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Research Paper

Role of circular economy, energy transition, environmental policy stringency, and supply chain pressure on CO_2 emissions in emerging economies

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ABSTRACT

This paper investigates the effect of the circular economy on CO_2 emissions growth by considering the role of energy transition, climate policy stringency, industrialization, and supply chain pressure from 1997 to 2020 using panel quantile Autoregressive Distributed Lags (QARDL) and the panel PMG. We employ cointegration association in the long run among the variables, and the results of the two models confirm this. Findings reveal that circular economy and climate policy stringency significantly negatively impact carbon emissions. On the other hand, the energy transition, industrialization, and supply chain pressures are crucial to determining CO_2 emissions in the short and long run. The finding further explores that municipal waste generation recycling is considerable at the mean and upper 90th quantiles than the lower quantile. Therefore, the empirical results of the current study provide acumens for policymakers of advanced economies and emerging markets to maintain the balance among circular economy, energy transition, environmental policy stringency, and supply chain pressure for reducing CO_2 emissions without halting economic growth and sustainable development. Furthermore, practical implications are reported through the lens of carbon neutrality and structural changes.

1. Introduction

The research on the circular flow of economy came into the limelight from the reformulations of Marx's reproduction schemes (Marx, 1987) and *Tableau économique* (de Riquetti and Quesnay, 1758). Besides physiocrats and de Riquetti and Quesnay (1758), some other economists highlighted the economy's circular flow but have yet to use the word "Circular Economy". Even Boulding (1966) was not used the word circular economy in his seminal work. In this context, for preserving human life, he further urged the urgent requirement of closed-loop systems as a precondition for economic well-being. Circular Economy (CE) is an economic model through which reprocessing operations, production, resourcing, and purchasing are planned and designed for people's well-being and the environment's conservation (Murray et al., 2017; Mohammed et al., 2022). Furthermore, CE directs sustainable competitive strategies for better economic performance without harming the resources through cost-effective waste management, energy efficiency, green technology innovations, and environmental conservation (Bastein et al., 2013; MacArthur, 2013; Genovese et al., 2017; Abbey and Guide, 2018). Based on the social transformation and political approach, the feasibility of the CE perspective for a fairer society has been addressed (Genovese and Pansera, 2020; Jia et al., 2023). With the help of CE techniques, valuable eco-efficient inputs are added to wastes that could be recycled, reused, and repaired (Guide and Van Wassenhove, 2009; Goltsos et al., 2018). Moreover, through employment opportunities, enhancing supply chain relationships, and reducing price volatility, CE improves the business models of the supply chain (SC) and different public and private organizations (Atasu et al., 2010; Kok et al., 2013; Battini et al., 2017; Mokhtar et al., 2019). Although due to a lack of proper regulations, institutional support, economic incentives, and environmental awareness, the transition towards CE is affecting severely (Souza, 2013; Agnello et al., 2015;

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Möllemann, 2016). At the same time, previous research advocated the barriers and drivers of inter and intra organizations which are responsible for CE readiness for performing their routine supply chain affairs (Shi, 2003; Zhou et al., 2017). Governmental regulations and social pressure are identified as key capabilities for managing CE initiatives in inter-organizational (Sangle, 2010; Lozano, 2012; Singh et al., 2016), whereas environmental commitment for the intra-organizational capabilities as significant antecedents which affect the transition of circular economy (Montalvo, 2003). Additionally, for institutional theory's sustainable development, inter and intra-organizational capabilities play a significant role (Dzhengiz, 2020).

CO_2 emissions, circular economy, energy transition, and supply chain pressure are key and recent interconnected issues (refer Fig. 1). Due to the escalation of demands and calls for a fundamental shift in global energy policies to reduce emissions, the circular economy is gaining momentum nowadays as a leading solution to climate change (Gallego-Schmid et al., 2020). The circular economy is essential to support the energy transition, along with getting the most out of the raw materials, reusing them and designing them for recycling into the economy, and then eliminating wastes and even producing energy locally. Global municipal waste generated 2.01 billion tonnes yearly and more than 2000 million tonnes in 2016 (Kaza et al., 2018). The report predicts that, by 2050, the annual growth of municipal waste worldwide will increase to 3.4 billion tonnes. In 2018, more than 54% of the waste was treated; thus, 38% went to recycling, 10% to backfilling, and 6% to produce energy. As for disposal, landfill and others account for 45% (Eurostat, 2021). Indeed, recycling is now occupying a particular place among the objectives of the Paris climate agreement, aiming to reduce the temperature to 1.5° and eliminate emissions by 2050 (United Nations, 2015). The circular economy would not be complete unless the waste generation is recycled through renewable energy, such as solar, wind, and geothermal, away from traditional energy sources (Mutezo and Mulopo, 2021). Recently, the inflationary environment coming from supply chain disruptions has given impetus to the circular economy to increase supply chain resilience by bringing inputs for manufacturing closer to the production location through reusing and recycling. For example, providing energy input through municipal waste rather than mining and importing can cut more carbon emissions. Furthermore, the energy transition has shown to be amongst the critical other vital solutions to reduce carbon dioxide gas emissions, at which a large proportion of the pollution comes from traditional energy consumption.

In this context, little previous literature has shed light on the effect of a circular economy on environmental degradation, but the results are inconclusive. Magazzino and Falcone (2022) demonstrate the causality of municipal waste to GHG emissions in high-income countries (Switzerland) and Denmark. Mongo et al. (2021) find that the circular economy is the primary determinant of CO_2 emission for the European Union. They also documented that recycling waste reduces CO_2 emissions in the short and long run. In the same region (EU), Bayar et al. (2021) establish the negative impact of waste recycling on CO_2 emission in the long run, while this effect is not revealed in the short run. Sun et al. (2018) reported that the carbon mission of the waste generation treatment in China is much higher than the emission on the case in Japan. Lee et al. (2016) detect the absence of the causality between waste generation with recycling waste variables and GHG emissions from waste during the period 1992 to 2012 in the USA. This study aims to investigate the effect of the circular economy on CO_2 emission and by considering the supply chain and energy transition.

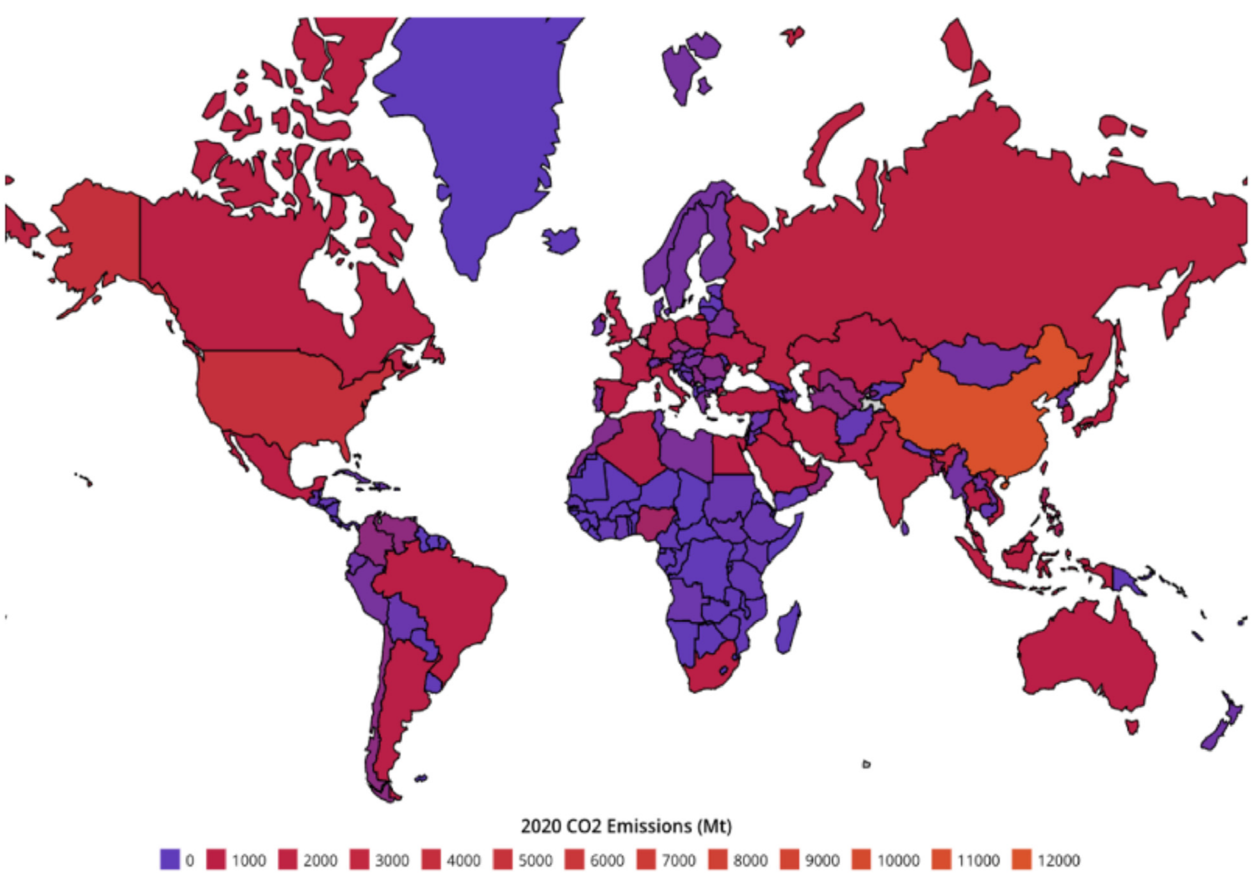

Fig. 1. Country wise CO_2 emission.

We offer many contributions to the literature. First, the literature needs to discuss more the effect of the circular economy on environmental degradation so that we extend the prior literature by providing an updated analysis and filling the gaps. Second, to the best of the authors' knowledge, this is the first study focused on examining this association between circular economy and waste recycling and CO_2 emission at quantile. The data has outliers regardless of the COVID-19 pandemic, European debt crisis, or subprime crisis periods, making quantile models more performant than other techniques. Cho et al. (2015) developed QARDL, a comprehensive approach to Pesaran and Shin (1998). This technique permits scrutinizing different independent variables' effects at the dependent variable's upper, medium, and lower quantile levels in the short and long run (Anwar et al., 2021).

The previous literature has paid critical attention to the impact of logistics and different transportation ways and negligible the supply chain term to determine the CO_2 emission (Arvin et al., 2015; Rehman Khan et al., 2018; Alola et al., 2021; Shafique et al., 2021; Santosa et al., 2022). This study uses the supply chain index developed by Benigno et al. (2022) to examine this effect. Further, this study used the energy transition index developed by Hu et al. (2022) for the first time to analyze its impact on environmental degradation. This index is calculated based on clean energy (coal, oil, gas, and nuclear) and traditional energy (wind, geothermal, solar, bio, and hydro). Extensive studies examine renewable and non-renewable energy consumption on carbon emission (Isik et al., 2021; Ibrahim et al., 2022; Mesagan and Olunkwa, 2022). This research is the first study to use these new indices alongside circular economy to explain environmental degradation. Following is the remainder of the paper; Section 2 documents the review analysis, followed by Section 3, which describes methods and materials. Section 4 entails the results and discusses the findings. Lastly, Section 5 concludes the paper.

2. Literature review

In the business world, the concept of "circular economy" is used as a strategy for waste elimination. To achieve "zero waste" companies have sought to close the loops in their supply network in the context of discarded materials. CE not only reduces ecological footprint and offers economic benefits, but also reduces dependence upon long-distance supply chains and scarce resources through increasing community and business resilience. As a cost-effective means of improving corporate resilience and sustainability, the CE has been implemented by progressive business leaders (Ellen MacArthur Foundation, 2017). To minimize the negative effects on the environment, corporate environmental management consists of tactical decisions and operational and strategic activities across all the verticals under the umbrella of the circular economy. Therefore, to avail more benefits of CE, corporate houses are integrating their business strategies with environmental management practices (Cramer, 1998; Resta et al., 2015; Boffelli et al., 2019). CE mainly focuses on channeling materials at each stage of the value chain, energy efficiency, and resource management (Aranda-Uson et al., 2020). It also aims to protect and prevent (e.g., biodiversity conservation and climate change) the environment and reduce the waste of natural resources (Stewart and Niero, 2018). The CE model uses fewer resources to maintain constant consumption and production, and use recycled raw materials, to reduce varied resources (Figge et al., 2018). The CE acts on recovery, reduction, remanufacture, recycling, refurbishing, and reuse (Prieto-Sandoval et al., 2019).

A systems approach is required to operate the circular economy that considers the components of commercial supply chains, i.e., environmental, economic, and social. Fig. 2 shows this system approach in accordance with the business value chain for the disposition and generation of waste. This approach highlights the interdependence of three different and distinct systems; environment, communities, and industries, and follows the triple value framework (Fiksel et al., 2014). Through production processes, resources are moved to create value for markets soon after extraction from the environment, and then wastes are recycled or disposed of. The various stages of the lifecycle are reflected in Fig. 2, including packaging into finished products after extraction, manufacturing, processing, and transport. Further, the final product is distributed to consumer use of products via various market channels, again recycling the residual wastes.

A CE makes a significant change in companies' political and economic systems based on market requirements. Sustainable environmental practices like recycled or renewable materials, energy

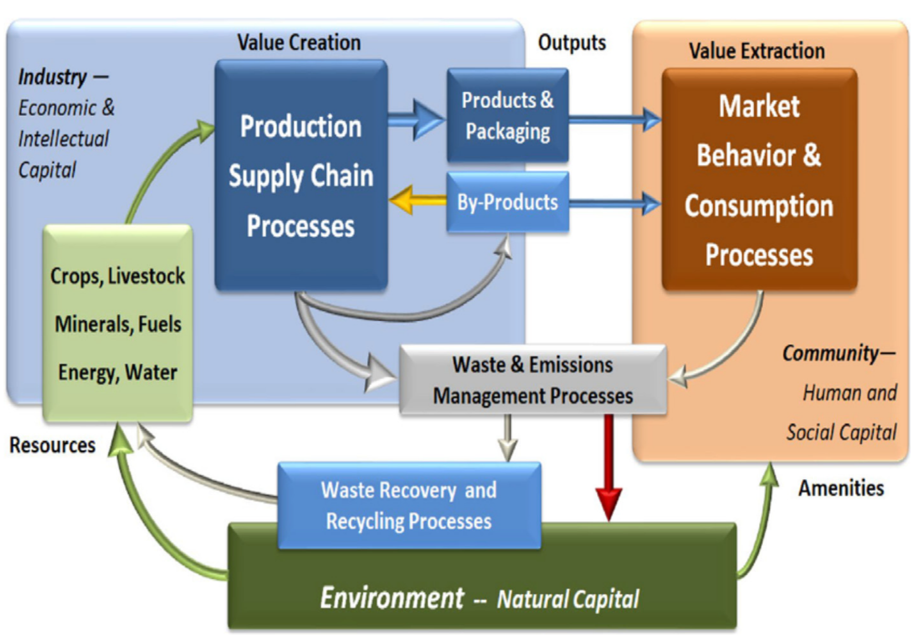

Fig. 2. A systems view of circular economy processes (Fiksel et al., 2021).

efficiency, and waste recovery are strongly related to the circular economy (Lieder and Rashid, 2016; Moreno et al., 2016). Therefore, there is a need to make changes in companies' business models before adopting CE (Pieroni et al., 2019). To achieve sustainable development by using the circular business model, the target of businesses not only get economic benefits but also reduce CO_2 emissions and improve environmental well-being (Chen et al., 2023; Shahzad et al., 2023; Sharif et al., 2023a, 2023b). However, these days organizations are focusing on the effective use of green technology innovations, energy transition, and environmental policy stringency via adopting corporate environmental management policies (Robèrt et al., 2002; Korhonen et al., 2018; Lozano, 2020). In this regard, organizations must focus on environmental innovations and balance social impacts, environment, and competitiveness rather than manage economic benefits (Ormazabal et al., 2018). Thus, corporate environmental management of the circular economy model creates sustainable practices and new opportunities for emerging economies via offering collaborative production, reducing CO_2 emissions, and using waste as resources (Baumgartner, 2018).

Fig. 3 shows the different kinds of opportunities created by the circular economy by 2030 through strategies like value recovery from waste streams, reduction of CO_2 emissions, improved utilization of capital assets and products, energy resources, and reduction of wasted materials. To create high economic value, CE is transforming the existing system of environmental of corporate management from their material life cycles (Bocken et al., 2016). In that sense, CE's environmental and social principles would comply with the resigned products and services of the businesses. Thus, CE supports both inter-organizational and internal sustainable management (Korhonen et al., 2018). Through public incentives and environmental regulations, sustainable CE practices of the organizations at the micro level have been shaped (Ghisellini et al., 2016; Aranda-Uson et al., 2020). Governments' legislative regulations under the circular economy should not only support waste management and recycling but also focus on the supply chain, sorting mechanism, product monitoring, collection, and monitoring (Lazarevic and Valve, 2017; Jia et al., 2020; Ye et al., 2023).

In order to enhance corporate environmental management, energy transition, environmental policy stringency, and supply chain, the governments play a very crucial role. Their legislation, policies, and regulations are much needed for the transition of CE. Further, CE practices could be developed with the help of governmental actions in view of the environment, energy, and economic well-being. During the transition to the CE, consumer behaviour, business practices, and governmental policies faced

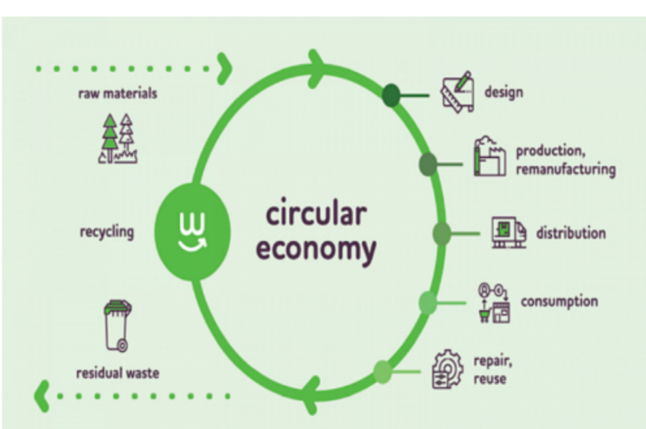

Fig. 3. Value realization potential from circular business models by 2030 (FICCI, 2018).

fundamental changes. Thus, consistent and appropriate strategies and policies must be formulated (van Buren et al., 2016; Manninen et al., 2018). Consensus and collaboration need to have about CE among all the associated stakeholders (Braun et al., 2018). Organizations can easily adopt CE policies by setting environmental regulations (Scupola, 2003). Another, improving public knowledge and awareness about the integration of energy transition, environmental policy stringency, and supply chain with principles of CE is a need of the hour, and the government has an impressive role to play (Mathiyazhagan et al., 2013; van Buren et al., 2016). Therefore, existing legislation systems and environmental regulation should integrate with CE legal arrangements. Following supporting, systems and regulations must cover audit and monitoring guidelines, collaboration platforms, financial initiatives, incentive policies, and technical support within the transparent supply chain (Lewandowski, 2016). Already several research advocated that regional and governments authorities need to play an important role in setting a framework to monitor, promote, and regulate the transition of CE in the context of managing environmental issues such as CO_2 emissions and climate change, etc. (van Buren et al., 2016; Galvão et al., 2018; Jia et al., 2018; Manninen et al., 2018). In this view, this study aims to measure the effect of circular economy, energy transition, environmental policy stringency, and supply chain pressure on CO_2 emissions collectively, which has not been investigated earlier.

3. Methods and material

3.1. Panel quantile ARDL

We employ the panel quantile ARDL to examine the effect of circular economy, energy transition, supply chain pressure, environmental policy, and industry sector on CO_2 growth. The model developed by Sim and Zhou (2015) and used in the recent stream literature to assess the effect of the quantile dependent variable on the quantile explanatory variable under different market conditions (bearish, normal, and bullish) (Adebayo et al., 2022; Mo et al., 2022; Su et al., 2022). It was much more feasible and performant to capture the outcome in the short and long run. The panel quantile ARDL model is appropriate with a time of more than 20 and the presence of cointegration and mixed (Arshed et al., 2022). Panel Quantile ARDL is preferably used when data is mixed between level (0) and level (1), and data has outliers. The mathematical equation of Panel QARDL is estimated as follows:

$$\begin{aligned}\Delta CO_{2it} = {} & \alpha + \beta_1 \Delta MWGR^{\theta}{}_{it} + \beta_2 \Delta GSCPI^{\theta}{}_{it} + \beta_3 \Delta ETI^{2,\theta}{}_{it} \\ & + \beta_4 \Delta EPSI^{\theta}{}_{it} + \beta_5 \Delta Industry^{\theta}{}_{it} + \beta_6 MWGR^{\theta}{}_{it} \\ & + \beta_7 GSCPI^{2\theta}{}_{it} + \beta_8 ETI^{\theta}{}_{it} + \beta_9 EPSI^{\theta}{}_{it} + \beta_{10} Industry^{\theta}{}_{it} + \varepsilon_t{}^{\theta}\end{aligned} \tag{1}$$

where CO_2 depicts the carbon emissions growth, MWGR is the recycling of the municipal waste generation, GSCPI represents the supply chain disruption index, ETI represents the energy transition index, EPSI is the policy stringency index, and the last variable is the industry as a percentage. β_1, β_2, β_3, β_4, and β_5 are the coefficients in the short run, whereas β_5, β_6, β_7, β_8, β_9, and β_{10} are the coefficients in the long run while θ is the quantile level. Finally, ε_t^{θ} represent the quantile error correction term correcting of speed adjustment error term.

3.2. PMG ARDL model

This study also employs the panel approach (Shin et al., 2014) to check the robustness. This technique is appropriate for the large T panel, homogeneity slope, and mixed stationarity (0 and 1). It is also suitable because it is much more feasible and performant in the long and short-run estimation.

4. Results and discussion

4.1. Data

This study examines the effect of circular economy, energy transition, supply chain pressure, environmental policy, and industry sector on CO_2 emission growth. The period estimation started in 1997 and spans from 2020 for a panel of annual data in high GDP countries, namely the Euro area, China, South Korea, Japan, the UK, and the USA. To benchmark circular economy and based on the streaming literature, we select municipal waste generation was recycling (MWGR) per million tonnes unit (Sun et al., 2018; Moraga et al., 2019; Singh et al., 2020; De Pascale et al., 2021; Shahzad et al., 2022). The source of this data was downloaded from organization for Economic Cooperation and Development (OECD). The second data includes renewable CO_2 emissions growth per percentage, collected from the popular link Our World in Data. CO_2 emissions have become faster since the second half of the 1990s, especially in the top CO_2 high intense countries represented in or estimation (Mirziyoyeva and Salahodjaev, 2022; Yirong, 2022). Botta and Koźluk (2014) developed Environment Policy stringency Index (EPSI) as the essential way in environmental transparency and governance. It is drawn to capture 13 instruments applied (tax, tariffs, expenditures for the research and development related to ecological, technology support, certificates) to curtain GHG emissions and retrieved from the OCED database (Wang et al., 2020; Yirong, 2022). Policy stringency index ranges between 0 and 6 scales, with a high score indicating strong regulation and commitment to policy in favor of the environment and vice versa. Furthermore, our study also uses two new indices to capture supply chain pressures and energy transition. The first is the global supply chain pressure index (GSCPI) which regroups 27 indicators, including logistics, Harper index, Baltic maritime index, transportation, container shipping costs, and Purchase Manager Index (PMI) surveys. It was downloaded from the Federal Reserve Bank of New York. The second refers to the energy transition from dirtier to renewable energy. It's calculated by Hu et al. (2022) based on the critic (Neofytou et al., 2020) from the energy transition index (ETI) for the world economy forum (Singh et al., 2019). The data and formula are available in the journal website (Hu et al., 2022).

To investigate the industry-environmental nexus, we selected share industry as a percent of GDP was collected from the World Development Indicators. Many kinds of literature confirm that industrialization is the primary determinant of CO_2 emissions (Ullah et al., 2020; Mongo et al., 2021).

4.2. Summary statistics

Tables 1 and 2 present the summary statistics of the panel and individual variables, respectively. The mean of carbon emission growth is negative to the panel data and close to zero, indicating that CO_2 emission decreased during the period estimations. These results confirmed the individual data except in South Korea, where the CO_2 emission increased by about 2.31%. Korea's minimum and maximum CO_2 emissions remain high at 10 and −15. The minimum is observed during the Asian crisis during 1997–1998, while the maximum is evidently after the subprime crisis. UK, USA, and Japan set the record decrease in CO_2 emissions during the COVID-19 pandemic. The Euro area sets the high record for European sovereign debt.

The policy stringency index for panel data is less than 2. This score computes above the average, indicating all countries' commitment to environmental sustainability. The Euro area ranks as the first nation with the strictest environmental policies, followed by Japan and South Korea. UK and USA are relative laggards compared to other countries' estimates. On average, EPSI increased across all counties over time. The energy transition index indicates that the transition from clean energy will show remarkably in South Korea and UK, and the Euro area, while the USA relatively moves less toward efficient, clean energy and abandon the dirty energy class. The share industry as a percent of GDP converges between the countries (25%) for the panel and country-specific data during the period estimation. As shown in Table 2, the USA and the Euro area generate high recycling, 53 and 44 million tonnes at the mean respectively compared to less recycling generated by the rest countries (less than 10 million tonnes).

Additionally, we observe the high supply chain disruption index during the COVID-19 pandemic and subprime crisis, respectively. By country, we keep that Japan is less volatile in standard deviation supply chain disruption. According to Table 1, the Jarque-Bera test and normality for all the panel variables are significant, meaning the panel data are not a normal distribution.

4.3. Unit root test

Table 3 presents the unit tests root for the panel. We consider two types of panel unit root tests. The first type is applied with a common process using the Levin-Lin-Chu test (Levin et al., 2002). The second type uses (Maddala and Wu, 1999; Im et al., 2003) to examine unit roots with the individual process. Our results are drawn from mixed stationarity tests at the level and the first difference. The supply chain, carbon emission, energy transition, and industry variables establish the alternative unit root hypothesis with common and individual processes and indicate the stationarity case for these variables. The individual and common unit root

Table 1
Descriptive statistics for panel variables.

	CO_2_GR	EP	ET	Industry	SCH	MWGI
Mean	−0.057097	1.944957	0.228079	25.51694	−0.129383	25.15978
Median	0.700000	1.824781	0.205536	23.84526	−0.094638	10.30400
Maximum	10.45000	3.520833	1.166215	35.39647	1.347466	61.28900
Minimum	−14.99000	0.500000	0.045674	18.16519	−3.929505	2.265000
Std. Dev.	3.849590	0.865448	0.173785	5.512437	0.602850	21.61052
Skewness	−0.696250	0.179781	3.080674	0.469321	−2.517621	0.514093
Kurtosis	5.120523	1.896816	15.15692	1.791242	18.55981	1.458483
Jarque-Bera	24.93823	5.216910	719.7921	9.075821	1036.413	13.30458
Probability	0.000004	0.073648	0.000000	0.010696	0.000000	0.001291
Sum	−5.310000	180.8810	21.21135	2373.075	−12.03260	2339.860
Sum Sq. Dev.	1363.380	68.90803	2.778514	2795.600	33.43535	42,965.33
Observations	93	93	93	93	93	93

Table 2
Descriptive statistics for individual data.

Variable	Statistics	Euro area	USA	JPN	UK	South Korea
CO_2_GR	Mean	−0.432632	−0.191053	−0.073158	−1.656842	2.318235
	Maximum	4.950000	3.610000	4.440000	3.850000	10.45000
	Minimum	−7.980000	−7.370000	−5.610000	−9.290000	−14.99000
	Std. Dev.	3.021883	2.797332	3.128397	3.807433	5.439943
EPSI	Mean	2.316323	1.937281	2.037939	1.251097	2.210049
	Maximum	3.450000	3.166667	3.500000	2.208333	3.520833
	Minimum	1.198465	1.050000	1.333333	0.500000	0.750000
	Std. Dev.	0.759255	0.764406	0.712155	0.618659	1.085929
ETI	Mean	0.218422	0.146901	0.197802	0.239983	0.350136
	Maximum	0.314674	0.267327	1.001740	0.474622	1.166215
	Minimum	0.133769	0.045674	0.051326	0.086015	0.094463
	Std. Dev.	0.050582	0.062201	0.216105	0.097105	0.279744
Industry	Mean	23.68368	20.73387	29.63780	20.37157	34.05668
	Maximum	25.78619	23.13210	33.92870	23.79032	35.39647
	Minimum	21.84346	18.58713	26.56264	18.16519	32.51022
	Std. Dev.	1.328781	1.394650	2.308870	1.779721	0.861473
GSCPI	Mean	−0.089677	−0.079140	−0.051259	−0.147429	−0.297059
	Maximum	1.347466	1.043740	0.268549	0.674771	0.606790
	Minimum	−1.201787	−1.134727	−0.260412	−0.768655	−3.929505
	Std. Dev.	0.559994	0.642880	0.150078	0.409030	1.007981
MWGR	Mean	46.47549	53.77074	8.797789	6.064603	8.987986
	Maximum	60.45087	61.28900	10.30400	8.557788	11.11200
	Minimum	29.49170	43.47200	5.860000	2.265000	5.076060
	Std. Dev.	9.182672	5.819004	1.219483	2.345701	2.028448

Table 3
Panel unit root test results.

Unit root with common process	SCH	CE	ET	EP	CO_2	Industry
Levin-Lin-Chu	−3.71050 (a)*	−2.33944 (b)*	−9.582569. (b)*	−4.63158 (b)*	−1.53729 (a)***	−2.82576(a)*
Individual unit root process						
Im, Pesaran and Shin W-stat	−5.91212(a)*	−2.67187 (b)*	−2.22916 (a)*	−4.10867 (b)*	−3.82264* (a)	−1.68546 (a)**
ADF – Fisher Chi-square	52.2028 (a)*	28.0277 (b)*	20.0179 (a)*	35.7734(b)*	36.6088* (a)	17.3719 (a)***
PP – Fisher Chi-square	308.670 (a)*	28.4938 (b)*	52.5359 (a)	71.0450 (b)*	59.5484* (a)	18.0306 (a)***

Note: ***, **, and * denote 10, 5, and 1 statistical significance levels, respectively. a and b are stationarity at the level, and the first difference, respectively.

process show that municipal waste generation recycling and environmental policy stringency contains a unit root and confirm integration at the first difference. In addition, mixed stationarity with larger T (1997–2020) compared to the small N (5 nation) favorite the appropriate panel ARDL models.

4.4. Cointegration test

Table 4 documents the results of the cointegration test. In this section, we use Kao's (1999) test, Westerlund's (2007) test, and Pedroni's (1999, 2004) test. All cointegration types indicate a significant relationship in the long run among the variables accepting the alternative hypothesis. Recycling of municipal waste, environmental policy stringency, energy transition, industry, and supply chain are associated with carbon emission growth in the long run.

Table 4
Cointegration results.

	Statistic	p-value
Modified Dickey-Fuller t (Kao test)	10.15*	0.0000
Dickey-Fuller t (Kao test)	−11.77*	0.0000
Augmented Dickey-Fuller t (Kao test)	−5.83 *	0.0000
Variance ratio (Westerlund test)	1.36 ***	0.0854
Phillips–Perron t (Pedroni test)	−7.45*	0.0000
Homogenous test		

Note: ***, **, and * denote 10, 5, and 1 statistical significance levels, respectively. a and b are stationarity at the level, and the first difference, respectively.

4.5. The panel quantile ARDL results

Table 5 presents the panel quantile ARDL model for the impact of environmental policy stringency**,** circular economy, energy transition, industry sector, and supply chain pressure on CO_2 emission growth in developed (Euro area, Japan, UK, USA) and emerging markets (South Korea). The process estimation checks for both the short-run and the long-run. The results explore that manicupal waste generation recycling affects significantly in the short-run and the long-run on the carbon emissions at all quantiles. Still, the mean and upper quantile influence is more important than the lower quantile. At low quantiles, the impact of one million MWGI processed leads to a decrease in the emission growth of carbon by −0.71% and −0.41% from low quantiles (10th and 30th), while the effect exceeds 1.2% at upper 90th quantile for the short run.

Similarly, in the long run, the impact of MWGI is neutral at a lower quantile. At the same time, it increases at the mean and upper quantile about −2% and −1.61%, respectively, indicating that adopting a circular economy is a more significant benefit to cutting

Table 5
Panel quantile ARDL.

	Short run					
Quantile	**ET**	**SCH**	**EP**	**Industry**	**CE**	**ECT_{t-1}**
0.100	11.59777 (1.205102)*	−0.1389223 (0.1392685)	−5.840183(0.5054973) *	1.85912(0.0880691) *	−0.717448 (0. 0.3764705)*	−1.229286*
0.300	9.08666(0.0500775) *	0.3332807(0.0079045) *	−2.696321(0.0123615) *	2.646664(0.0073238) *	-0.4063862 (0.0937992)*	−1.06485*
0.500	8.924913(0.2380709) *	0.5529689(0.0607165) *	−1.419168(0. 1284621) *	0.966297(0.0880691) *	−0.1223446(0.06976) *	−1, 18,873 *
0.700	10.62031(0.0824203) *	1.422958(0.0524879) *	−3.532025 (0 0.0488421)*	0.4286254(0. 130449) *	−0.3739264(0.0193129) *	−0,1023*
0.900	10.00631(0.070999) *	1.816239(0.0430953) *	−2.642411(0.0348664) *	0.0132998 (0. 0.051949)	−1.241205(0.2203143) *	−0.1095*
	Long run					
	ET	**SCH**	**EP**	**Industry**	**MWR**	
0.100	17.17232 (2.282273)*	0 0.7537165 (0.7055397)	−3.109495 (0. 0.4030487)	0.6780892 (0.0420638.) *	−0.0164445(0.5641831) *	
0.300	9.849014 (0 0.042944)*	1.140495 (0 0.0103257)*	−2.607861(0.0067182) *	0.3415603(0.0015492) *	−1.852704(0.3837946) *	
0.500	8.509285(0.7259033) *	1.093642(0.1188516) *	−2.212935(0.1059011) *	0.3844499(0.0140027) *	−2.079364(0.1532924) *	
0.700	12.31091 (0 0.079339)*	0.8108762(0.0390497) *	−2.738403(0.0178374) *	0.4506551 (0.0056467)*	−1.36121(0.0119058) *	
0.900	13.41716 (1.572322)*	1.793789 (0.0683989)*	−2.620999 (0.0412438)*	0. 5,241,753(0. 0043579) *	−1.621339 (0.0643085)	

environmental degradation. These results align with prior studies (Sun et al., 2018; Abad-Segura et al., 2020; Bayar et al., 2021; Magazzino and Falcone, 2022) that indicate that waste treatment help to reduce and save CO_2 emissions.

Referring to the energy transition variable, the strong effect on CO_2 emission growth was revealed to be significant for both the short and long run and at all quantile levels. One score or 10% increase of the energy transition index leads to a rise in CO_2 growth by 1.1% and 1.7% at lower quantiles for the short and long run, respectively. Likewise, the effect is relatively decreased for the mean and upper quantile. This finding can be explained by still high remains for fossil fuels demand. Despite investments in renewable energy, fossil fuels still represent the majority of energy source investments. Transportation, manufacturing, and other sectors still heavily depend on fossil fuel resources, which consume more than 65% of CO_2 emissions from traditional energy (Lacal Arantegui and Jäger-Waldau, 2018). Notably, the energy transition increased over time. The flat trend over the past two decades will continue to rise during the last years, mainly driven by to decline in CO_2 emissions during and post-COVID-19 (Sakah et al., 2017; Li et al., 2022a, 2022b; Tian et al., 2022).

Moving to the policy stringency index, the effect on CO_2 emissions growth at extreme quantile is significant and more important than the effect at the mean. For the short run, A rise by one score of the policy stringency index leads to a decline by 5.8% of carbon emission growth at 10th quantile, then decreasing at −1.4% at the mean, then increasing again at −2.6%. Meanwhile, the effect of one PESI leads to a decline the CO_2 growth by −3.1% and 2.6% for the lower and upper quantile, respectively.

Policy action in the countries estimating massive exhibit input to reduce pollution effect and its shows helpful to measure stringency commitment adopted by these countries. This result is consistent with prior literature (Sadik-Zada and Ferrari, 2020; Afshan et al., 2022; Li et al., 2022a, 2022b; Wang et al., 2022; Yirong, 2022).

We also observe that the impact of the share industry as a percent of economic growth on carbon emissions, in the long run, is significantly positive at low, intermediate, and upper quantiles. The effect in the short run seems more critical than in the long run. These results support the finding that industrialization's impact leads to increased CO_2 emissions (Nondo and Kahsai, 2020; Zafar et al., 2020; Huang et al., 2021).

It noted that GSCPI significantly affects carbon emission growth except at the lower quantile (0.1) for the short and long run. The positive effect indicates substantial evidence of environmental degradation and supply chain index association. One standard deviation of the supply chain disruption leads CO_2 growth to rise about 1.14% and 1.73% at extreme quantile for the short and long rung, respectively. These results explained whether the supply chain enhances economic growth and trade directly through logistics and transportation, which would indirectly increase the emissions of CO_2 indirectly (Karaduman et al., 2020; Alola et al., 2021; Sohail et al., 2021). Finally, the adjustment coefficient (ECM) speed seems negative and significant, indicating that the model corrects itself to equilibrium at the mean by 1.18%. Similarly, lower and upper quantiles show the converge towered more deeply in the bullish and bearish macroeconomic conditions.

4.6. Results of PMG panel model

In this section, we check the results of the panel quantile ARDL using the PMG ARDL model (see Table 6). The PMG ARDL used widely to robustness check tests in the stream literature (Isiksal and Assi, 2022; Usman et al., 2022). The PMG estimator containers the long-run coefficients to be homogeneous while allowing the short-run heterogeneity coefficients and error correction terms (Pesaran et al., 2008). Next, and before illustrating the PMG PANEL

Table 6
Results from multicollinearity test.

Variable	VIF	1/VIF
CE	1.77	0.564206
EP	1.50	0.668204
Industry	1.46	0.685660
ET	1.45	0.688446
SCH	1.18	0.850713
Mean VIF		1.47

ARDL, we examine the homogeneity and multicollinearity test (Mensah et al., 2019). The results are presented in Tables 4 and 5, respectively. Table 5 shows the confirmed absence of multicollinearity among the variable in which the alternative hypothesis is rejected. Therefore, Table 6 implies that delta and adjusted delta slope homogeneity values are more than 1, which is statistically significant and indicates that the coefficient slope is homogenous across the panel ARDL technique. We confusedly move to PMG PANEL ARDL.

Table 7 presents the results of the effect of circular economy, energy transition, industrialization, climate policy, and supply chain variables on CO_2 emission growth. The findings depict the same results of the quantile panel, especially at the long and short-run mean. The first results implied that EPSI and circular economy negatively affect short- and long-run carbon emissions. Second, the energy transition, industrialization, and supply chain positively influence CO_2 emissions growth. Furthermore, Table 8 and Figs. 4 and 5 show that in both cases short and long run ET (energy transition) has highest significant impact and association with CO_2 emissions positive and negative, respectively.

Table 7
Results from homogeneity test.

Delta	p-value
−1.006	0.314
adj. −1.291	0.197

Table 8
Results from PMG test.

Variables	Coefficient	t-Statistic	Prob.*
Short Run Est.			
EP	−1.042501	0.530569	0.055
ET	11.03331	2.087580	0.000
SCH	0.528890	0.220558	0.020
Industry	0.675347	0.303864	0.026
CE	−0.192671	−1.523311	0.134
Long Run Est.			
ECT_{t-1}	−1.367177	−7.401746	0.000
D(EP)	−1.485682	−3.443664	0.001
D(ET)	−5.846693	−2.088739	0.042
D(SCH)	2.831494	4.511221	0.000
D(Industry)	2.444538	3.039164	0.003
D(CE)	−1.485682	−3.443664	0.001
C	−17.41658	−5.049847	0.000

5. Conclusion and policy implications

This paper investigates the effect of a circular economy on CO_2 emissions growth from 1997 to 2020 using panel quantile Autoregressive Distributed Lags (QARDL) and the panel PMG (PMG). We also examine the effect of the energy transition, climate policy stringency, industrialization, and supply chain pressure on CO_2 emissions. We find the mixed stationary test at the level and the first one. We further report the cointegration association in the long run between carbon emissions and its determinants. The adjustment coefficient (ECM) speed seems negative and significant, indicating that the model quickly corrects itself to equilibrium at the mean is more than one. The circular economy and climate policy stringency significantly negatively impact carbon emissions. At the same time, the energy transition, industrialization, and supply chain pressures positively affect CO_2 emissions in the short and long run. The finding further explores that municipal waste generation recycling is considerable at the mean and upper 90th quantiles than the lower quantile.

As it has been documented from the empirical analysis that circular economy and environmental policy stringency have negative impacts on carbon emissions, therefore emerging economies and markets are directed to ensure maximum use of circular economy, greener energies, environmental innovations to minimize the CO_2 emissions, and other environmental issues such as climate change and global warming. Furthermore, CE must be designed to be inclusive so that all segments of people, such as stakeholders, poor people, local communities, and underrepresented segments of society, actively participate in management decisions. Additionally, social capital and stewardship of natural capital, like community solidarity and ecological resources, will help in CO_2 and waste reduction and benefits the business partners and stakeholders to earn respect and appreciation for the good cause. In line with achieving sustainable development goals, waste sources (municipal, agricultural and industrial) can advance progress via judicious management. In particular, goal 12–responsible consumption and

Fig. 4. Short run coefficient of different designed variables.

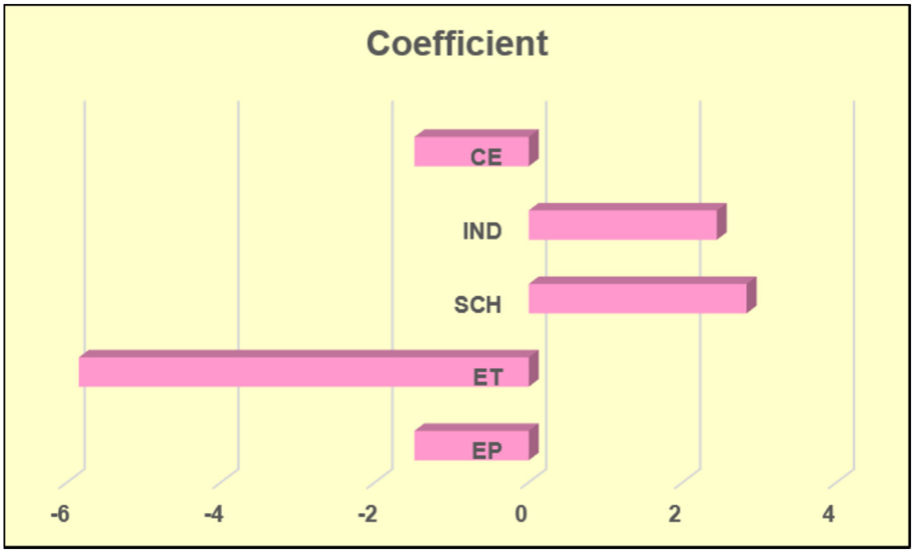

Fig. 5. Long run coefficient of different designed variables.

production, and goal 3–good health and well-being are directly related to core principles of the circular economy; therefore, the reduction of CO_2 emissions and deaths due to environmental pollution must be ensured through adopting the practices of CE, and environmental policy stringency.

On the other hand, energy transition, industrialization, and supply chain pressures positively affect CO_2 emissions in the short and long run. This finding supports the studies of Kok et al. (2013), Dhull and Narwal (2016), and Leendertse (2016). Since supply chain pressures, industrialization, and energy transition provide a suitable situation for environmental degradation, CO_2 emissions, and climate change. Thus, circular economy, green technology innovations, and environmental policy stringency have the potential to counterbalance CO_2 emissions and other environmental issues in both the short and long run. For the more impactful implications of policies and stringent for sustainability, legislation is gaining an important role in adopting the CE principles and strategies within corporate environmental management. Along with other stipulated barriers, the lack of proper legislation for efficient CE could be more disgraceful because it does not maintain ecological balance. This is parallel related to Mangla et al. (2018), Govindan and Hasanagic (2018), and Masi et al. (2018) findings. They highlighted insufficient environmental regulations and laws as prominent reasons for barriers to the transition of a CE. Hence, a collective CE framework should be there, wherein energy transition, policy stringency, and supply chain would work in a balancing manner for the well-being of the environment and sustainable development. In addition, generation of waste remains the serious matter of concern and numbers are surprising (see Fig. 6). As per World Bank data, 2.01 billion tonnes municipal solid waste generated by world annually. Out of that, around 33% is not managing properly and become the leading cause environmental problems like CO_2 emissions.

In terms of future research outlook, we will examine the effect on large countries for future research and update the prior estimation. Moreover, it would evaluate the impact of the COVID-19 pandemic and the Russia-Ukraine conflict. The present study work is limited to investigating the effects of circular economy, energy transition, environmental policy stringency, and supply chain pressure on CO_2 emission, which directs future research to conduct

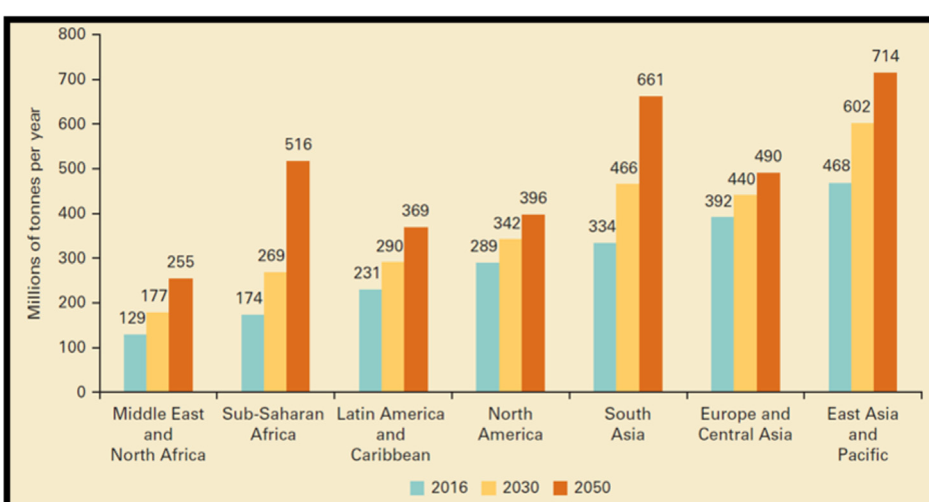

Fig. 6. Projected waste generation by region (World Bank).

similar studies in poor and high economies. Furthermore, studying the total waste by sectors (construction, food, energy, households, manufacturing) on GHG emissions is more helpful.

CRediT authorship contribution statement

Sunil Tiwari: Conceptualization, Formal analysis, Data curation. **Kamel Si Mohammed:** Methodology, Project administration. **Grzegorz Mentel:** Writing – review & editing, Writing – original draft. **Sebastian Majewski:** Investigation, Software, Resources. **Irum Shahzadi:** Validation, Visualization, Supervision.

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.

References

Abad-Segura, E., Fuente, A.B.D.L., González-Zamar, M.D., Belmonte-Ureña, L.J., 2020. Effects of circular economy policies on the environment and sustainable growth: Worldwide research. Sustainability 12 (14), 5792.

Abbey, J.D., Guide Jr, V.D.R., 2018. A typology of remanufacturing in closed-loop supply chains. Int. J. Prod. Res. 56 (1–2), 374–384.

Adebayo, T.S., Rjoub, H., Akinsola, G.D., Oladipupo, S.D., 2022. The asymmetric effects of renewable energy consumption and trade openness on carbon emissions in Sweden: new evidence from quantile-on-quantile regression approach. Environ. Sci. Pollut. Res. 29 (2), 1875–1886. https://doi.org/10.1007/s11356-021-15706-4.

Afshan, S., Ozturk, I., Yaqoob, T., 2022. Facilitating renewable energy transition, ecological innovations and stringent environmental policies to improve ecological sustainability: Evidence from MM-QR method. Renew. Energ. 196, 151–160. https://doi.org/10.1016/j.renene.2022.06.125.

Agnello, X., Naveen, J., Ravichandran, M., Balamurugan, J., 2015. Clean technology and its efficacy: strategies of environmental management. J. Environ. Soc. Sci. 2 (2), 1–10.

Alola, A.A., Lasisi, T.T., Eluwole, K.K., Alola, U.V., 2021. Pollutant emission effect of tourism, real income, energy utilization, and urbanization in OECD countries: a panel quantile approach. Environ. Sci. Pollut. Res. 28, 1752–1761.

Anwar, A., Sharif, A., Fatima, S., Ahmad, P., Sinha, A., Rehman Khan, S.A., Jermsittiparsert, K., 2021. The asymmetric effect of public private partnership investment on transport CO2 emission in China: Evidence from quantile ARDL approach. J. Clean. Prod. 288. https://doi.org/10.1016/j.jclepro.2020.125282.

Aranda-Uson, A., Portillo-Tarragona, P., Scarpellini, S., Llena-Macarulla, F., 2020. The progressive adoption of a circular economy by businesses for cleaner production: An approach from a regional study in Spain. J. Clean. Prod. 247,. https://doi.org/10.1016/j.jclepro.2019.119648 119648.

Arshed, N., Nasir, S., Saeed, M.I., 2022. Impact of the external debt on standard of living: A case of Asian countries. Soc. Indic. Res. 0123456789. https://doi.org/10.1007/s11205-022-02906-9.

Arvin, M.B., Pradhan, R.P., Norman, N.R., 2015. Transportation intensity, urbanization, economic growth, and CO_2 emissions in the G-20 countries. Util. Policy 35, 50–66. https://doi.org/10.1016/j.jup.2015.07.003.

Atasu, A., Guide Jr, V.D.R., Van Wassenhove, L.N., 2010. So what if remanufacturing cannibalizes my new product sales? Calif. Manage. Rev. 52 (2), 56–76.

Bastein, T., Roelofs, E., Rietveld, E., Hoogendoorn, A., 2013. Opportunities for a Circular Economy in the Netherlands. Delft, TNO.

Battini, D., Bogataj, M., Choudhary, A., 2017. Closed loop supply chain (CLSC): Economics, modelling, management and control. Int. J. Prod. Econ. 183, 319–321.

Baumgartner, R.J., 2018. Circular economy: Sustainability implications and corporate management challenges. https://dev.cec4europe.eu/wp-content/uploads/2022/01/Chapter-4.6._Baumgartner_Circular-Economy-Sustainability-Implications-and-corporate-management-challenges.pdf.

Bayar, Y., Gavriletea, M.D., Sauer, S., Paun, D., 2021. Impact of municipal waste recycling and renewable energy consumption on CO_2 emissions across the European Union (EU) member countries. Sustainability 13 (2), 1–12. https://doi.org/10.3390/su13020656.

Benigno, G., Giovanni, J. Di, Groen, Ja., Noble, A., 2022. Global Supply Chain Pressure Index: March 2022 Update. Federal Reserve Bank of New York Liberty Street Economics.

Bocken, N.M., De Pauw, I., Bakker, C., van der Grinten, B., 2016. Product design and business model strategies for a circular economy. J. Ind. Prod. Eng. 33 (5), 308–320.

Boffelli, A., Dotti, S., Gaiardelli, P., Carissimi, G., Resta, B., 2019. Corporate environmental management for the textile industry: Toward an empirical typology. Sustainability 11 (23), 6688–6712.

Botta, E., Koźluk, T., 2014. Measuring Environmental Policy Stringency in OECD Countries. OECD Economics Department Working Papers No. 1177, 47.

Boulding, K.E., 1966. The economics of knowledge and the knowledge of economics. Am. Econ. Rev. 56 (1/2), 1–13.

Braun, A.T., Kleine-Möllhoff, P., Reichenberger, V., Seiter, S., 2018. Survey concerning enablers for material efficiency activities in manufacturing, their supply chains and the transformation towards circular economy. Reutlinger Diskussionsbeiträge zu Marketing & Management. No. 2018-3.

Chen, F., Tiwari, S., Mohammed, K.S., Huo, W., Jamróz, P., 2023. Minerals resource rent responses to economic performance, greener energy, and environmental policy in China: Combination of ML and ANN outputs. Resour. Policy 81, 103307.

Cho, J.S., Kim, T.H., Shin, Y., 2015. Quantile cointegration in the autoregressive distributed-lag modeling framework. J. Econometrics 188 (1), 281–300.

Cramer, J., 1998. Environmental management: From "fit" to "stretch". Bus. Strategy Environ. 7, 162–172.

De Pascale, A., Arbolino, R., Szopik-Depczyńska, K., Limosani, M., Ioppolo, G., 2021. A systematic review for measuring circular economy: The 61 indicators. J. Clean. Prod. 281,. https://doi.org/10.1016/j.jclepro.2020.124942 124942.

de Riquetti, V., Quesnay, F., 1758. "L'" ami des hommes, ou traité de la population (Vol. 3). Chez Chrétien Herold.

Dhull, S., Narwal, M., 2016. Drivers and barriers in green supply chain management adaptation: A state-of-art review. Uncertain Supply Chain Manag. 4 (1), 61–76.

Dzhengiz, T., 2020. A literature review of inter-organizational sustainability learning. Sustainability 12, 4876.

Ellen MacArthur Foundation, 2017. What is a circular economy? https://www.ellen macar thurf ounda tion.org/circu lar-econo my (accessed 23 Dec 2017).

Eurostat, 2021. Waste statistics. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics.

FICCI, Accenture Strategy, 2018. Accelerating India's circular economy shift: A half-trillion USD opportunity future-proofing growth in a resource-scarce world. FICCI Circular Economy Symposium 2018. https://www.ficcices.in/pdf/FICCI-Accenture_Circular%20Economy%20Report_OptVer.pdf.

Figge, F., Thorpe, A.S., Givry, P., Canning, L., Franklin-Johnson, E., 2018. Longevity and circularity as indicators of eco-efficient resource use in the circular economy. Ecol. Econ. 150, 297–306.

Fiksel, J., Bruins, R., Gatchett, A., Gilliland, A., ten Brink, M., 2014. The triple value model: a systems approach to sustainable solutions. Clean Technol. Environ. Policy 16 (4), 691–702.

Fiksel, J., Sanjay, P., Raman, K., 2021. Steps toward a resilient circular economy in India. Clean Technol. Environ. Policy 23, 203–218.

Gallego-Schmid, A., Chen, H.M., Sharmina, M., Mendoza, J.M.F., 2020. Links between circular economy and climate change mitigation in the built environment. J. Clean. Prod. 260. https://doi.org/10.1016/j.jclepro.2020.121115.

Galvão, G.D.A., de Nadae, J., Clemente, D.H., Chinen, G., de Carvalho, M.M., 2018. Circular economy: Overview of barriers. Procedia CIRP 73, 79–85.

Genovese, A., Pansera, M., 2020. The circular economy at a crossroads: Technocratic ecomodernism or convivial technology for social revolution? Capital. Nat. Soc. 32, 95–113.

Genovese, A., Acquaye, A.A., Figueroa, A., Koh, S.L., 2017. Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications. Omega 66, 344–357.

Ghisellini, P., Cialani, C., Ulgiati, S., 2016. A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. J. Clean. Prod. 114, 11–32.

Goltsos, T.E., Ponte, B., Wang, S., Liu, Y., Naim, M.M., Syntetos, A.A., 2018. The boomerang returns? Accounting for the impact of uncertainties on the dynamics of remanufacturing systems. Int. J. Prod. Res., 1–34

Govindan, K., Hasanagic, M., 2018. A systematic review on drivers, barriers, and practices towards circular economy: A supply chain perspective. Int. J. Prod. Res. 56 (1–2), 278–311.

Guide Jr, V.D.R., Van Wassenhove, L.N., 2009. The evolution of closed-loop supply chain research. Oper. Res. 57 (1), 10–18.

Hu, K., Sinha, A., Tan, Z., Ibrahim, M., Abbas, S., 2022. Achieving energy transition in OECD economies : Discovering the moderating roles of environmental governance. Renew. Sust. Energ. Rev. 168,. https://doi.org/10.1016/j.rser.2022.112808 112808.

Huang, J., Li, X., Wang, Y., Lei, H., 2021. The effect of energy patents on China's carbon emissions: Evidence from the STIRPAT model. Technol. Forecast. Soc. Change 173,. https://doi.org/10.1016/j.techfore.2021.121110 121110.

Ibrahim, M., Foglia, M., Shahzad, U., Fareed, Z., 2022. Green innovation, resource price and carbon emissions during the COVID-19 times: New findings from wavelet local multiple correlation analysis. Technol. Forecast. Soc. Change 184,. https://doi.org/10.1016/j.techfore.2022.121957 121957.

Im, K.S., Pesaran, M.H., Shin, Y., 2003. Testing for unit roots in heterogeneous panels. J. Econometrics 115 (1), 53–74. https://doi.org/10.1016/S0304-4076(03)00092-7.

Isik, M., Ari, I., Sarica, K., 2021. Challenges in the CO_2 emissions of the Turkish power sector: Evidence from a two-level decomposition approach. Utilities Policy 70,. https://doi.org/10.1016/j.jup.2021.101227 101227.

Isiksal, A.Z., Assi, A.F., 2022. Determinants of sustainable energy demand in the European economic area: Evidence from the PMG-ARDL model. Technol. Forecast. Soc. Change 183,. https://doi.org/10.1016/j.techfore.2022.121901 121901.

Jia, Z., Tiwari, S., Zhou, J., Farooq, M.U., Fareed, Z., 2023. Asymmetric nexus between Bitcoin, gold resources and stock market returns: Novel findings from quantile estimates. Resour. Policy 81, 103405.

Jia, F., Zuluaga-Cardona, L., Bailey, A., Rueda, X., 2018. Sustainable supply chain management in developing countries: An analysis of the literature. J. Clean. Prod. 189, 263–278.

Jia, F., Yin, S., Chen, L., Chen, X., 2020. Circular economy in textile and apparel industry: A systematic literature review. J. Clean. Prod. 259,. https://doi.org/10.1016/j.jclepro. 2020.120728 120728.

Kao, C., 1999. Spurious regression and residual-based tests for cointegration in panel data. J. Econometrics 90 (1), 1–44. https://doi.org/10.1016/S0304-4076(98)00023-2.

Karaduman, H.A., Karaman-Akgül, A., Çağlar, M., Akbaş, H.E., 2020. The relationship between logistics performance and carbon emissions: an empirical investigation on Balkan countries. Int. J. Clim. Chang. Strateg. Manag. 12 (4), 449–461. https://doi.org/10.1108/IJCCSM-05-2020-0041.

Kaza, S., Yao, L., Bhada-Tata, P., Van Woerden, F., 2018. What a waste 2.0: A Global Snapshot of Solid Waste Management to 2050. World Bank Publications.

Kok, L., Wurpel, G., Ten Wolde, A., 2013. Unleashing the Power of the Circular Economy. Circle Economy, Amsterdam, Netherland.

Korhonen, J., Nuur, C., Feldmann, A., Birkie, S.E., 2018. Circular economy as an essentially contested concept. J. Clean. Prod. 175, 544–552.

Lacal Arantegui, R., Jäger-Waldau, A., 2018. Photovoltaics and wind status in the European Union after the Paris Agreement. Renew. Sust. Energ. Rev. 81, 2460–2471. https://doi.org/10.1016/j.rser.2017.06.052.

Lazarevic, D., Valve, H., 2017. Narrating expectations for the circular economy: Towards a common and contested European transition. Energy Res. Soc. Sci. 31, 60–69.

Lee, S., Kim, J., Chong, W.O., 2016. The causes of the municipal solid waste and the greenhouse gas emissions from the waste sector in the United States. Procedia Engineering 145, 1074–1079. https://doi.org/10.1016/j.proeng.2016.04.139.

Leendertse, P.W., 2016. The transition from a linear to circular economy: an innovation system analysis of the composites industry. M.S. thesis, Utrecht University.

Levin, A., Lin, C.F., Chu, C.S.J., 2002. Unit root tests in panel data: Asymptotic and finite-sample properties. J. Econom. 108 (1), 1–24. https://doi.org/10.1016/S0304-4076(01)00098-7.

Lewandowski, M., 2016. Designing the business models for circular economy—Towards the conceptual framework. Sustainability 8 (1), 43–70.

Li, Z., Kuo, Y., Rahman, A., Nassani, A.A., Haffar, M., Muda, I., 2022b. Integration of renewable energy, environmental policy stringency, and climate technologies in realizing environmental sustainability : Evidence from OECD countries. Renew. Energ. 196, 1376–1384. https://doi.org/10.1016/j.renene.2022.07.084.

Li, K., Qi, S., Shi, X., 2022a. The COVID-19 pandemic and energy transitions : Evidence from low-carbon power generation in China. J. Clean. Prod. 368,. https://doi.org/10.1016/j.jclepro.2022.132994 132994.

Lieder, M., Rashid, A., 2016. Towards circular economy implementation: A comprehensive review in context of manufacturing industry. J. Clean. Prod. 115, 36–51.

Lozano, R., 2012. Towards better embedding sustainability into companies' systems: An analysis of voluntary corporate initiatives. J. Clean. Prod. 25, 14–26.

Lozano, R., 2020. Analysing the use of tools, initiatives, and approaches to promote sustainability in corporations. Corp. Soc. Responsib. Environ. Manag. 27 (2), 982–998.

MacArthur, E., 2013. Towards a Circular Economy—Economic and Business Rationale for an Accelerated Transition. Ellen MacArthur Foundation, Cowes, UK.

Maddala, G.S., Wu, S., 1999. A comparative study of unit root tests with panel data and a new simple test. Oxf. Bull. Econ. Stat. 61 (S1), 631–652. https://doi.org/10.1111/1468-0084.0610s1631.

Magazzino, C., Falcone, P.M., 2022. Assessing the relationship among waste generation, wealth, and GHG emissions in Switzerland: Some policy proposals for the optimization of the municipal solid waste in a circular economy perspective. J. Clean. Prod. 351,. https://doi.org/10.1016/j.jclepro.2022.131555 131555.

Mangla, S.K., Luthra, S., Mishra, N., Singh, A., Rana, N.P., Dora, M., Dwivedi, Y., 2018. Barriers to effective circular supply chain management in a developing country context. Prod. Plan. Control 29 (6), 551–569.

Manninen, K., Koskela, S., Antikainen, R., Bocken, N., Dahlbo, H., Aminoff, A., 2018. Do circular economy business models capture intended environmental value propositions? J. Clean. Prod. 171, 413–422.

Marx, K., 1987. Kritische Geschichte. In: F. Engels, ed. Anti-During € . MECW, 25.

Masi, D., Kumar, V., Garza-Reyes, J.A., Godsell, J., 2018. Towards a more circular economy: Exploring the awareness, practices, and barriers from a focal firm perspective. Prod. Plan. Control. 29 (6), 539–550.

Mathiyazhagan, K., Govindan, K., Haq, A.N., Geng, Y., 2013. An ISM approach for the barrier analysis in implementing green supply chain management. J. Clean. Prod. 47, 283–297.

Mensah, I.A., Sun, M., Gao, C., Omari-Sasu, A.Y., Zhu, D., Ampimah, B.C., Quarcoo, A., 2019. Analysis on the nexus of economic growth, fossil fuel energy consumption, CO_2 emissions and oil price in Africa based on a PMG panel ARDL approach. J. Clean. Prod. 228, 161–174. https://doi.org/10.1016/j.jclepro.2019.04.281.

Mesagan, E.P., Olunkwa, C.N., 2022. Heterogeneous analysis of energy consumption, financial development, and pollution in Africa: The relevance of regulatory quality. Utilities Policy 74,. https://doi.org/10.1016/j.jup.2021.101328 101328.

Mirziyoyeva, Z., Salahodjaev, R., 2022. Renewable Energy and CO_2 emissions intensity in the top carbon intense countries. Renew. Energ. 192, 507–512. https://doi.org/10.1016/j.renene.2022.04.137.

Mo, B., Li, Z., Meng, J., 2022. The dynamics of carbon on green energy equity investment: quantile-on-quantile and quantile coherency approaches. Environ. Sci. Pollut. Res. 29 (4), 5912–5922. https://doi.org/10.1007/s11356-021-15647-y.

Mohammed, K.S., Tiwari, S., Ferraz, D., Shahzadi, I., 2022. Assessing the EKC hypothesis by considering the supply chain disruption and greener energy: findings in the lens of sustainable development goals. Environ. Sci. Pollut. Res., 1–13

Mokhtar, A.R.M., Genovese, A., Brint, A., Kumar, N., 2019. Improving reverse supply chain performance: The role of supply chain leadership and governance mechanisms. J. Clean. Prod. 216, 42–55.

Möllemann, D., 2016. Framing the climate change policies and circular economy tenets for SMEs. Bachelor's thesis, University of Twente.

Mongo, M., Laforest, V., Belaïd, F., Tanguy, A., 2021. Assessment of the impact of the circular economy on CO_2 emissions in Europe. Journal of Innovation Economics & Management 39, 15–43. https://doi.org/10.3917/jie.pr1.0107.

Montalvo, C., 2003. Sustainable production and consumption systems—cooperation for change: assessing and simulating the willingness of the firm to adopt/develop cleaner technologies. The case of the in-bond industry in northern Mexico. J. Clean. Prod. 11 (2003), 411–426.

Moraga, G., Huysveld, S., Mathieux, F., Blengini, G.A., Alaerts, L., Van Acker, K., de Meester, S., Dewulf, J., 2019. Circular economy indicators: What do they measure? Resour. Conserv. Recycl. 146, 452–461. https://doi.org/10.1016/j.resconrec.2019.03.045.

Moreno, M., De los Rios, C., Rowe, Z., Charnley, F., 2016. A conceptual framework for circular design. Sustainability 8 (9), 937–951.

Murray, A., Skene, K., Haynes, K., 2017. The circular economy: an interdisciplinary exploration of the concept and application in a global context. J. Bus. Ethics 140, 369–380.

Mutezo, G., Mulopo, J., 2021. A review of Africa's transition from fossil fuels to renewable energy using circular economy principles. Renew. Sust. Energ. Rev. 137,. https://doi.org/10.1016/j.rser.2020.110609 110609.

Neofytou, H., Nikas, A., Doukas, H., 2020. Sustainable energy transition readiness: A multicriteria assessment index. Renew. Sust. Energ. Rev. 131,. https://doi.org/10.1016/j.rser.2020.109988 109988.

Nondo, C., Kahsai, M.S., 2020. The impact of energy intensity, urbanisation, industrialisation, and income on CO_2 emissions in South Africa: an ARDL bounds testing approach. African J. Economic Sustainable Dev. 7 (4), 307. https://doi.org/10.1504/ajesd.2020.106826.

Ormazabal, M., Prieto-Sandoval, V., Puga-Leal, R., Jaca, C., 2018. Circular economy in Spanish SMEs: Challenges and opportunities. J. Clean. Prod. 185, 157–167.

Pedroni, P., 1999. Critical values for cointegration tests in heterogeneous panels with multiple of economics and statistics. Oxf. Bull. Econ. Stat. 61 (S1), 653–670.

Pedroni, P., 2004. Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. Econ. Theory 20 (3), 597–625. https://doi.org/10.1017/S0266466604203073.

Pesaran, H.H., Shin, Y., 1998. Generalized impulse response analysis in linear multivariate models. Economics Letters 58 (1), 17–29.

Pesaran, M.H., Ullah, A., Yamagata, T., 2008. A bias-adjusted LM test of error cross-section independence. Econom. J. 11 (1), 105–127. https://doi.org/10.1111/j.1368-423X.2007.00227.x.

Pieroni, M.P., McAloone, T.C., Pigosso, D.C., 2019. Business model innovation for circular economy and sustainability: A review of approaches. J. Clean. Prod. 215, 198–216.

Prieto-Sandoval, V., Jaca, C., Santos, J., Baumgartner, R.J., Ormazabal, M., 2019. Key strategies, resources, and capabilities for implementing circular economy in industrial small and medium enterprises. Corp. Soc. Responsib. Environ. Manag. 26 (6), 1473–1484.

Rehman Khan, S.A., Zhang, Y., Anees, M., Golpîra, H., Lahmar, A., Qianli, D., 2018. Green supply chain management, economic growth and environment: A GMM based evidence. J. Clean. Prod. 185. https://doi.org/10.1016/j.jclepro.2018.02.226.

Resta, B., Dotti, S., Boelli, A., Gaiardelli, P., 2015. Environmental management practices for the textile sector. IFIP international conference on advances in production management systems, Vol. 459. Springer, Cham, Switzerland, pp. 625–631.

Robèrt, K.H., Schmidt-Bleek, B., De Larderel, J.A., Basile, G., Jansen, J.L., Kuehr, R., Wackernagel, M., 2002. Strategic sustainable development—Selection, design and synergies of applied tools. J. Clean. Prod. 10 (3), 197–214.

Sadik-Zada, E.R., Ferrari, M., 2020. Environmental policy stringency, technical progress and pollution haven hypothesis. Sustainability 12 (9), 3880. https://doi.org/10.3390/su12093880.

Sakah, M., Diawuo, F.A., Katzenbach, R., Gyamfi, S., 2017. Towards a sustainable electrification in Ghana: A review of renewable energy deployment policies. Renew. Sust. Energ. Rev. 79, 544–557. https://doi.org/10.1016/j.rser.2017.05.090.

Sangle, S., 2010. Empirical analysis of determinants of adoption of proactive environmental strategies in India. Bus. Strategy Environ. 19 (1), 51–63.

Santosa, W., Nilawati, Y., Kusuma, R., 2022. Analysis of the relationship between logistics performance and carbon emissions in Asean, in: Proceedings of the First Lekantara Annual Conference on Public Administration, Literature, Social Sciences, Humanities, and Education, LePALISSHE 2021, August 3, 2021, Malang, Indonesia. 10.4108/eai.3-8-2021.2315164.

Scupola, A., 2003. The adoption of Internet commerce by SMEs in the south of Italy: An environmental, technological and organizational perspective. J. Glob. Inf. Technol. Manag. 6 (1), 52–71.

Shafique, M., Azam, A., Rafiq, M., Luo, X., 2021. Investigating the nexus among transport, economic growth and environmental degradation: Evidence from panel ARDL approach. Transp. Policy 109, 61–71. https://doi.org/10.1016/j.tranpol.2021.04.014.

Shahzad, U., Jena, S.K., Tiwari, A.K., Doğan, B., Magazzino, C., 2022. Time-frequency analysis between Bloomberg Commodity Index (BCOM) and WTI crude oil prices. Resour. Policy 78,. https://doi.org/10.1016/j.resourpol.2022.102823 102823.

Shahzad, U., Mohammed, K.S., Tiwari, S., Nakonieczny, J., Nesterowicz, R., 2023. Connectedness between geopolitical risk, financial instability indices and precious metals markets: Novel findings from Russia Ukraine conflict perspective. Resour. Policy 80, 103190.

Sharif, A., Mehmood, U., Tiwari, S., 2023a. A step towards sustainable development: role of green energy and environmental innovation. Environ. Dev. Sustain. 1–22. https://doi.org/10.1007/s10668-023-03111-5.

Sharif, A., Kocak, S., Khan, H.H.A., Uzuner, G., Tiwari, S., 2023b. Demystifying the links between green technology innovation, economic growth, and environmental tax in ASEAN-6 countries: The dynamic role of green energy and green investment. Gondwana Res. 115, 98–106.

Shi, H., 2003. Cleaner production in China. In: Mol, A., van Buuren, J. (Eds.), Greening industrialization in Transitional Asian Countries: China and Vietnam. Lexington, Lanham, MD, pp. 63–82.

Shin, Y., Yu, B., Greenwood-Nimmo, M., 2014. Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In: Sickles, R., Horrace, W. (Eds.), Festschrift in Honor of Peter Schmidt. Springer, New York, NY, p.281-314. https://doi.org/10.1007/978-1-4899-8008-3_9.

Sim, N., Zhou, H., 2015. Oil prices, US stock return, and the dependence between their quantiles. J. Bank. Financ. 55, 1–8. https://doi.org/10.1016/j.jbankfin.2015.01.013.

Singh, H.V., Bocca, R., Gomez, P., Dahlke, S., Bazilian, M., 2019. The energy transitions index: An analytic framework for understanding the evolving global energy system. Energy Strategy Rev. 26,. https://doi.org/10.1016/j.esr.2019.100382 100382.

Singh, M.P., Chakraborty, A., Roy, M., 2016. The link among innovation drivers, green innovation and business performance: Empirical evidence from a developing economy. World Rev. Sci. Technol. Sustain. Dev. 12 (4), 316–334.

Singh, S., Kumar, R., Panchal, R., Tiwari, M.K., 2020. Impact of COVID-19 on logistics systems and disruptions in food supply chain. Int. J. Prod. Res. 59 (7), 1993–2008. https://doi.org/10.1080/00207543.2020.1792000.

Sohail, M.T., Ullah, S., Majeed, M.T., Usman, A., 2021. Pakistan management of green transportation and environmental pollution: a nonlinear ARDL analysis. Environ. Sci. Pollut. Res. 28 (23), 29046–29055. https://doi.org/10.1007/s11356-021-12654-x.

Souza, G.C., 2013. Closed-loop supply chains: A critical review, and future research. Decis. Sci. 44 (1), 7–38.

Stewart, R., Niero, M., 2018. Circular economy in corporate sustainability strategies: A review of corporate sustainability reports in the fast moving consumer goods sector. Bus. Strategy Environ. 27 (7), 1005–1022.

Su, X., Li, Y., Fang, K., Long, Y., 2022. Does China's direct investment in "Belt and Road Initiative" countries decrease their carbon dioxide emissions? J. Clean. Prod. 339,. https://doi.org/10.1016/j.jclepro.2022.130543 130543.

Sun, L., Li, Z., Fujii, M., Hijioka, Y., Fujita, T., 2018. Carbon footprint assessment for the waste management sector: A comparative analysis of China and Japan. Front. Energy 12 (3), 400–410. https://doi.org/10.1007/s11708-018-0565-z.

Tian, J., Yu, L., Xue, R., Zhuang, S., Shan, Y., 2022. Global low-carbon energy transition in the post-COVID-19 era. Appl. Energy 307,. https://doi.org/10.1016/j.apenergy.2021.118205 118205.

Ullah, S., Ozturk, I., Usman, A., Majeed, M.T., Akhtar, P., 2020. On the asymmetric effects of premature deindustrialization on CO_2 emissions: evidence from Pakistan. Environ. Sci. Pollut. Res. 27 (12), 13692–13702. https://doi.org/10.1007/s11356-020-07931-0.

United Nations, 2015. Paris Agreement, in: Report of the conference of the parties to the United Nations framework convention on climate change (21st session, 2015: Paris). Retrived December (Vol. 4, p. 2017), HeinOnline.

Usman, A., Ozturk, I., Naqvi, S.M.M.A., Ullah, S., Javed, M.I., 2022. Revealing the nexus between nuclear energy and ecological footprint in STIRPAT model of advanced economies: Fresh evidence from novel CS-ARDL model. Prog. Nucl. Energy 148,. https://doi.org/10.1016/j.pnucene.2022.104220 104220.

van Buren, N., Demmers, M., van der Heijden, R., Witlox, F., 2016. Towards a circular economy: The role of Dutch logistics industries and governments. Sustainability 8 (7), 647–663.

Wang, K., Yan, M., Wang, Y., Chang, C.P., 2020. The impact of environmental policy stringency on air quality. Atmospheric Environ. 231,. https://doi.org/10.1016/j.atmosenv.2020.117522 117522.

Wang, Z., Yen-Ku, K., Li, Z., An, N.B., Abdul-Samad, Z., 2022. The transition of renewable energy and ecological sustainability through environmental policy stringency: Estimations from advance panel estimators. Renew. Energ. 188, 70–80. https://doi.org/10.1016/j.renene.2022.01.075.

Westerlund, J., 2007. Testing for error correction in panel data. Oxf. Bull. Econ. Stat. 69 (6), 709–748. https://doi.org/10.1111/j.1468-0084.2007.00477.x.

Ye, M., Si Mohammed, K., Tiwari, S., Ali Raza, S., Chen, L., 2023. The effect of the global supply chain and oil prices on the inflation rates in advanced economies and emerging markets. Geol. J. 58 (7), 2805–2817. https://doi.org/10.1002/gj.4742.

Yirong, Q., 2022. Does environmental policy stringency reduce CO_2 emissions? Evidence from high-polluted economies. J. Clean. Prod. 341,. https://doi.org/10.1016/j.jclepro.2022.130648 130648.

Zafar, A., Ullah, S., Majeed, M.T., Yasmeen, R., 2020. Environmental pollution in Asian economies: Does the industrialisation matter? OPEC Energy Review 44 (3), 227–248. https://doi.org/10.1111/opec.12181.

Zhou, L., Naim, M.M., Disney, S.M., 2017. The impact of product returns and remanufacturing uncertainties on the dynamic performance of a multi-echelon closed-loop supply chain. Int. J. Prod. Econ. 183, 487–502.