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Testing the equity-pollution dilemma from a global perspective: Does reducing consumption inequality impose environmental burdens?

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A B S T R A C T

The theory of equity pollution dilemma suggests that income redistribution causes environmental pollution. However, little research has been done to test the validity of the equity-pollution dilemma hypothesis on a global scale. Hence, the objective of this study is to examine how reducing consumption inequality imposes environmental burden in the form of greenhouse gas intensity across the world. The choice of the other variables such as natural resource rents and technological innovation also based on the previous empirical works. We consider 61 countries based on the availability of data and divide the countries into different income groups according to the World Bank classification. We use several other independent variables such as quality of governance, climate change mitigation law and access to electricity. We apply two-step system GMM technique for the full sample and one step system GMM for the income groups. The results depict that reducing consumption inequality increases GHG emissions all over the world. Natural resource rents and technological innovation helps to increase GHG emission. On the other hand, access to electricity has a negative impact on GHG emissions, whereas climate change mitigation law has an opposite impact on GHG emission intensity. The results vary for the income groups. Policy implications are suggested based on the outcome.

1. Introduction

Different countries across the world are trying to increase the welfare of their citizens with economic growth. However, economic growth also increases the demand for energy, leading to global environmental problems. Since most of the energy consumption is still met from fossil fuels, energy consumption also increases the greenhouse gas emissions released into the atmosphere, which causes the world to face problems such as climate change and environmental pollution. With the emergence of environmental pollution and the effect of globalization, environmental issues were discussed on a global scale for the first time at the Environment and Human Conference held in Stockholm in 1972 by the United Nations. In this meeting, countries sought solutions to issues such as the depletion of the ozone layer, global warming, melting glaciers, changing seasons, and deforestation (Ehrlich, 2008). The concept of sustainable development was first introduced by Brundlandt (1987). This term refers to meeting the present's needs while not harming future generations' resources. For this purpose, the United Nations announced 17 Sustainable Development Goals (SDGs)[1] in the field of energy, climate change, inequality, poverty, hunger, decent work, health, education, urbanization and industrialization.

Carbon neutrality means offsetting CO_2 emissions through carbon capture, storage, and conversion within a certain time in order to achieve net-zero emissions (Wu et al., 2022). The concept of carbon neutrality refers to the transition to the decarbonization process at the individual, institutional and national levels. The most urgent issue on Earth is to achieve carbon neutrality by 2050 in response to the escalating global climate change. However, Carbon neutrality requires a rapid and comprehensive transformation in the energy and industrial sectors. Under the Paris Agreement, 197 countries have agreed to limit global warming to well below 2 °C and to make efforts to limit it to 1.5 °C. This consensus was strengthened at the COP27 meeting held in Sharm el-Sheikh, Egypt

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[1] See also https://sdgs.un.org/goals.

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in November 2022.Within the framework of the INDC mechanism, each country will try to reach the net zero emission target by 2050 according to its domestic dynamics.

Income inequality is an important problem that hinders the increase in welfare, especially in developing countries (Tan and Law, 2012). Economic development, financial development, public expenditures, education, inflation, population growth and openness are the most critical factors affecting income inequality (Rehman et al., 2008). In Fig. 1, we provide a depiction of consumption inequality across the world using the average of 2005–2018.

However, many studies link income inequality with environmental problems (Torras and Boyce, 1998; Demir et al., 2019a, 2019b; Belaïd et al., 2020; Zhao et al., 2021; Ehigiamusoe et al., 2022). The Environmental Kuznets Curve (EKC) is the most studied theory for the relationship between income and the environment. The EKC hypothesis was inspired by Kuznets' (1955) study, which examined the relationship between economic growth and income inequality. According to Kuznets (1955), while income inequality increases in the first stage of economic development, it begins to decrease after a turning point. On the other hand, Grossman and Krueger (1991) modified Kuznet's (1955) hypothesis and found similar results for the relationship between per capita income and environmental quality. Then, Panayotou (1994) investigated the relationship between economic growth and environmental factors within the framework of the EKC hypothesis. According to the findings, per capita income triggers environmental degradation. However, after reaching a certain income and welfare level, societies become more sensitive to environmental issues. Increasing environmental awareness puts pressure on policymakers to tighten environmental regulations and standards; thus, environmental quality tends to increase. According to Khan et al. (2022), people may ignore the environment to raise their living standards in low-income countries. For example, they may consume more fossil fuel-based natural resources to meet their needs. In these countries, the motivation to protect the environment is low since education is insufficient. At the same time, these countries cannot adapt to technological innovations due to poverty and cannot benefit from highly efficient renewable energy sources. However, some studies found that decreasing income inequality increases CO_2 emissions. This situation is defined as equity-pollution dilemma in the literature.

Boyce (1994a, 1994b) argued that income inequality could be an essential determinant of environmental degradation. According to the equity-pollution dilemma, efforts to increase poor households' income to reach a higher income level will ultimately increase their energy consumption and carbon footprint. Thus, reducing income inequality will lead to environmental pollution. It is possible to find studies that empirically support this hypothesis (Ravallion et al., 2000; Hao et al., 2016; Sager, 2019a, 2019b; Hailemariam et al., 2020a, 2020b). Belaïd et al. (2020) supported the equity-pollution dilemma and argued that countries with high inequalities generally do not have carbon-intensive economies. These societies have limited access to electricity or other modern energy sources. For this reason, higher income inequality contributes to environmental quality through lower CO_2 emissions in these countries. In addition to income inequality, consumption inequality, one of the main determinants of economic welfare, is also a component of economic inequality. However, it is expected to be less than income inequality since it is a significant part of the consumption of goods and services to meet basic needs.

Natural resources play a vital role in the development of any region, but they can also be a threat for some countries. As shown in Fig. 2, different countries have different natural resources and their roles are also different.

Countries with abundant natural resources benefit more from the rents obtained from these resources (Safdar et al., 2022) and achieve sustainable development if they provide conditions such as education, democracy and freedom. However, strong institutions and good governance are the factors that positively affect sustainable development (Nakabashi et al., 2013; Acemoglu et al., 2014; Vianna and Mollick, 2018). Technological change also can provide the flexibility needed to transition to a low-carbon economy (Gerlagh, 2007) and facilitate the achievement of sustainable development goals by encouraging the development of new energy sources (Xu and Lin, 2018).

The motivation of this study is to test the validity of the equity-pollution dilemma hypothesis on a global scale. The contributions can be listed as follows. To the best of our knowledge, i) this is the first study to describe the impact of consumption inequality on GHG intensity in the context of the equity-pollution dilemma. ii) Using consumption inequality as the dependent variable, we applied the two-step System GMM analysis, giving robust results. Another advantage of the two-step System GMM analysis is smoothing the assumptions of independence and homoscedasticity (Baltagi, 2005; Khadraoui and Smida, 2012a, 2012b). iii) We divided the economies based on income level according to the World Bank ranking. In this way, we reached specific findings for each country group. We also examine the impact of natural resources, technology, governmental policy and electricity access in the model. Therefore, the study suggests various policy recommendations regarding inequity and the environment. Finally, iv) the governments generally neglect the environmental impact of inequalities. In this context, the empirical findings will help authorities address income inequalities from an environmental perspective.

Sustainable development goals include both improving environmental degradation and reducing inequalities. However, reducing consumption inequality can increase the use of energy-intensive products and cause additional emissions as Fatai Adedoyin et al. (2021) found that energy consumption increases CO_2 emissions. Therefore, achieving consumption equity and environmental quality targets worldwide will be complicated. The objective of this study is to examine how reducing consumption inequality reduces environmental quality by increasing greenhouse gas emissions. For this purpose, we examine the validity of the equity-pollution dilemma for 61 countries. We also divide the countries into different income groups according to world bank classification. In this way, we obtained different empirical results according to the income levels and suggest specific policy recommendations.

The study consists of five parts. The first part gives theoretical information about the concepts of the equity-pollution dilemma. The second part presents the literature review. The third part illustrates the methodology, empirical model and findings. Section 4 discusses empirical results. The final section presents some policy recommendations.

2. Literature review

Inequalities are one of the problems governments are trying to solve. However, another problem that governments are trying to solve is environmental pollution. Solving these two problems together may require complex economic policies. Because reducing income inequality or consumption inequality can increase environmental pollution by increasing per capita GHG emissions. In this section, we survey the studies examining the effects of inequalities on environmental pollution. In addition, we examine the studies focused on the relationship between technology, bureaucratic quality and the environment of renewable energy.

Studies examining the relationship between income inequality and environmental quality have increased recently (Qu and

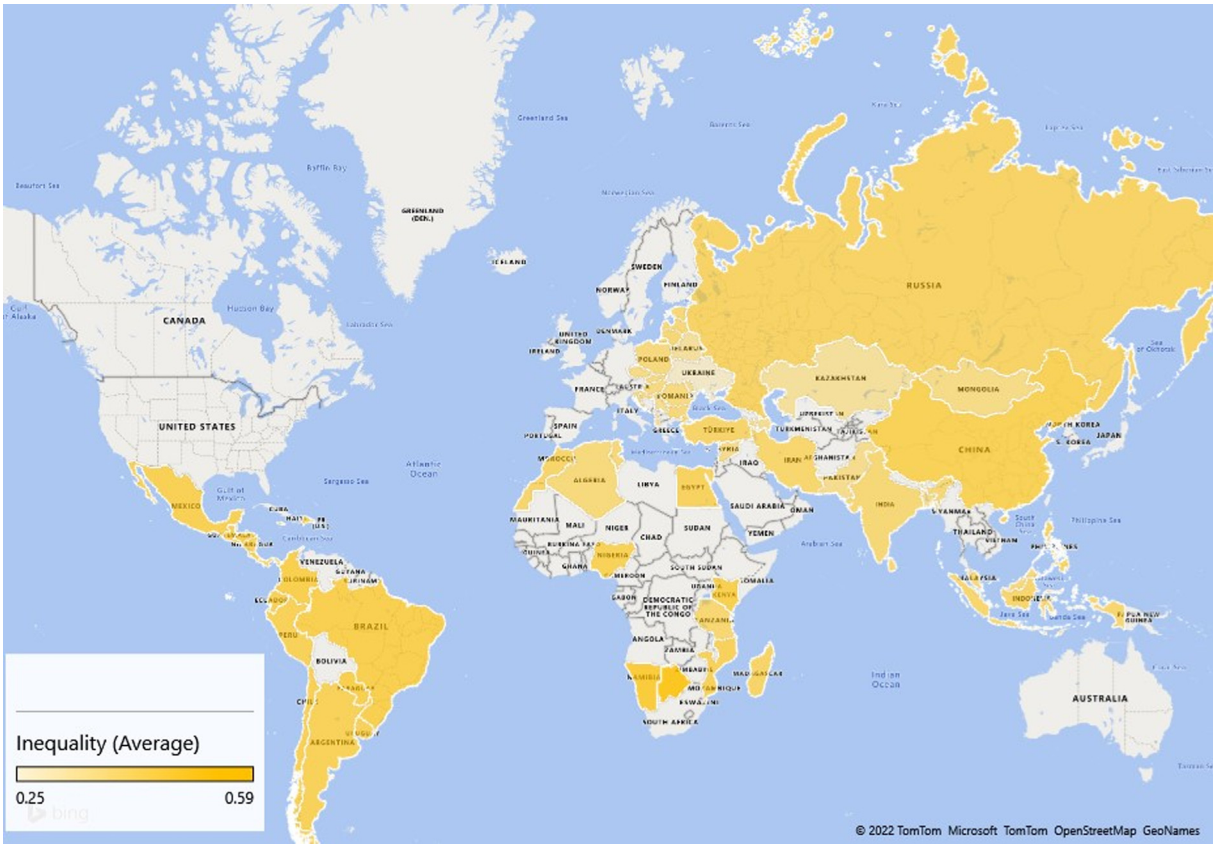

Fig. 1. Consumption Inequality across the selected countries in the world.

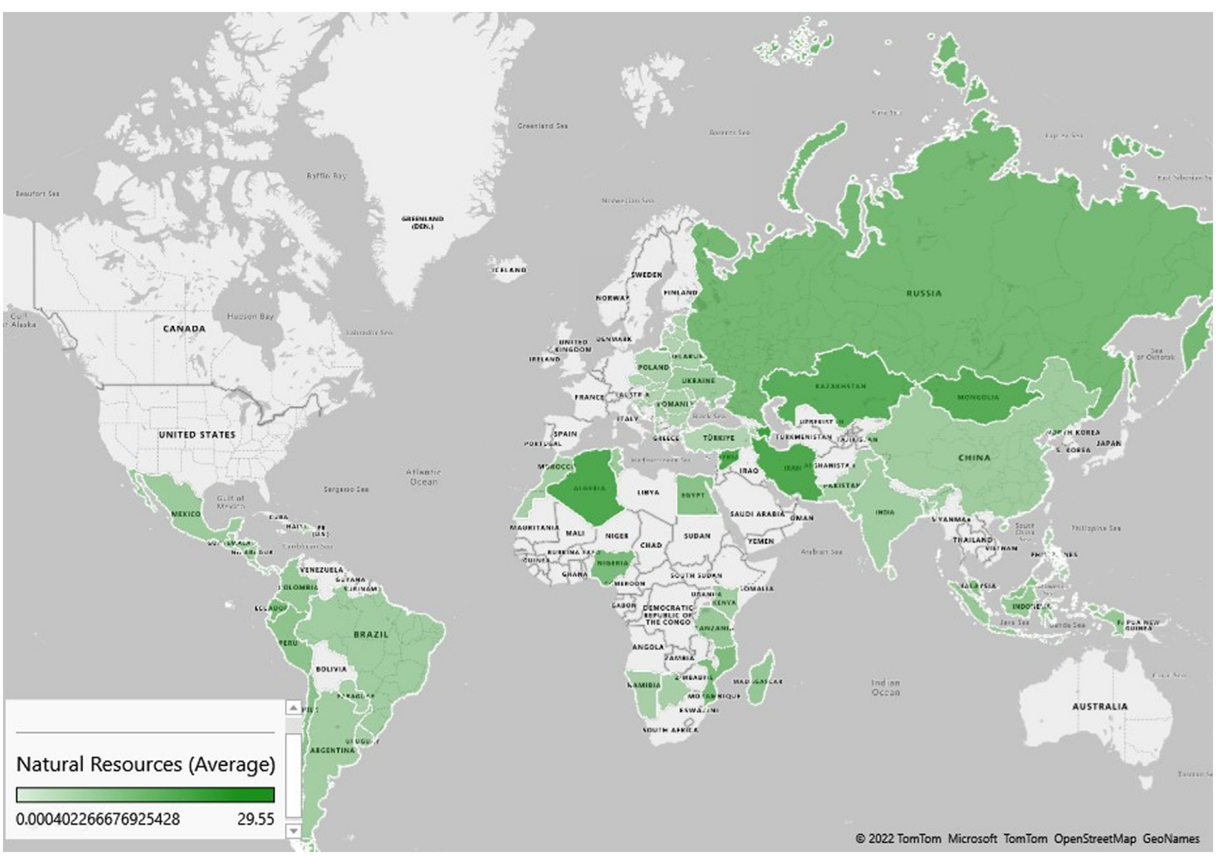

Fig. 2. Natural Resource Rents across the selected countries in the world.

Zhang 2011; Zhang and Zhao 2014; Hübler, 2017; Demir et al., 2019a, 2019b; Baloch et al., 2020; Langnel et al., 2021; Khan et al., 2022). However, the findings on the relationship between inequality and the environment may be contradictive depending on the sample. First, Magnani (2000) discovered that individuals' environmental concerns and cooperation could decline as inequalities increased. Ravallion et al. (2000) argued that income distribution is an important environmental factor and they found that increased inequalities reduce emissions per capita. This assumption has been supported by many studies in the literature (Heerink et al., 2001; Guo, 2014; Berthe and Elie, 2015; Demir et al., 2019a, 2019b). Similarly, Researchers suggested implementing long-term environmental strategies by combining economic growth and equity policies. On the contrary, it is possible to find studies showing that improvements in income inequality decrease environmental sustainability (Torras and Boyce, 1998; Golley and Meng, 2012; Baek and Gweisah, 2013). For instance, Hailemeriam et al. (2019) examined OECD countries and found that an increase in income inequality leads to higher emissions. Another study by Hao et al. (2016) asserts that higher income gap leads to higher emissions.

Renewable energy, technological innovation and bureaucratic quality indicators can also increase environmental sustainability. Renewable energy undoubtedly contributes to the fight against climate change since it does not cause emissions like fossil fuel consumption and helps to decrease in greenhouse gas emissions (Jaforullah and King, 2015; Wang et al., 2018). Hasanov et al. (2021) found that renewable energy, technological innovation and export increase environmental quality. However, economic growth and imports reduce environmental quality. Ahmed et al. (2022) assume that public investments in clean energy research and development-oriented projects improve environmental quality. Similarly, He et al. (2021) concluded that green technology innovations reduce environmental pollution. Although technological innovation has an economic cost, it can contribute to reducing environmental pollution, especially through energy efficiency (Ockwell et al., 2010). Renewable energy technological innovation can significantly reduce CO_2 emissions (Lin and Zhu, 2019). Many studies argue that technological innovation improves environmental quality, especially through efficiency and new low-carbon technologies (Gerlagh, 2007; Ang, 2009; Zhao et al., 2013; Sohag et al., 2015; Ahmed et al., 2016; Yang and Li, 2017). However, there are also studies suggesting that technological innovation does not affect the environment (Garrone and Grilli, 2010; Cheng et al., 2017; Amri, 2018) or has negative effects (Newell, 2009; Danish et al., 2018; Cheng et al., 2019; Koçak and Ulucak, 2019). Strong institutional quality is needed to foster technological innovation. Therefore, institutional quality can positively affect environmental quality by increasing the skills of governance (Tamazian and Bhaskara Rao, 2010). Similarly, Liu et al. (2020) found that economic governance positively impacts environmental quality. Many studies found that governance reduces CO_2 emissions and improves environmental quality (Dutt, 2009; Samimi et al., 2012; Danish et al., 2019a, 2019b, 2019c; Omri and Ben Mabrouk, 2020).

3. Data description and methodology

3.1. Data description

The main objective of this study is to examine whether solving inequality creates environmental burden. For achieving this objective, we consider 61 countries for the period 2005–2019. Environmental burden is measured by the greenhouse gas intensity which is collected from the Yale Center for Environmental Law & Policy (Wendling et al., 2020). A 3D visual geographic heat map for the GHG emission intensity for 2019 is presented in Fig. 3.

As for the inequality, we consider consumption inequality which comes from the Global Consumption and Income Project or GCIP. In addition, we include other variables such as natural resource rents, technological innovation, quality of governance, climate change mitigation law and access to electricity. The data for natural resource rents and access to electricity come from WDI, technological innovation is from World Intellectual Property Organization (WIPO) which is measured by the patent applications. Quality of governance as well as climate change mitigation law come from the Quality of Government standard dataset. Fig. 4 and Fig. 5 depict the heat map for technological innovation and access to electricity respectively in these 61 countries during the period of 2005–2019.

The basic equation of this study can be specified as follows:

$$GHG = f(CINEQ, RES, TI, QOG, CML, AE) \tag{1}$$

Here, GHG refers to greenhouse gas intensity, CINQ is consumption inequality, RES is natural resource rents, TECH is technological innovation, QOG is quality of governance, CML is climate change mitigation law, AE is access to electricity. The above equation can be expressed in the logarithm as follows:

$$\begin{aligned} lnGHG_{it} = {} & a_0 + a_1 lnCINQ_{it} + a_2 lnRES_{it} + a_3 lnTI_{it} + a_4 lnQOG_{it} \\ & + a_5 lnCML_{it} + a_5 lnAE_{it} + \epsilon_{it} \end{aligned} \tag{2}$$

In Table 1, we provide the description of these data and their sources.

3.2. Methodology

This study employs two-step system generalized method of moments (GMM) estimators. In the GMM method introduced by Arellano and Bond (1991), a nonlinear dynamic panel model is estimated with first differenced series. However, the first difference transform is still weak when time dimension is smaller and using unbalanced panel data. For this reason, System GMM developed by Arellano and Bover (1995) is recommended instead of using first differenced data. Blundell and Bond (1998), argued that the tools of the GMM model revealed by Arellano and Bond (1991) do not solve the endogenity problem. A systems-based approach has been suggested to overcome this problem. In the GMM and System-GMM models, single-stage error conditions are assumed to be homoscedastic and independent in terms of observations and time. However, in the second stage, the residues obtained in the first stage are used to create a consistent variance–covariance matrix estimation. Thus, the two-stage estimator becomes much more asymptotic and efficient as it smooths the assumptions of independence and homoscedasticity (Baltagi, 2005; Khadraoui and Smida, 2012a, 2012b). With the improvements made by Bun and Windmeijer (2010), a finite sample correction is provided to the two-stage covariance matrix and it was proved that the two-stage estimator will give more robust results than the one-stage estimator. Arellano (2003) illustrated the GMM model as follows:

$$Y_{it} = Y_{i(t-1)} + x_{it}\beta + n_i + u_{it} \text{ and } E(u_{it} \mid x_{i1}, \cdots\cdots, x_{iT} n_i) = 0 (t = 1, \cdots..T) \tag{3}$$

Eq. (2) shows the lagged values of X and Y. One-stage estimation (GMM1) accepts that error terms have constant variance between groups and time, while two-stage estimation (GMM 2) considers that error terms can have varying variance (Windmeijer, 2005). Arellano and Bond (1991) show a dynamic panel data model estimated with the GMM estimator as follows.

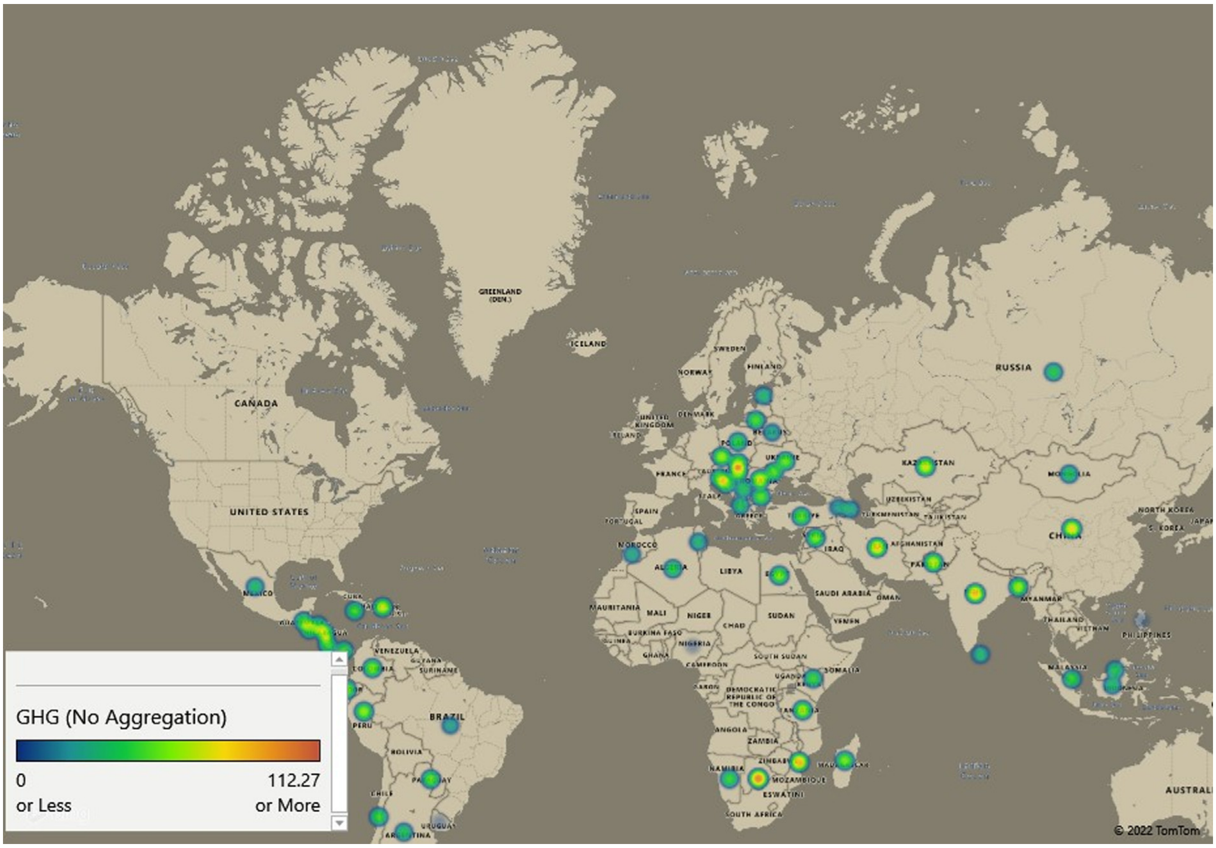

Fig. 3. GHG emission Intensity Heat map across the 61 countries.

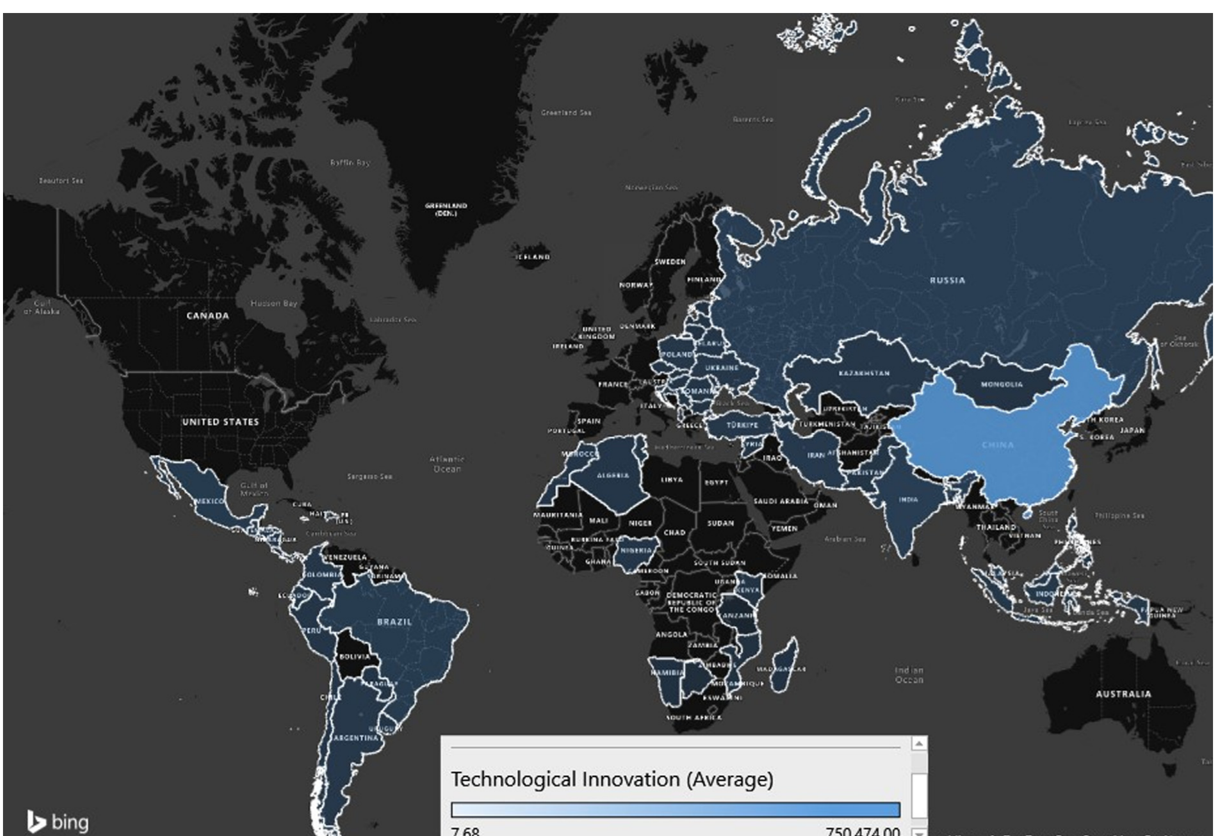

Fig. 4. Technological Innovation Heat map across the 61 countries.

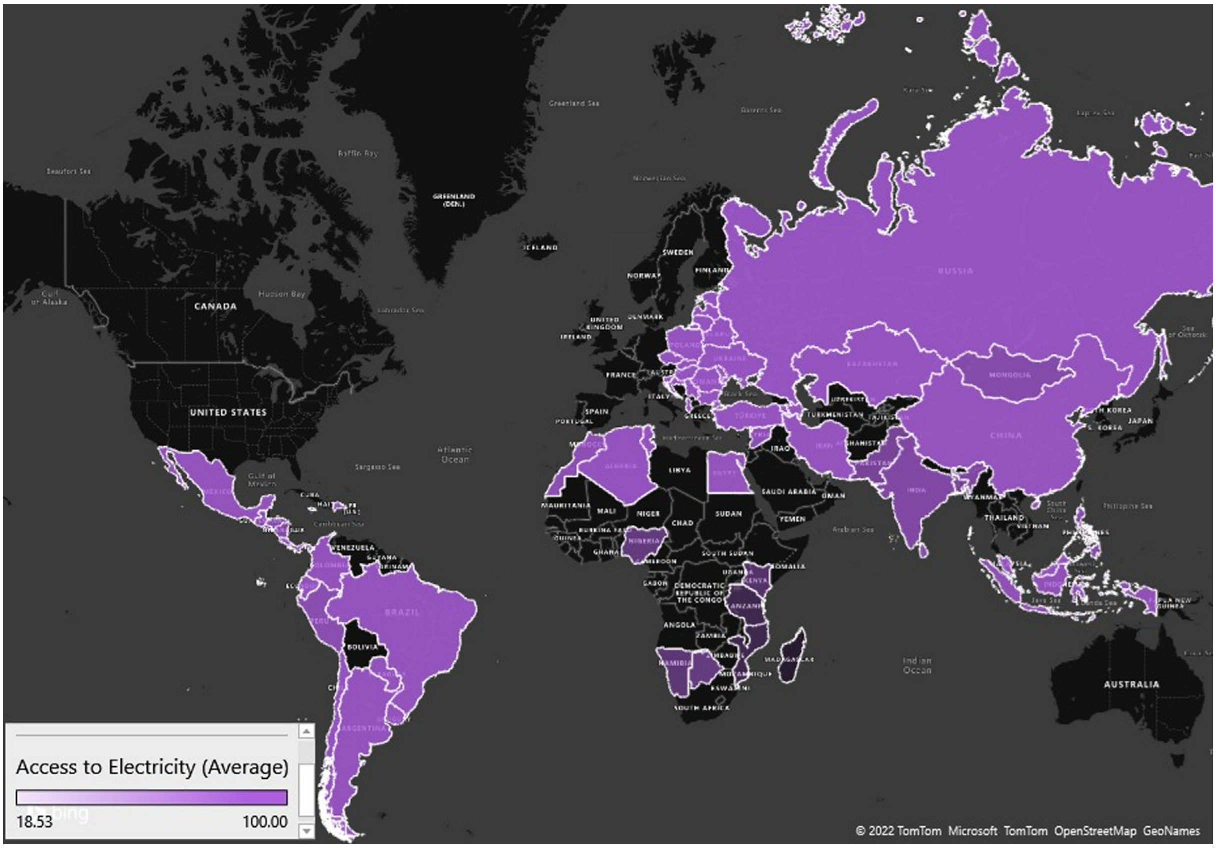

Fig. 5. Access to electricity Heat map across the 61 countries.

Table 1
Description of the data.

Variables	Description	Data source
GHG	Greenhouse gas intensity (growth rate)	Yale Center for Environmental Law & Policy
QOG	Quality of governance (index)	Quality of Government standard dataset
CML	Climate change mitigation law (number)	Quality of Government standard dataset
CINQ	Consumption inequality (Gini)	Global Consumption and Income Project or GCIP
TECH	Technological innovation (proxied by patent application)	World Intellectual Property Organization (WIPO)
RES	Natural resource rents (percentage of GDP)	WDI
AE	Access to electricity (% of population)	WDI

$$Y_{it} = Y_{i(t-1)}a_1 + Y_{i(t-p)}a_p + x_{it}b_1 + w_{it}b_2 + v_1 + e_{it} and \\ i = [1, \cdots, N], t = [1, \cdots \mathrm{N}] \quad (4)$$

In Eq. (3), $a_1 \cdots a_p$ shows the parameters to be estimated. x_{it}, represents exogenous variables in the (1* k1) vector. b_1 represents the parameters to be estimated in the (k1* 1) vector. w_{it} represents the predicted variables in the vector (1*k2). b_2, represents the parameters to be estimated in the vector (k2* 1). Finally, v_1 shows random effects.

In our study, we use two step system GMM for the full sample and one step GMM for the income country groups. The reason for this is because of the number of observations that each group has. The advantage of the system GMM over other techniques is that they can take care of any endogenoety issue that may arise between the study variables.

3.3. Empirical results

Table 2 provides a descriptive statistics of the variables used in the study without logarithm. The highest mean value is observed for the technological innovation variable, followed by the access to electricity and greenhouse gas intensity. Table 3 provides a correlation matrix and Table 4 provides a VIF test. The VIF test shows that there is no severe multicollinearity problem. Table 5 provides a weak cross sectional dependence test of Chudik and Pesaran (2015) which shows that some variables have weak coss sectional dependency while some has strong dependency.

In Figs. 6 and 7, we provide the depiction of which distribution fits our data the better for all the variables except TI which we could not fit.

The primary objective of the current study is to inspect the effect of consumption CINEQ on greenhouse gas emissions (GHG ems) by using the GMM approach. We divided the economies based on income level according to the world band ranking. Table 6 elaborates on the global outcomes. The results depict that a higher level of CINEQ is significantly negatively connected with GHG emissions around the globe. It indicates that a 1% increase in CINEQ leads to a decline in GHG to about 0.54% at a 1% significance level.

Additionally, the outcome depicts that natural resource rent (RES) contributes to GHG over the globe. The result suggests that a 1% increase in RES significantly stimulates the pollution emissions by approximately 0.134% at t a 10% significance. Hence, the findings revealed that technological innovation (TI) and climate change mitigation law (CML) substantially affect GHG around the globe. The turns indicate that a 1% rise in TI and CML enhances the GHG by 0.057% and 0.126%, respectively, at a 10% significance level. Further, the outcome highlights that access to electricity (AE) is negatively connected with GHG worldwide. The finding infers

Table 2
Descriptive Statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
GHG	915	49.312	19.948	0	100
CINQ	915	0.389	0.071	0.167	0.618
RES	915	5.46	7.788	0	42.258
TI	885	16174.899	114680.11	1	1,500,000
QOG	915	0.489	0.117	0.25	0.889
CML	915	0.673	1.022	−2	7
AE	915	88.668	21.307	11.2	100.747

Table 3
Matrix of correlations.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) lnGHG	1.000						
(2) lnCINQ	−0.037	1.000					
(3) lnRES	−0.032	0.109	1.000				
(4) lnTI	−0.014	−0.026	0.035	1.000			
(5) lnQOG	−0.082	−0.154	−0.343	0.122	1.000		
(6) lnCML	−0.014	0.038	0.029	0.162	0.035	1.000	
(7) lnAE	0.014	−0.247	−0.196	0.464	0.222	0.020	1.000

Table 4
Variance inflation factor.

	VIF	1/VIF
lnCINQ	1.09	0.917
lnRES	1.184	0.845
lnTI	1.358	0.737
lnAE	1.455	0.687
lnQOG	1.185	0.844
lnCML	1.033	0.968
Mean VIF	1.218	.

Table 5
Weak cross sectional dependence test.

Variables	Statistics	Variables	Statistics
lnGHG	−0.138	lnCINQ	12.762***
lnRES	56.524 ***	lnTI	2.567 *
lnQOG	5.882 ***	lnCML	−0.289
lnAE	52.250***		

***, ** and * stands for 1%, 5% and 10% levels of significance invidually.

that a 1% increase in AE led to a decline in GHG to about 0.126% at a 10% significance level.

Table 7 elaborates on the low-income economies' outcome by employing one step GMM estimation technique. The turns out depict that rise in the level of CINEQ is negatively linked with GHG in the low-income economies. The results explore that a 1% rise in the level of CINEQ declines the GHG by approximately 1.946% at a 1% significance level in low-income economies. Furthermore, the results show that RES adds to GHG in low-income economies. The results indicate that a 1% increase in RES significantly increases pollutant emissions by roughly 0.2percent at a 10% significance level. Thus, the results indicate that increases in TI are considerably negatively associated with GHG. It suggests that a 1% increase in TI results in the decline of GHG to about 0.271 at a 5% significance level. Although, the finding revealed that raising the level of CML enhances the GHG. The results infer that a 1% increase in a CML meaningfully rises the GHG by 0.877% at a 5% significance level in low-income economies.

Table 8 discusses the outcome of lower-middle-income economies using the GMM estimate approach. The findings show that an increase in the level of CML is adversely related to GHG emissions in lower- middle income economies. The results show that a 1% increase in CML reduces GHG emissions by nearly 0.246 percent at a 1% significance level in lower-income economies. However, other consider attributes show an insignificant effect on GHG in the lower-middle income economies.

Table 9 examines the results of upper-middle-income economies using the system GMM estimation method. The findings suggest that increasing the level of CINEQ has a negative impact on GHG emissions in upper-middle-income nations. At a 10% significance level, the result indicates that a 1% increase in CINEQ decreases GHG by about 0.354 percent in upper-income countries. Furthermore, the outcome highlights that RES is considerably negatively correlated with GHG in upper-middle-income nations at a 10% significance level. Although, the finding revealed that CML is positively connected with GHG. The results infer that a 1% rise in the level of CML meaningfully contributed to GHG by approximately 0.042% in the upper-middle-income economies at a 10% significance level. On the other hand, CINEQ, TI, and AE have an insignificant effect on GHG.

Table 10 evaluates the system GMM estimate technique outcomes for higher-income economies. According to the findings, raising the level of CINEQ positively influences GHG emissions in higher-income countries. The results show that a 1% increase in CINEQ enhances GHG emissions by around 0.496 percent in higher-income nations. Furthermore, the results show that RES is significantly positively connected with GHG in higher-income countries. It depicts that a 1% rise in the level of RES stimulates the GHG by about 1.263% in the higher-income economies at a 10% significance level. Nonetheless, the findings demonstrated that TI, QI, CML, and EA have an insignificant impact on GHG.

3.4. Discussion

The objective of the current study is to inspect the CINEQ on GHG for low-income, lower-middle-income, upper-income, and higher-income economies over the period 2007–2019 by employing one step GMM estimation approach. The finding depicts that CINEQ is negatively connected with GHG in over the globe, in low-income economies, lower-middle-income economies, and upper-middle-income economies**.** On the other hand, the outcome for higher income the CINEQ is positively linked with GHG. Thus, several empirical investigations have demonstrated that CINEQ negatively influences environmental quality**.** For example, Hailemariam et al. (2020a, 2020b) showed that increased CINEQ

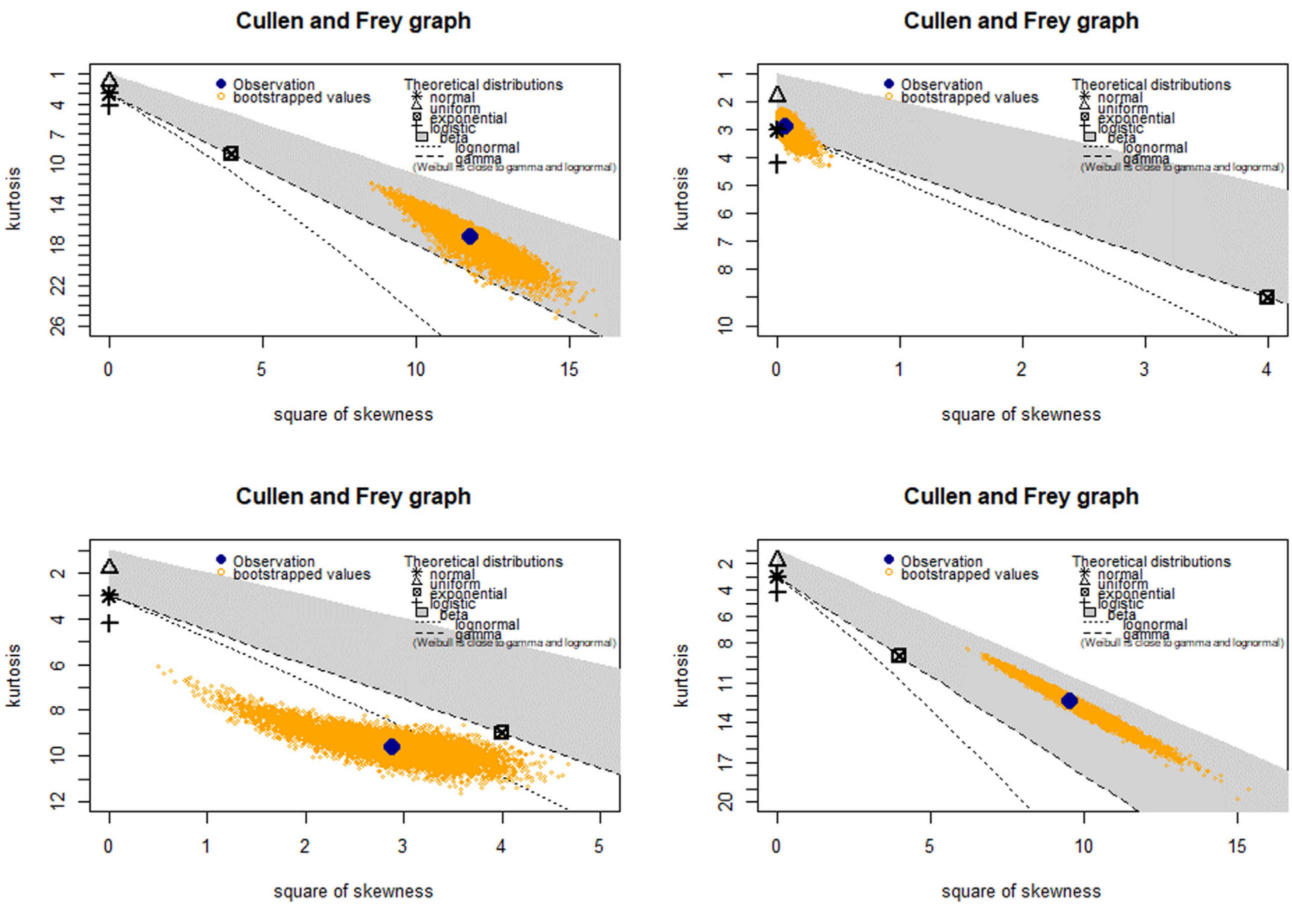

Fig. 6. Distribution Characteristics for GHG, CINQ, RES and AE.

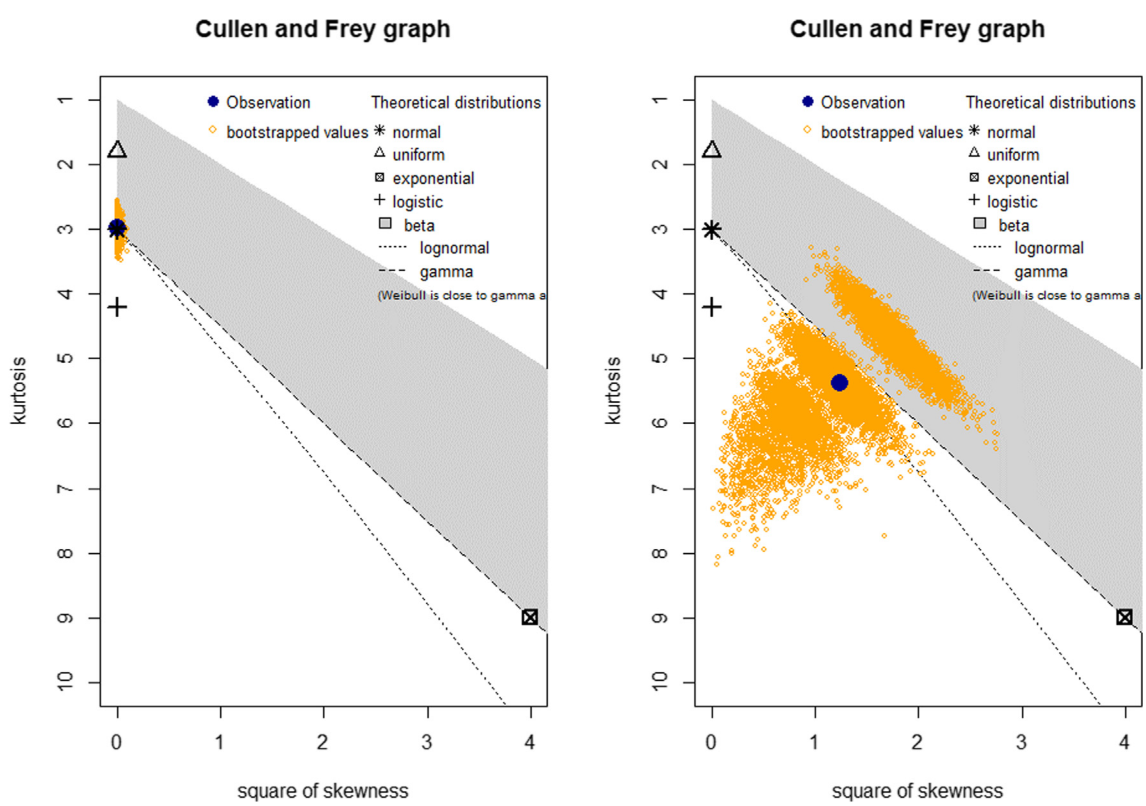

Fig. 7. Distribution Characteristics for QOG and CML.

Table 6
Results of Two step system GMM for full sample.

Variables	Coef.	St.Err.
L.lnGHG	0.997**	0.033
lnCINQ	−0.54***	0.183
lnRES	0.134*	0.069
lnTI	0.057*	0.03
lnQOG	−0.073	0.066
lnCML	0.126*	0.066
lnAE	−0.12***	0.072
Constant	−4.287	0.301
Year Dummy	Yes	
AR(2) P value	0.729	
Hansen test P value	0.85	
Wald chi2	4183.65***	

*** p <.01, ** p <.05, * p <.1.

Table 7
Results of one step GMM for low income country.

Variables	Coef.	St.Err.
L.lnGHG	0.855***	0.081
lnCINQ	−1.946**	1.023
lnRES	0.2	0.114
lnTI	−0.271**	0.111
lnQOG	−1.039	0.812
lnCML	0.877**	0.374
lnAE	0.272	0.176
Constant	−3.409**	1.549
Year Dummy	Yes	
AR(2) P value	0.63	
Hansen test P value	1	
Wald chi2	8.72	

*** p <.01, ** p <.05, * p <.1.

Table 8
Regression results of lower middle income country.

Variables	Coef.	St.Err.
L.lnGHG	0.794***	0.064
lnCINQ	−0.259	0.208
lnRES	−0.285	0.465
lnTI	0.047	0.077
lnQOG	0.023	0.108
lnCML	−0.246*	0.127
lnAE	−0.299	0.193
Constant	1.884**	0.949
Year Dummy	Yes	
AR(2) P value	0.292	
Hansen test P value	1	
Wald chi2	6559.76***	

*** p <.01, ** p <.05, * p <.1.

Table 9
Regression results of one step system GMM result for upper middle income country.

Variables	Coef.	St.Err.
L.lnGHG	0.796***	0.053
lnCINQ	−0.354*	0.186
lnRES	−0.294*	0.171
lnTI	0.142	0.101
lnQOG	0.227	0.171
lnCML	0.042*	0.022
lnAE	0.252	0.179
Constant	0.004	0.1
Year Dummy	Yes	
AR(2) P value	0.326	
Hansen test P value	0.577	
Wald chi2	18791.4***	

*** p <.01, ** p <.05, * p <.1.

Table 10
Results of one step system GMM for high income group.

Variables	Coef.	St.Err.
L.lnGHG	0.637***	0.179
lnCINQ	0.496**	0.232
lnRES	1.263*	0.746
lnTI	−1.94	1.559
lnQOG	−0.008	0.279
lnCML	0.227	0.231
lnAE	−4.128	2.637
Constant	1.923*	1.134
Year Dummy	Yes	
AR(2) P value	0.147	
Hansen test P value	1	
Wald chi2	350.71***	

*** p <.01, ** p <.05, * p <.1.

reduces ecological damage. This point of view is based on the marginal propensity to emit (MPE), which states that environmental degradation fluctuates as wealth distribution changes. Despite their differences, these two perspectives established a vital link between environmental deterioration in terms of GHG and CINEQ. In other words, significant CINEQ in low-income, lower-middle-income, and upper-middle-income correlates to less ecological destruction. One possible argument is that lower Gini index values in the least developed countries may reduce economic competitiveness. Besides, affordability of high-carbon emitting and energy-consuming sources among disadvantaged populations. As a result, a lack of economic rivalr**y** results in a common environmentally friendly source of energy and, as a result, a high level of environmental deterioration in terms of GHG. Another factor is that the small income gap in developing nations makes it difficult for people to invest in new and high-emitting technologies, resulting in enhanced GHG (Uddin et al., 2020; Demir et al., 2019a, 2019b). Hence**,** the current study's findings are intriguing and contradict the work of Boyce (1994a, 1994b). IT proposed that the higher-income difference produces a power imbalance between the elite and bottom classes in a community, which lowers the quality of the environment.

Wealthy individuals benefit from differences in economic position, but impoverishe**d** people bear the environmental consequences. According to Boyce (1994a, 1994b), the rising CINEQ can lead to increased GHG and ecological deterioration. By widening the income gap between rich and poor, wealthy individuals cannot exploit natural resources for their luxurious lifestyles. The results demonstrate that high CINEQ is ecologically beneficial but creates a significant societal challenge. The current study's findings are consistent with those of Grunewald et al. (2017) for Third World countries, Kounetas (2018) for European countries, Uddin et al. (2020) for the Group of Seven (G7), Wang and Ye (2017) for China, and Demir et al. (2019a, 2019b) for Turkey. Conversely, the finding infers that higher-income economies significantly contributed to GHG because affluent individuals strongly impact policymaking in higher-income economies. CINEQ can contribute to political instability since the wealthy embrace policies that overexploit natural resources and export profits offshore (Boyce, 1994a, 1994b).

RES positively and considerably influences GHG worldwide in low-income, lower-middle-income, and higher-income countries. Furthermore, given the statistically significant production, a rise in RES would result in increased GHG. This discovery about the influence of RES on GHG points to natural resource extraction or unsustainable usage of RES. Because the over-exploitation of RES has forced countries to rely on imported energ**y,** such as oil and gas**,** most economies continue to rely on **f**ossil fuels. This conclusion might be connected to the fact that low-income, lower-middle-income, and higher-income countries rely on energy imports to satisfy their energy needs. Rather than using their energy sourc**es**, such as alternative energy sources (water, air, and solar). Countries exploit scarce natural resources in an unsustainable manner for economic gain. A vital resource management system and a good ownership structure might ensure sustainable natural resource consumption. In addition to its economic effects, natural resources may be a curse for development by deceiving policymakers. The resource curse may also contribute to governance issues by showing itself via rent-seeking and corruption in these countries (OECD, 2011).

Additionally, using efficient energy-saving technology leads to improving environmental quality. Furthermore, recycling, reuse, innovation, value-addition, and illusionary sources that replace natural resources can boost economic development while lowering environmental deterioration (Bekun et al., 2019). The findings are consistent with Danish et al. (2019a, 2019b, 2019c), who discovered that RES increases GHG in BRICS economies and South Africa. In contrast, the findings revealed that RES reduces pollution levels in higher-income economies with distinct environmental rules and awareness structures. In this regard, nations' socioeconomic dynamics and systems are critical in getting negative or positive coefficients for natural resources and comparable factors to highlight their influence on environmental degradation (Balsalobre-Lorente et al., 2019).

Furthermore, TI causes GHG majority of countries around the world. One of the possible reasons is that most countries are in the transition stage. Further, the overhead cost of TI makes it challenging to incorporate into manufacturing processes at an initial phase of development for clean production. According to Raiser et al. (2017), most innovators tightly restrict their technical concepts from being shared with third parties. Our findings might be attributed to a reduction in worldwide access to available technology. It is also expected that the shift to technological innovation will be a lengthy process. Albino et al. (2014) observed that some of the world's most advanced nations in innovation do not necessarily lower emissions as they develop. The findings are similar to (Santra, 2017; Destek & Sarkodie, 2019). Alternatively, the results for low-income economies imply that TI significantly cuts GHG.

Additionally, the negative link between TI and the GHG is justified because TI is an essential aspect to be studied and implemented in emerging economies for sustainable development. Furthermore, technical advancements aid in the promotion of GHG and energy efficiency. The moderating impacts of technological evolutions correspond to the findings of (Cho & Sohn, 2018; Mensah et al., 2018; Shahbaz et al., 2020)**.** Besides, the finding depicts that CML considerably contributed to GHG around the globe in low-income and upper-middle-income economies. The result suggested that weak environmental policies enhance corruption and deteriorate ecological degradation. Further, in the case of lower-middle-income economies, CML significantly declines in GHG. The finding is consistent with Barido and Marshal (2014). The outcome shows that AE is negatively linked with GHG around the globe while insignificant for all income groups on GHG.

4. Conclusion and policy recommendations

Massive economic growth is attributed to an increase in income inequality and environmental deterioration. In recent years, a growing number of academics have focused on the role of wealth disparity in climate change. In this study, we examine the effects of income inequality on global carbon emissions. Furthermore, we classified the economies depending on their income level, i.e., low-income, lower-middle-income, upper-income, and higher-income. Moreover, we use the system GMM technique to investigate the CINEQ on GHG. The findings give valuable insights for policymakers seeking to enhance the sustainability of economic growth and address climate change issues.

The outcome proved that CINEQ suggests a significant and negative effect on GHG across the globe and low and upper middle-income sample. On the other hand, the results infer that CINEQ considerably improves the environmental quality in the high-income group. The finding shows an insignificant effect of CINEQ on GHG in lower-middle-income economies. Also, the outcome depicts that RES significantly contributed to GHG over the globe in low-income and higher-income economies. While for, upper income shows a negative effect on GHG. The results infer that TI is positively connected with GHG worldwide and implies an adverse impact on GHG in low-income economies. However, surprisingly the finding highlights that CML meaningfully shows a positive effect on GHG In low-income and upper-middle-income economies. Hence, the outcome for lower-middle-income CML negatively affected GHG.

Our findings on the relationship between CINEQ and GHG suggest the presence of a potential trade-off between both, known as the "equity pollution conundrum," in which income redistribution causes environmental pollution (Sager, 2019a, 2019b). This quandary may have ramifications for measures aimed at promoting redistribution in across the globe. At first glance, the "equity-pollution dilemma," as noted by Sager (2019a, 2019b), does not necessarily imply that redistribution of income is undesirable; instead, the optimized degree of income redistribution law dictates the grasp of behavioural finance and will base on a lot of presumptions regarding market dynamics, domestic well-being, and preferred social outcomes. Another conclusion is that economic redistribution policies in the context of rigorous environmental protection regulations, such as the promotion of renewable energies, would help to improve environmental quality. Furthermore, the relationship between wealth redistribution and the environment will provide an essential platform for developing suitable environmental policies that capitalize on each country's economic benefit and resource endowments. In this sense, such a link recommends that all nations should coordinate their redistributive and environmental policies at both the national and regional levels (Masud et al., 2018; Rasiah et al., 2018).

We suggest the following policy recommendations based on the above findings. First, the government must focus more on the quality of economic development while maintaining stable growth in resident income. Furthermore, while modifying income distribution, it is vital to provide a steady income growth mechanism for low- and middle-income households. Policymakers must guarantee that gains in income for the poor do not result in increased emissions. As a result, by distributing wealth more equally, environmental strain can be decreased**.** Second, policy development and implementation may consider regional carbon emissions disparities. The goal of policies should be to increase society's genera**l** well-being and to decrease regional inequalities in carbon emissions and economic development levels across the globe. All efforts should be directed toward regional convergence. Regions with higher carbon emissions should invest more in guiding poor people's consumption and addressing environmental governance and wealth distribution. The government should raise the rich's obligations in ecological conservation and management, such as collecting environmental taxes connected to income levels. Finally, encouraging a green lifestyle through legislative guidance and increasing residents' environmental knowledge are practical approaches to cutting carbon emissions. The government should provide more environmentally friendly public products and services. As a result, advanced technology may be implemented to help citizens raise their desire for green products. Moreover, various measures such as advantages in tax, incentives for the reduction of carbon as well as financial aid to different entities which produce renewable energy infrastructures should be promoted to reduce emissions. A paradigm shift is required in these countries in order to move from fossil fuel based economies to renewable ones (Bekun, 2022). In this case, quality of governance should be enhanced.

Although, conventional, economically advanced capitalist nations have robust social security systems, and even their low-income populations are doing well globally. As a result, in these nations, it may be better to go forward by implementing fair national income distribution policies, making necessary changes to the welfare system, and achieving a balance between the level of emissions and the standard of life of the population. The optimum outcome of a redistribution project depends on the coordination of different conditions relating to market structure, welfare systems, and social will. It requires a thorough analysis of economic forecasts and environmental assessments. Additionally, by regulating an eco-friendly lifestyle, the government can create a rank levy system for individuals of various income levels. Residents must also raise their level of awareness regarding environmental preservation and GHG reduction.

The limitation of this study is that it only includes 61 countries in the analysis due to the lack of data. However, the number of panels, observations, and periods is sufficient for carrying out the empirical analysis. This study has a significant future recommendation for researchers. The equity-pollution dilemma could be examined by using decomposition analysis. Thus, we can observe whether there is a decoupling between consumption inequality and environmental degradation after the completion of the economic development process. Studies determine that environmental quality can increase by reducing consumption inequality will contribute to the sustainable development literature. Moroever, the study did not include some factors that contribute to environmental degradation because of the restricted availability of data. The socioeconomic, demographic, agricultural, forestry, land use, energy usage, water productivity, value-added agrarian services, and environmental restrictions may all be studied in future studies. Future research may examine the ecological footprint, PM2.5 emissions, ecological footprint, and expenditure on health as dependent variables because this study also examined CO_2 as a dependent variable. Similarly, it is possible to study the relationship between environmental degradation and other disparity indicators, wealth inequality, wage inequality, and the top 1% of earners as independent variables. In addition, the presence of the EKC hypothesis for the same variables will have an impact on literature and policy.

CRediT authorship contribution statement

Qingran Guo: Conceptualization, Formal analysis, Investigation, Resources, Writing – original draft, Supervision. **Waheed Ahmad:** Resources, Formal analysis, Writing – review & editing. **Emrah Sofuoğlu:** Resources, Writing – original draft, Formal analysis. **Shujaat Abbas:** Resources, Supervision, Writing - original draft, Writing - review & editing.

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.

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