inverse but insignificant link between renewable energy consumption and global carbon emissions, arguing that it was possibly because of the huge nonrenewable energy consumption worldwide that depressed the beneficial impacts of renewables. The coefficients of renewable electricity show a declining trend across the 10th through 90th quantiles for all models. This outcome suggests that an increase in renewable electricity can reduce energy intensity, with a more substantial contribution to the countries with relatively low energy intensity and vice versa. The possible explanation is that already energy-efficient countries manifest more inclination toward energy-efficient solutions such as renewable electricity, mitigating environmental degradation and improving environmental sustainability.

Furthermore, we unveil an energy intensity driving influence of employment to population ratio, meaning that an enhanced economically active population may adversely impact environmental sustainability in models 1–6. To elaborate, the intensification in employment to population ratio implies enhanced economic activities involving energy consumption in all the sectors of the economy and consequently increasing environmental degradation. For all the six models, coefficients of LEMPO exhibit an increasing trend from the 10th through 90th quantiles and express a statistically significant impact. This outcome suggests that a higher level of employment to population ratio can more vigorously reduce energy efficiency in countries with higher energy intensity. To illustrate, a transition towards sustainable growth can create new employment opportunities. This transition will create more jobs in "clean" and energy-efficient sectors and close positions in energy-intensive sectors with high ecological footprints and anthropogenic emissions. However, the statistically significant positive coefficient with employment to population ratio in our study clearly expresses that the labor market of the selected OECD countries failed to prepare for this transition; therefore, the benefits from sustainable growth for employment are not maximized in the region. Contrarily, we reveal a negative and statistically significant relationship between economic progress and energy intensity, inferring that economic progress-driven technique and composition effects exceed the scale effect, accelerating the energy efficiency in OECD economies. The coefficients of LGDP are significant in all the models for all quantiles except for the 10th, 20th and 90th quantiles, for which negative but statistically insignificant estimates are obtained. The strength of association increases from 10th to 90th quantiles, exhibiting that economic progress more starkly improves the energy efficiency and environmental sustainability for relatively more energy-intensive countries. The plausible intuition of why economic progress supports ecological performance improvement in the OECD region is the adoption of environmentally friendly transformations along with the acceleration of economic progress. Particularly, the selected seven OECD economies have adequate economic growth, enabling them to resist environmentally unfriendly economic activities and negative environmental externalities.

Besides, to check the robustness of our baseline results, we estimate alternative models by using the production-based CO_2 intensity to capture the environmental impacts as a dependent variable. Table A1 presents the results of all six alternative models (i.e., models 7–12) (see Appendix A). The alternative models' findings align with our baseline models, confirming the robustness of our empirical results.

4. Conclusions and policy implications

Unlike previous works, we empirically inquired into how twin facets of natural resources (i.e., NRD and NRA) moderate the effects of fiscal decentralization and financial inclusion on environmental sustainability. Based on the findings from novel panel data MMQR, the following key conclusions are drawn:

First, fiscal decentralization revealed an environmental sustainability acceleration effect, with more substantial contributions for relatively less energy- and carbon-efficient economies, indicating that OECD members prefer the "*race to the top*" style of local governance. On the contrary, financial inclusion uncovered environmental sustainability deceleration influence in that it upsurged the energy and carbon efficiency, with more pronounced effects in countries with less energy efficiency. *Second*, catalyzing the energy intensity, NRD and NRA demonstrated an environmental sustainability deterring effect, with a high degree of influence in relatively more energy- and carbon-efficient nations. It supported the idea of the *lock-in effect* of natural resources. *Third*, most importantly, NRA and NRA positively moderated the effects of fiscal decentralization and financial inclusion on energy and carbon intensity, manifesting an environmental degradation effect. This influence was more powerful in countries displaying more energy efficiency. The positive moderation for expenditure decentralization could be attributed to the rent-seeking behavior of resource-rich and resource-dependent economies. *Among control variables*, environmental innovation induced an environmental sustainability enhancement effect for all quantiles, indicating that the R&D budget accrued to the ecological protection diffused beneficial environmental impacts. Next, renewable electricity also brought environmentally sustainable outcomes in that it improved energy efficiency, with more vigorous effects for less energy-intensive countries. After that, the employment to population ratio predicted the energy intensity acceleration effect, deteriorating the environmental quality more powerfully in less energy-efficient economies. In closing, economic progress unfolded an environmental sustainability escalation effect, with a more intensive impact in more energy- and carbon-intensive countries. It means the technique and composition effects of economic production dominated the scale effects in the OECD region.

Given our cornerstone empirical results, the following policy implications are derived:

First, fiscal decentralization's environmental sustainability improvement effect implicates that subnational governments of OECD members with less energy efficiency implement environmental protection policies more effectively. Since our finding on the governmental R&D budget unfolded environmental sustainability enhancement effect, the state-level governments of OECD members are spending on energy transformation from energy-intensive to technology-intensive industrial structures. It implies that OECD economies are on track to green growth policy implementation by phasing out energy and carbon taxation cuts (OECD, 2021a). However, for OECD members observing natural resource richness and abundance, subnational governments seem to exercise policies supportive of rent-seeking behavior, thereby overlooking the provision of quality public goods such as environmentally friendly products. A coordinated development policy framework should be shaped for better accountability and transparency of the local governments, particularly those rich in and dependent on natural resources, avoiding rent-seeking behavior and the resulting environmental deterioration. *Second*, since financial inclusion deteriorates the environmental quality, economic agents should be provided with more green growth-oriented financial services to strengthen the energy-efficient and low-carbon development plan, among other SDGs. For instance, households should be offered green credits to spend on environmentally friendly products, and firms should be given loans directed at green investments. Also, our findings unveiled that renewable electricity ameliorates energy efficiency; therefore, renewable energy adoption driven by improved inclusive finance would mitigate the harmful effects of financial inclusion on environmental sustainability. Findings also uncovered that financial inclusion failed to curb the use of energy-intensive industries in resource-rich and resource-dependent countries. It implies that natural resource-rich governments heavily relied on and kept the factors of production engaged in the resource-based sector, overlooking a transition to technology-based industries. This is also visible from our finding showing adverse environmental effects of employment to population ratio, meaning that resource-rich governments did not promote sufficient employment in the technology-intensive sectors to advance ecological performance. OECD members with resource bonanza should use green natural resource extraction techniques since ongoing practices exploit environmental quality.

Future research works are encouraged to employ global panel data to explore moderation relationships of natural resources across the spectrum of economies with heterogeneous levels of economic development. From theoretical fronts, while this study employed an environmental modeling framework, future studies may integrate environmental indicators into an economic modeling setup to examine the influence mechanisms of macroeconomic indicators on environmental sustainability. Though this study considered the financial development index to measure financial inclusion, follow-up works may employ diversified financial inclusion indicators to observe their heterogeneous contributions to environmental sustainability, securing more insightful findings.

Credit author statement

Munir Ahmad: Conceptualization, Writing original draft, Visualization, Theoretical model, Writing- Reviewing and Editing. Elma Satrovic: Data curation, Methodology, Software, Writing original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A

Table A1
Robustness analysis: Estimation results from panel quantile regression model (COIN - dependent variable)

Model	Var./QR	.1 QR		.3 QR		.5 QR		.7 QR		.9 QR	
		Coef.	P > z	Coef.	P > z	Coef.	P > z	Coef.	P > z	Coef.	P > z
7	LGDP	−1.021b	0.016	−0.983a	0.000	−0.955a	0.000	−0.930a	0.000	−0.904a	0.000
	LRDENV	−0.038	0.317	−0.043c	0.067	−0.047a	0.003	−0.050a	0.001	−0.053b	0.017
	LREW	−0.132a	0.006	−0.128a	0.000	−0.125a	0.000	−0.123a	0.000	−0.120a	0.000
	LEMPO	1.636a	0.001	1.734a	0.000	1.807a	0.000	1.873a	0.000	1.942a	0.000
	LFDEX	−0.310	0.233	−0.317b	0.048	−0.322a	0.003	−0.32a7	0.002	−0.332b	0.030
	LFDIN	0.167	0.429	0.179	0.172	0.187b	0.034	0.194b	0.025	0.202	0.104
	LNRD	0.083c	0.054	0.056b	0.039	0.035c	0.056	0.017	0.356	−0.002	0.922
8	LGDP	−1.021b	0.016	−0.983a	0.000	−0.955a	0.000	−0.930a	0.000	−0.904a	0.000
	LRDENV	−0.038	0.317	−0.043c	0.067	−0.047a	0.003	−0.050a	0.001	−0.053b	0.017
	LREW	−0.132a	0.006	−0.128a	0.000	−0.125a	0.000	−0.123a	0.000	−0.120a	0.000
	LEMPO	1.636a	0.001	1.734a	0.000	1.807a	0.000	1.873a	0.000	1.942a	0.000
	LFDEX	−0.394	0.130	−0.373b	0.020	−0.358a	0.001	−0.344a	0.001	−0.329b	0.031
	LFDIN	0.167	0.429	0.179	0.172	0.187b	0.034	0.194b	0.025	0.202	0.104
	LMod1	0.083c	0.054	0.056b	0.039	0.035c	0.056	0.017	0.356	−0.002	0.922
9	LGDP	−1.021b	0.016	−0.983a	0.000	−0.955a	0.000	−0.930a	0.000	−0.904a	0.000
	LRDENV	−0.038	0.317	−0.043c	0.067	−0.047a	0.003	−0.050a	0.001	−0.053b	0.017
	LREW	−0.132a	0.006	−0.128a	0.000	−0.125a	0.000	−0.123a	0.000	−0.120a	0.000
	LEMPO	1.636a	0.001	1.734a	0.000	1.807a	0.000	1.873a	0.000	1.942a	0.000
	LFDEX	−0.310	0.233	−0.317b	0.048	−0.322a	0.003	−0.327a	0.002	−0.332b	0.030
	LFDIN	0.084	0.697	0.123	0.357	0.151c	0.092	0.178b	0.044	0.205	0.106
	LMod2	0.083c	0.054	0.056b	0.039	0.035b	0.056	0.017	0.356	−0.002	0.922
10	LGDP	−1.189a	0.001	−1.093a	0.000	−1.025a	0.000	−0.962a	0.000	−0.901a	0.000
	LRDENV	−0.038	0.229	−0.044b	0.020	−0.049a	0.000	−0.053a	0.001	−0.057a	0.009
	LREW	−0.136a	0.001	−0.130a	0.000	−0.126a	0.000	−0.122a	0.000	−0.118a	0.000
	LEMPO	1.680a	0.000	1.761a	0.000	1.819a	0.000	1.872a	0.000	1.924a	0.000
	LFDEX	−0.316	0.130	−0.319b	0.011	−0.322a	0.000	−0.324a	0.002	−0.326b	0.024
	LFDIN	0.155	0.370	0.176c	0.092	0.190b	0.012	0.204b	0.016	0.217c	0.069
	LNRA	0.070b	0.016	0.045b	0.012	0.027b	0.040	0.011	0.446	−0.005	0.800
11	LGDP	−1.189a	0.001	−1.093a	0.000	−1.025a	0.000	−0.962a	0.000	−0.901a	0.000
	LRDENV	−0.038	0.229	−0.044	0.020	−0.049a	0.000	−0.053a	0.001	−0.057a	0.009
	LREW	−0.136a	0.001	−0.130a	0.000	−0.126a	0.000	−0.122a	0.000	−0.118a	0.000
	LEMPO	1.680a	0.000	1.761a	0.000	1.819a	0.000	1.872a	0.000	1.924a	0.000
	LFDEX	−0.386c	0.064	−0.364a	0.004	−0.349a	0.000	−0.335a	0.001	−0.321b	0.026
	LFDIN	0.155	0.370	0.176c	0.092	0.190b	0.012	0.204b	0.016	0.217c	0.069
	LMod3	0.070b	0.016	0.045b	0.012	0.027b	0.040	0.011	0.446	−0.005	0.800
12	LGDP	−1.189a	0.001	−1.093a	0.000	−1.025a	0.000	−0.962a	0.000	−0.901a	0.000
	LRDENV	−0.038	0.229	−0.044b	0.020	−0.049a	0.000	−0.053a	0.001	−0.057a	0.009
	LREW	−0.136a	0.001	−0.130a	0.000	−0.126a	0.000	−0.122a	0.000	−0.118a	0.000
	LEMPO	1.680a	0.000	1.761a	0.000	1.819a	0.000	1.872a	0.000	1.924a	0.000
	LFDEX	−0.316	0.130	−0.319b	0.011	−0.322a	0.000	−0.324a	0.002	−0.326b	0.024
	LFDIN	0.085	0.626	0.131	0.216	0.163b	0.035	0.193b	0.025	0.222c	0.066
	LMod4	0.070b	0.016	0.045b	0.012	0.027b	0.040	0.011	0.446	−0.005	0.800

Note: a ($p < 0.01$), b ($p < 0.05$), c ($p < 0.10$), Mod1 = NRD*FDEX, Mod2 = NRD*FDIN, Mod3 = NRA*FDEX, Mod4 = NRA*FDIN, QR = Quantile regression.

References

Abul, S.J., Satrovic, E., 2021. Revisiting the environmental impacts of railway transport: does EKC exist in south-eastern europe? Polish J. Environ. Stud. 31, 1–11. https://doi.org/10.15244/pjoes/141329.

Adedoyin, F.F., Satrovic, E., Kehinde, M.N., 2021. The anthropogenic consequences of energy consumption in the presence of uncertainties and complexities: evidence from World Bank income clusters. Environ. Sci. Pollut. Res. https://doi.org/10.1007/s11356-021-17476-5.

Ahmad, M., Muslija, A., Satrovic, E., 2021. Does economic prosperity lead to environmental sustainability in developing economies ? Environmental Kuznets curve theory. Environ. Sci. Pollut. Res. 28, 22588–22601. https://doi.org/10.1007/s11356-020-12276-9.

Ahmad, M., Wu, Y., 2022a. Household-based factors affecting uptake of biogas plants in Bangladesh: implications for sustainable development. Renew. Energy 194, 858–867. https://doi.org/10.1016/j.renene.2022.05.135.

Ahmad, M., Wu, Y., 2022b. Combined role of green productivity growth, economic globalization, and eco-innovation in achieving ecological sustainability for OECD economies. J. Environ. Manag. 302, 113980 https://doi.org/10.1016/j.jenvman.2021.113980.

Ahmad, M., Zhu, X., Wu, Y., 2022. The criticality of international tourism and technological innovation for carbon neutrality across regional development levels. Technol. Forecast. Soc. Change 182, 121848. https://doi.org/10.1016/j.techfore.2022.121848.

Aldieri, L., Gatto, A., Paolo, C., 2021. Evaluation of energy resilience and adaptation policies : an energy efficiency analysis. Energy Pol. 157, 112505 https://doi.org/10.1016/j.enpol.2021.112505.

Aldieri, L., Gatto, A., Vinci, C.P., 2022. Is there any room for renewable energy innovation in developing and transition economies? Data envelopment analysis of energy behaviour and resilience data. Resour. Conserv. Recycl. 186, 106587 https://doi.org/10.1016/j.resconrec.2022.106587.

Allen, F., Demirguc-Kunt, A., Klapper, L., Martinez Peria, M.S., 2016. The foundations of financial inclusion: understanding ownership and use of formal accounts. J. Financ. Intermediation 27, 1–30. https://doi.org/10.1016/j.jfi.2015.12.003.

Antal, M., Plank, B., Mokos, J., Wiedenhofer, D., 2020. Is working less really good for the environment? A systematic review of the empirical evidence for resource use,

greenhouse gas emissions and the ecological footprint. Environ. Res. Lett. 16 https://doi.org/10.1088/1748-9326/abceec.
Atil, A., Nawaz, K., Lahiani, A., Roubaud, D., 2020. Are natural resources a blessing or a curse for financial development in Pakistan? The importance of oil prices, economic growth and economic globalization. Resour. Pol. 67, 101683 https://doi.org/10.1016/j.resourpol.2020.101683.
Auty, R.M., 1990. Resource-based Industrialization: Sowing the Oil in Eight Developing Countries. Oxford University Press, New York.
Balsalobre-Lorente, D., Sinha, A., Driha, O.M., Mubarik, M.S., 2021. Assessing the impacts of ageing and natural resource extraction on carbon emissions: a proposed policy framework for European economies. J. Clean. Prod. 296, 126470 https://doi.org/10.1016/j.jclepro.2021.126470.
Bhattacharya, M., Inekwe, J.N., Sadorsky, P., 2020. Consumption-based and territory-based carbon emissions intensity: determinants and forecasting using club convergence across countries. Energy Econ. 86, 104632 https://doi.org/10.1016/j.eneco.2019.104632.
Breusch, A.T.S., Pagan, A.R., 1980. The Lagrange multiplier test and its applications to model specification in econometrics. Rev. Econ. Stud. 47, 239–253.
Brückner, M., 2010. Natural resource dependence, non-tradables, and economic growth. J. Comp. Econ. 38, 461–471. https://doi.org/10.1016/j.jce.2010.06.002.
Burgess, R., Pande, R., 2005. Do rural banks matter? Evidence from the Indian social banking experiment. Am. Econ. Rev. 95, 780–795.
Cai, H., Treisman, D., 2006. Did government decentralization cause China's economic miracle? World Polit. 58, 505–535.
Chen, Y., Wang, Z., Zhong, Z., 2019. CO2 emissions, economic growth, renewable and non-renewable energy production and foreign trade in China. Renew. Energy 131, 208–216. https://doi.org/10.1016/j.renene.2018.07.047.
Cheng, Y., Awan, U., Ahmad, S., Tan, Z., 2021. How do technological innovation and fiscal decentralization affect the environment? A story of the fourth industrial revolution and sustainable growth. Technol. Forecast. Soc. Change 162, 120398. https://doi.org/10.1016/j.techfore.2020.120398.
Dietz, T., Rosa, E.A., 1997. Effects of population and affluence on CO2 emissions. Natl. Acad. Sci. USA 94, 175–179.
Ding, N., Field, B.C., 2005. Natural resource abundance and economic growth. Land Econ. 81, 496–502. https://doi.org/10.3368/le.81.4.496.
Dong, K., Dong, X., Jiang, Q., 2020. How renewable energy consumption lower global CO2 emissions? Evidence from countries with different income levels. World Econ. 43, 1665–1698. https://doi.org/10.1111/twec.12898.
Drago, C., Gatto, A., 2022. Policy, regulation effectiveness, and sustainability in the energy sector: a worldwide interval-based composite indicator. Energy Pol. 167, 112889 https://doi.org/10.1016/j.enpol.2022.112889.
Fritz, B., Feld, L.P., 2020. Common pool effects and local public debt in amalgamated municipalities. Publ. Choice 183, 69–99. https://doi.org/10.1007/s11127-019-00688-2.
Gatto, A., Drago, C., 2021. When renewable energy, empowerment, and entrepreneurship connect: measuring energy policy effectiveness in 230 countries. Energy Res. Social Sci. 78, 101977 https://doi.org/10.1016/j.erss.2021.101977.
Gelb, A.H., 1988. Windfall Gains: Blessing or Curse? Oxford University Press, New York.
Gimenes, N., Guerre, E., 2022. Quantile regression methods for first-price auctions. J. Econom. 226, 224–247. https://doi.org/10.1016/j.jeconom.2021.02.009.
Ginsburg, N., 1957. Natural resources and economic development. Ann. Assoc. Am. Geogr. 47, 197–212.
Gradstein, M., Klemp, M., 2020. Natural resource access and local economic growth. Eur. Econ. Rev. 127 https://doi.org/10.1016/j.euroecorev.2020.103441.
Grossman, G., Krueger, A., 1991. Environmental impacts of a north American free trade agreement. Natl. Bur. Econ. Res. https://doi.org/10.3386/w3914.
Im, S.K., Pesaran, M.H., Shin, Y., 2003. Testing for unit roots in heterogeneous panels. J. Econom. 115, 53–74. https://doi.org/10.1016/S0304-4076(03)00092-7.
Imboden, K., 2005. Building inclusive financial sectors: the road to growth and poverty reduction. J. Int. Aff. 58, 65–86.
IMF, 2020. International Monetary Fund. Financ. Dev. Index Database [WWW Document]. https://data.imf.org/?sk=F8032E80-B36C-43B1-AC26-493C5B1CD33B. accessed 10.6.21.
IMF, 2018. International monetary fund [WWW document]. Int. Monet. Fund Annu. Rep. 1–104, 2018. https://www.imf.org/external/pubs/ft/ar/2018/eng/.
Jabeen, G., Ahmad, M., Zhang, Q., 2021. Perceived critical factors affecting consumers ' intention to purchase renewable generation technologies : rural-urban heterogeneity. Energy 218, 119494. https://doi.org/10.1016/j.energy.2020.119494.
Kassouri, Y., 2022. Fiscal decentralization and public budgets for energy RD&D: a race to the bottom. Energy Pol. 161, 112761 https://doi.org/10.1016/j.enpol.2021.112761.
Kazemzadeh, E., Fuinhas, J.A., Koengkan, M., 2021. The impact of income inequality and economic complexity on ecological footprint: an analysis covering a long-time span. J. Environ. Econ. Policy 1–21. https://doi.org/10.1080/21606544.2021.1930188.
Khan, Muhammad Atif, Gu, L., Khan, Muhammad Asif, Oláh, J., 2020. Natural resources and financial development: the role of institutional quality. J. Multinatl. Financ. Manag. 56, 100641 https://doi.org/10.1016/j.mulfin.2020.100641.
Khan, Z., Ali, S., Dong, K., Li, R.Y.M., 2021. How does fiscal decentralization affect CO2 emissions? The roles of institutions and human capital. Energy Econ. 94, 105060 https://doi.org/10.1016/j.eneco.2020.105060.
Krugman, P., 1987. The narrow moving band, the Dutch disease, and the competitive consequences of Mrs. Thatcher. Notes on trade in the presence of dynamic scale economies. J. Dev. Econ. 27, 41–55. https://doi.org/10.1016/0304-3878(87)90005-8.
Langnel, Z., Babington, G., Donkor, P., Kwame, J., 2021. Income inequality, human capital, natural resource abundance, and ecological footprint in ECOWAS member countries. Resour. Pol. 74, 102255 https://doi.org/10.1016/j.resourpol.2021.102255.
Le, T., Le, H., Taghizadeh-hesary, F., 2020. Does financial inclusion impact CO 2 emissions? Evidence from Asia. Finance Res. Lett. 34, 101451 https://doi.org/10.1016/j.frl.2020.101451.
Li, B., Liu, X., Li, Z., 2015. Using the STIRPAT model to explore the factors driving regional CO2 emissions: a case of Tianjin, China. Nat. Hazards 76, 1667–1685. https://doi.org/10.1007/s11069-014-1574-9.
Li, Z., Shao, S., Shi, X., Sun, Y., Zhang, X., 2019. Structural transformation of manufacturing, natural resource dependence, and carbon emissions reduction: evidence of a threshold effect from China. J. Clean. Prod. 206, 920–927. https://doi.org/10.1016/j.jclepro.2018.09.241.
Lin, B., Zhou, Y., 2021. Does fiscal decentralization improve energy and environmental performance? New perspective on vertical fiscal imbalance. Appl. Energy 302, 117495. https://doi.org/10.1016/j.apenergy.2021.117495.
Liu, Y., Zhu, J., Li, E.Y., Meng, Z., Song, Y., 2020. Environmental regulation, green technological innovation, and eco-efficiency: the case of Yangtze river economic belt in China. Technol. Forecast. Soc. Change 155, 119993. https://doi.org/10.1016/j.techfore.2020.119993.
Machado, J.A.F., Silva, J.M.C.S., 2019. Quantiles via moments. J. Econom. 213, 145–173. https://doi.org/10.1016/j.jeconom.2019.04.009.
Majeed, A., Wang, L., Zhang, X., Kirikkaleli, D., 2021. Modeling the dynamic links among natural resources , economic globalization , disaggregated energy consumption , and environmental quality : fresh evidence from GCC economies. Resour. Pol. 73, 102204 https://doi.org/10.1016/j.resourpol.2021.102204.
Mao, W., Wang, W., Sun, H., Yao, P., Wang, X., Luo, D., 2021. Urban industrial transformation patterns under natural resource dependence: a rule mining technique. Energy Pol. 156, 112383 https://doi.org/10.1016/j.enpol.2021.112383.
Marcelin, I., Egbendewe, A.Y.G., Oloufade, D.K., Sun, W., 2021. Financial inclusion, bank ownership, and economy performance: evidence from developing countries. Finance Res. Lett. 102322 https://doi.org/10.1016/j.frl.2021.102322.
Martinez-Vazquez, J., McNab, R.M., 2003. Fiscal decentralization and economic growth. World Dev. 31, 1597–1616. https://doi.org/10.1016/S0305-750X(03)00109-8.
Mujtaba, A., Jena, P.K., Mishra, B.R., Kyophilavong, P., Hammoudeh, S., Roubaud, D., Dehury, T., 2022. Do economic growth, energy consumption and population damage the environmental quality? Evidence from five regions using the nonlinear ARDL approach. Environ. Challenges 8. https://doi.org/10.1016/j.envc.2022.100554.
Musgrave, R.A., 1959. The Theory of Public Finance: a Study in Public Economy. McGraw-Hill, New York.
Nawaz, K., Lahiani, A., Roubaud, D., 2020. Do natural resources determine energy consumption in Pakistan? The importance of quantile asymmetries. Q. Rev. Econ. Finance. https://doi.org/10.1016/j.qref.2020.10.003.
Nawaz, K., Lahiani, A., Roubaud, D., 2019. Natural resources as blessings and finance-growth nexus: a bootstrap ARDL approach in an emerging economy. Resour. Pol. 60, 277–287. https://doi.org/10.1016/j.resourpol.2019.01.007.
OECD, 2021a. OECD Economic Surveys.
OECD, 2021b. The Organisation for Economic Co-operation and Development. Gross Domest. Spend. R&D [WWW Document]. https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm. accessed 9.26.21.
OECD, 2020. The Organisation for Economic Co-operation and Development. Green growth Indic [WWW Document]. https://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH#. accessed 9.30.21.
OECD, 2019. Organization for Economic Cooperation and Development. OECD.Stat [WWW Document]. https://stats.oecd.org/. accessed 3.15.21.
Pata, U.K., Aydin, M., Haouas, I., 2021. Are natural resources abundance and human development a solution for environmental pressure? Evidence from top ten countries with the largest ecological footprint. Resour. Pol. 70, 101923 https://doi.org/10.1016/j.resourpol.2020.101923.
Pesaran, M.H., 2015. Testing weak cross-sectional dependence in large panels. Econom. Rev. 34, 1089–1117. https://doi.org/10.1080/07474938.2014.956623.
Pesaran, M.H., 2007. A simple panel unit root test in the presence of cross-section dependence. J. Appl. Econom. 22, 265–312. https://doi.org/10.1002/jae.
Pesaran, M.H., 2004. General diagnostic tests for cross section dependence in panels. University of cambridge, faculty of economics, cambridge working papers in economics No. 0435. Cent. Econ. Stud. Ifo Inst. Econ. Res. CESifo 41.
Poumanyvong, P., Kaneko, S., 2010. Does urbanization lead to less energy use and lower CO 2 emissions ? A cross-country analysis. Ecol. Econ. 70, 434–444. https://doi.org/10.1016/j.ecolecon.2010.09.029.
Qin, L., Raheem, S., Murshed, M., Miao, X., Khan, Z., Kirikkaleli, D., 2021. Does financial inclusion limit carbon dioxide emissions? Analyzing the role of globalization and renewable electricity output. Sustain. Dev. 29, 1138–1154. https://doi.org/10.1002/sd.2208.
Rajan, R.G., Zingales, L., 2003. The great reversals: the politics of financial development in the twentieth century. J. Financ. Econ. 69, 5–50. https://doi.org/10.1016/S0304-405X(03)00125-9.
REPN, 2019. REN21. Renew. Energy Policy Netw. 21st Century [WWW Document]. https://www.c2es.org/content/renewable-energy/.
Robinson, J.A., Torvik, R., Verdier, T., 2006. Political foundations of the resource curse. J. Dev. Econ. 79, 447–468. https://doi.org/10.1016/j.jdeveco.2006.01.008.
Rousseau, P.L., Wachtel, P., 2002. Inflation thresholds and the finance-growth nexus. J. Int. Money Finance 21, 777–793. https://doi.org/10.1016/S0261-5606(02)00022-0.
Sachs, J., Warner, A., 1995. Natural reaource abundance and econmic growth. NBER Work. Pap. 3, 47.
Sachs, J.D., Warner, A.M., 2001. Natural resources and economic development the curse of natural resources. Eur. Econ. Rev. 45, 827–838.

Sachs, J.D., Warner, A.M., 1997. Sources of slow growth in african economies. J. Afr. Econ. 6, 335–376.
Sadik-Zada, E.R., Gatto, A., 2022. Civic engagement and energy transition in the Nordic-Baltic Sea Region: parametric and nonparametric inquiries. Socioecon. Plann. Sci. 101347 https://doi.org/10.1016/j.seps.2022.101347.
Sadik-Zada, E.R., Gatto, A., 2021. The puzzle of greenhouse gas footprints of oil abundance. Socioecon. Plann. Sci. 75, 100936 https://doi.org/10.1016/j.seps.2020.100936.
Satrovic, E., Abul, S.J., Al-Kandari, A., 2022. Modeling the dynamic linkages between agriculture, electricity consumption, income and pollutant emissions for southeastern europe. Pol. J. Environ. Stud. 31, 4259–4267. https://doi.org/10.15244/pjoes/147825.
Satrovic, E., Adedoyin, F.F., 2022. An empirical assessment of electricity consumption and environmental degradation in the presence of economic complexities. Environ. Sci. Pollut. Res. https://doi.org/10.1007/s11356-022-21099-9.
Satrovic, E., Ahmad, M., Muslija, A., 2021. Does democracy improve environmental quality of GCC region? Analysis robust to cross-section dependence and slope heterogeneity. Environ. Sci. Pollut. Res. https://doi.org/10.1007/s11356-021-15020-z.
Schoenmaker, D., 2021. Greening monetary policy. Clim. Pol. 21, 581–592. https://doi.org/10.1080/14693062.2020.1868392.
Seles, B.M.R.P., Lopes de Sousa Jabbour, A.B., Jabbour, C.J.C., Latan, H., Roubaud, D., 2019. Do environmental practices improve business performance even in an economic crisis? Extending the win-win perspective. Ecol. Econ. 163, 189–204. https://doi.org/10.1016/j.ecolecon.2019.04.013.
Shahbaz, M., Ali, M., Roubaud, D., 2018. Environmental degradation in France : the effects of FDI , fi nancial development , and energy innovations. Energy Econ. 74, 843–857. https://doi.org/10.1016/j.eneco.2018.07.020.
Shahbaz, M., Li, J., Dong, X., Dong, K., 2022. How financial inclusion affects the collaborative reduction of pollutant and carbon emissions: the case of China. Energy Econ. 107, 105847 https://doi.org/10.1016/j.eneco.2022.105847.
Shan, S., Ahmad, M., Tan, Z., Adebayo, T.S., Li, R.Y.M., Kirikkaleli, D., 2021. The role of energy prices and non-linear fiscal decentralization in limiting carbon emissions: tracking environmental sustainability. Energy 121243. https://doi.org/10.1016/j.energy.2021.121243.
Shen, H., Chen, Yilin, Russell, A.G., Hu, Y., Shen, G., Yu, H., Henneman, L.R.F., Ru, M., Huang, Y., Zhong, Q., Chen, Yuanchen, Li, Y., Zou, Y., Zeng, E.Y., Fan, R., Tao, S., 2018. Impacts of rural worker migration on ambient air quality and health in China: from the perspective of upgrading residential energy consumption. Environ. Int. 113, 290–299. https://doi.org/10.1016/j.envint.2017.11.033.
Song, M., Zhao, X., Shang, Y., Chen, B., 2020. Realization of green transition based on the anti-driving mechanism: an analysis of environmental regulation from the perspective of resource dependence in China. Sci. Total Environ. 698, 134317 https://doi.org/10.1016/j.scitotenv.2019.134317.
Sovacool, B.K., Newell, P., Carley, S., Fanzo, J., 2022. Equity, technological innovation and sustainable behaviour in a low-carbon future. Nat. Human Behav. https://doi.org/10.1038/s41562-021-01257-8.
Stiglitz, J.E., Weiss, A., 1981. Credit rationing in markets with imperfect information. Am. Econ. Rev. 71, 393–410.
Sun, Y., Razzaq, A., 2022. Composite fiscal decentralisation and green innovation: imperative strategy for institutional reforms and sustainable development in OECD countries. Sustain. Dev. 1–14. https://doi.org/10.1002/sd.2292.
Verbič, M., Satrovic, E., Muslija, A., 2021. Environmental Kuznets curve in Southeastern Europe: the role of urbanization and energy consumption. Environ. Sci. Pollut. Res. https://doi.org/10.1007/s11356-021-14732-6.
Wang, J., Dong, X., Dong, K., 2021. How renewable energy reduces CO2 emissions? Decoupling and decomposition analysis for 25 countries along the Belt and Road. Appl. Econ. 53, 4597–4613. https://doi.org/10.1080/00036846.2021.1904126.
WB, 2021. World Bank. World Dev. Indic [WWW Document]. https://databank.worldbank.org/source/world-development-indicators. accessed 10.1.21.
Wong, Y.L.A., Lewis, L., 2013. The disappearing environmental Kuznets curve: a study of water quality in the lower mekong basin (LMB). J. Environ. Manag. 131, 415–425. https://doi.org/10.1016/j.jenvman.2013.10.002.
Xiaoman, W., Majeed, A., Vasbieva, D.G., Yameogo, C.E.W., Hussain, N., 2021. Natural resources abundance, economic globalization, and carbon emissions: advancing sustainable development agenda. Sustain. Dev. 29, 1037–1048. https://doi.org/10.1002/sd.2192.
Yang, X., Li, N., Mu, H., Zhang, M., Pang, J., Ahmad, M., 2021. Study on the long-term and short-term effects of globalization and population aging on ecological footprint in OECD countries. Ecol. Complex. 47, 100946 https://doi.org/10.1016/j.ecocom.2021.100946.