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RESEARCH ARTICLE

Towards sustainable development in China: do political rights and civil liberties matter for environmental quality?

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Abstract

China is a rising power of the twenty-first century with its brilliant economic performance as a result of the transition to the free market economy model. However, China's economic development process has caused high environmental costs. For the past decade, China has been the leading country responsible for global carbon dioxide emissions (CO_2). Therefore, determining the dynamics that have a reducing effect on CO_2 emissions in China is very important for the development of sustainable environmental policies. This paper aims to examine the impacts of the institutional structure on environmental sustainability in China. To this end, the study follows the method of cointegration with multiple breaks that produce robust econometric results and consider structural changes. According to the results, (i) the validity of an N-shaped EKC relationship is supported between economic growth and environmental pollution. (ii) Industrialization and trade have an increasing impact on environmental pollution. (iii) Political rights and civil liberties have a reducing effect on environmental pollution. Consequently, this study implies that political rights and civil liberties can make an important contribution to achieving sustainability goals in China.

Keywords Sustainability · Political rights · Civil liberties · Carbon dioxide (CO_2) · Environmental Kuznets Curve (EKC) · China

Introduction

Global warming is one of the most critical problems of the twenty-first century that directly affects our economy, social life, health, policies, and lifestyle (Hasegawa et al. 2016; Lu and Lu 2019; Zhang et al. 2019). The decrease in amounts of snow and ice, the rise in sea level, and the increase in average temperatures are evidence of climate change observed in the last 50 years (IPCC 2014). There is a strong consensus in academic and political circles that the source of this problem is the rapid increase in human-induced greenhouse gas emissions/carbon dioxide (Ur Rahman et al. 2019; Bai et al. 2019; Mele and Randazzo 2019). Industrialization, urbanization, trade, transportation, and energy demand, which are the result of the development of the modern economy is the main dynamics of the increase in greenhouse gases, especially CO_2 (Koçak and Ulucak 2019; Mamipour et al. 2019; Danish et al. 2019; Farhani and Balsalobre-Lorente 2020). As of today, however, the process of economic development is no longer sustainable. In particular, the economic development process based on the use of energy and natural resources is under the threat of instability in economic growth in the long run (Euchi et al. 2018) and is also very risky in terms of environmental quality (Ulucak et al. 2020). As in previous Climate Change summits, the UN Climate Change Conference in Paris (2015) re-emphasizes the urgent necessity of reducing greenhouse gas emissions to combat global warming. Similarly, scientists reiterate their warnings that if greenhouse gases continue to increase, we will pass the threshold of global warming becoming irreversible (Ulucak et al. 2019). Therefore, in many countries, policy makers are under pressure to meet environmental sustainability needs (Omri et al. 2019).

To address the threats of increasing climate change, researchers intensively examine greenhouse gas emissions and especially the dynamics of carbon dioxide (CO_2) emissions

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(Lv 2017; Usman et al. 2019; Koçak et al. 2019; Danish 2019; Zmami and Ben-Salha 2020). The economic literature emphasizes that the driving force behind carbon emissions is the process of economic development. With this approach, many researchers examine the relationship between GDP per capita and environment within the scope of the Environmental Kuznets Curve (EKC) hypothesis (Lægreid and Povitkina 2018; Dogan et al. 2020). In addition, in the EKC model, a wide variety of proxy variables can be used as environmental pollutants (Sinha et al. 2019).

According to this hypothesis, economic activities and growth in the early stages of the economic development process increase environmental pollution (scale effect). The ongoing growth process contributes to the development of new, cleaner, and more efficient technologies. When per capita income reaches a specific turning point in this process, production structure changes and people demand a cleaner environment (structural and technological effects). Eventually, although economic development initially increases environmental pollution, it reduces environmental pollution after the turning point in the long run (Koçak and Şarkgüneşi 2018).

On the other hand, political scientists argue that explaining changes in CO_2 emissions only by economic factors is not an adequate approach. Because changes in emissions are also closely related to environmental policies determined by the institutional structure (Kinda 2016; Lægreid and Povitkina 2018). Therefore, they argue that environmental, energy, and sustainable development issues should be evaluated within an institutional approach (Scott et al. 2011; Zelli and van Asselt 2013; Haque and Ntim 2018).

Recently, however, the economic and political approach has been evaluated together, and the relations between institutions, economic development, and the environment have become a hot topic of discussion in the literature (Abid 2016; Wang et al. 2018; Hassan et al. 2019; Kim et al. 2019). In these theoretical discussions, there is no consensus on the impact of economic development and institutions on environmental quality.

Furthermore, there is not much empirical evidence to support theoretical discussions on institution-economic development and the environment (Adams and Klobodu 2018; Povitkina 2018). Besides, the factors representing the institutions in the researches vary widely. Researchers use many factors such as law, corruption, bureaucracy, regime type (democracy or autocracy), and level of freedom to represent strong or weak institutions (Koçak and Uzay 2018). However, it is argued that democracy is the most potent indicator to represent the institutional structure of a country. The reason for this approach is based on the idea that democracy is a form of government in countries where the rule of law is valid, corruption is low, the bureaucratic structure is effective, and freedoms are protected (Doucouliagos and Ulubaşoğlu 2008; Acemoglu et al. 2019). To represent the institutions, we take into consideration the indicator of democracy and dwell on the relationship between democracy and the environment.

So, what can be said about China within the framework of these discussions?

According to international organizations such as the Freedom House, the Polity IV Project, and The PRS Group, which measure the level of democracy in countries, China is governed by an authoritarian regime and is a non-democratic country. On the other hand, when China is examined in the last 40 years, it is seen that a different and unique institutional structure emerged. After Mao's death in 1976, Deng Xiaoping came to power and began a new and reformist era of China's becoming a regional and internationally recognized player (Yılmaz and Bonaparte 2018). With these reforms, China experienced the transition to a market economy without democracy (Hasan et al. 2009). In this period, the country has changed from an agricultural society to an urban, industrial society, and from a communist to a globally oriented market economy (Yılmaz and Bonaparte 2018). In addition to liberalization, there have been institutional developments in the political and legal environment. China's leaders have long acknowledged the need for political reform and predated the congressional system that involved political electoral processes and institutions. A new state constitution, which emphasized the rule of law, came into force (Hasan et al. 2009). The transition to the market economy, globalization, and institutional developments have partly resulted in the improvement of political rights and civil liberties in China in the last 40 years, although not enough for a democratic regime.

China is undoubtedly the rising power of the twenty-first century, and China's economic performance over the last 40 years has been brilliant (Yılmaz and Bonaparte 2018). Currently, this successful economic performance of China has started to debate the question of whether China's authoritarian capitalism is successful (Chou 2015; Foa 2018). On the other hand, this brilliant economic performance has made China the largest energy consumer and the leading responsible country for global CO_2 emissions. It is well known that there is a close relationship between energy, economic growth, and CO_2 emissions (Hajko et al. 2018). According to the IEA (2018) report, China is responsible for 26% of global CO_2 emissions in 2016. However, China has taken two essential steps within the scope of its sustainable development target recently. Firstly, China prepared a millennium plan for national sustainable development in 2017, and China upgraded its national strategy from environmental protection to ecological civilization (Wang et al. 2020). This concept has attracted much attention both in academic and political circles (Marinelli 2018; Jiang et al. 2019). Second, China has committed to reducing CO_2 emissions by 2030 at the Climate Change Conference (2015) in Paris (Chen et al. 2019). These developments in China add a new question to the discussions of the authoritarian regime-economic development success relationship (Chou 2015; Lo 2015; Teets 2018): Can the authoritarian capitalist regime in China contribute to the improvement of environmental quality?

In this context, this article aims to explore the impact of the political regime in China on CO_2 intensity. Thus seeks an answer to the relevant question. To measure the political system in China, we use the democracy index developed by Freedom House (2018). Freedom House (2018) uses two essential criteria, political rights, and civil liberties, to measure a country's level of democracy (or autocracy). These two criteria are scored as one highest (democracy) and seven lowest (autocracy). The democracy index is calculated by averaging the scores of these two criteria. If the index value is one, that country is a perfect democracy regime.

On the contrary, if the index value is seven, that country is an autocratic regime. As the index value converges to one, the level of democracy in that country increases. As the index value converges to seven, the level of democracy decreases, and autocracy increases. The interpretation of the democracy index seems complicated. Therefore, we recalculate the index by taking the inverse of the index value. Thus, we can consider an increase in the index value as an increase in the level of democracy.

Overall, this paper focuses on the impact of changes in the level of democracy or autocracy on the environment/CO_2, and it firstly aims to examine the relevant literature in detail. Some seminal papers suggest that increases in the level of democracy have a positive effect on the quality of the environment, while other seminal papers state that democracy is putting pressure on environmental pollution. Therefore, the contributions of this paper are two-fold: First, this paper performs some advanced econometric methods such as cointegration and regression analysis to observe the possible positive or negative effects of the political regime on CO_2 intensity in China for the last 40 years. In this way, empirical contributions may be provided to the literature with robust econometric findings. Second, the results of this study for China, which has an authoritarian regime and a free market economy model, are expected to implement an alternative perspective to the discussions on the relationship between democracy and the environment.

The rest of the study is organized as follows. The "Literature" section provides reviews for the literature. The "Materials and methods" section depicts the model, method, and data set. The "Results and discussions" section presents the findings and discussion. The "Conclusion" section exhibits the conclusion of this paper.

Literature

When the theoretical arguments in the literature are evaluated, some of the studies in the literature state that democracy has a positive effect on environmental quality. In contrast, other studies argue that this effect is negative. But the more dominant view in the literature is that democracy improves environmental quality. For this reason, we first consider the arguments that a democratic regime is in favor of environmental quality.

According to Payne (1995), in democratic countries, (i) governments are more responsible and do not ignore the electorate's environmental concerns. (ii) Democracies facilitate greater access to information and enable citizens to learn more about environmental issues. (iii) Informs of government with freedom of expression and association, citizens are more likely to pressure governments on environmental problems and are more likely to organize. (iv) Democratic governments are more motivated to cooperate in international treaties to protect the environment. On the contrary, in autocracies, governments can restrict people's access to information, organization, and expression of their demands and concerns. Similarly, many studies claim that environmentalist voters in countries with democratic institutions have the power to exert pressure and influence on the political mechanism in the environmental policy-making process (Congleton 1992.; Deacon 2000; Li and Reuveny 2006; Schultz and Crockett 1990).

Other arguments about the importance of democracy in protecting the environment are as follows: Dasgupta and Mäler (1995) state that there is a secure link between environmental protection and civil and political rights, and that citizens' environmental quality preferences influence public policy. Magnani (2000) underlines that protected property rights, democratic voting systems, and respect for human rights may lead to higher levels and effectiveness in environmental policies. Lægreid and Povitkina (2018) point to institutional developments as a reason for economic progress to increase demand for a clean environment. Because after the increase in income with the economic progress process, politicians tend to follow environmental policies to maintain the feeling of satisfaction in the electorate. According to Adams and Acheampong (2019), unlike autocracies, democratic regimes contribute more public goods and are therefore more likely to develop strict environmental standards. These differences are expounded by the fact that non-democratic states are often governed by small elites who will be directly affected by a large part of high environmental costs. Mak Arvin and Lew (2011) explain the positive effects of democracy on the environment in several ways. In democratic regimes, (1) the public is more aware of environmental issues. (2) Citizens can protest against environmental problems. (3) The government may fear adverse public reaction if it does not develop or implement environmental protection laws. (4) There can be a collective instinct for positive environmental actions among democratic countries.

We secondly consider the arguments that increase in the level of democracy may impair environmental quality. The first argument emphasizes that democracy is the driving force of economic developments, and therefore, more economic growth will result in more ecological destruction (Desai 1998). This argument is supported by the fact that today's developed countries are both more democratic (see Freedom House (2018)) and have higher CO_2 emissions per capita (see IEA 2018). According to the second argument, democracies strongly protect individual freedoms and property rights. In this way, both individuals and entrepreneurs have the opportunity to exploit their potential to increase production and consumption sufficiently. If environmental regulations are not sufficient, the activities of producers and consumers increase the pressure on the environment (Neumayer 2002). Third, according to Dryzek (1987), lobbying activities in democratic countries may have an impact on government decisions. These activities, which aim to maximize their economic profits, can sometimes harm the environment. For instance, it is highly likely that government officials will be influenced by multinational companies and lobbies that want to influence and control political institutions, the legal and governance process. On the other hand, leaders in autocratic administrations are less likely to be affected by elite groups that are large, powerful, and retain most of the resources (Hatunoğlu and Yılmaz 2018).

When empirical studies on the relationship between democracy and environment are evaluated, we find that the literature findings differ and that the researchers do not provide outputs that strongly support a theoretical argument. Table 1 summarizes the empirical literature results.

The results of empirical researches indicate four possible outcomes. (1) The first group of studies reveals that democracy has a positive impact on environmental quality (Torras and Boyce 1998; Bhattarai and Hammig 2001; Li and Reuveny 2006; Buitenzorgy et al. 2011; Abid 2016; Adams and Klobodu 2017; Adams and Acheampong 2019). (2) The second group of studies shows that the effect of democracy on environmental is different from country to country (You et al. 2015; Lv 2017; Joshi and Beck 2018). According to these results, the impact of democracy on the environment is heterogeneous. (3) The third group studies provide evidence that democracy increases environmental pollution or that autocracy improves environmental quality (Sulemana et al. 2017; Wang et al. 2018; Kim et al. 2019). (4) Finally, there are also studies supporting the results that there is no statistically significant relationship between democracy and environmental quality (Charfeddine and Mrabet 2017; Adams and Klobodu 2018; Usman et al. 2019, 2020). Also, the results of the research are influenced by (a) the development levels of the country or country groups examined, (b) period, (c) pollution indicators, (d) democracy indicators, and (e) methodology (see Table 1).

Materials and methods

EKC is a basic model used to demonstrate the relationship between the environment and economic growth/income. Additionally, many indicators that have an impact on environmental pollution such as trade, energy, institutional quality, and financial development can be added to the EKC model (Bilgili et al. 2016; Zhu et al. 2018; Sarkodie and Strezov 2019; Omri et al. 2019). Following the literature, this paper constructs the following estimation model to examine the impact of democracy on carbon density in China for the period of 1973–2014 within the scope of the EKC hypothesis:

$$\mathrm{lnCI_t} = \beta_0 + \beta_1 \mathrm{lnY_t} + \beta_2 \mathrm{lnY_t^2} + \beta_3 \mathrm{lnY_t^3} + \beta_4 \mathrm{lnPR_t} + \beta 5 \mathrm{lnIND_t} + \beta_6 \mathrm{lnTR_t} + \varepsilon_t \quad (1)$$

In Eq. (1), CI, Y, PR, IND, and TR show CO_2 intensity, GDP per capita, level of democracy, industrialization, and foreign trade volume, respectively. B_0 represents the constant term and $\beta 1, \ldots, \beta 6$ are long-run coefficients that indicate the effect of GDP per capita, the square of GDP per capita, cube of income, democracy, industrialization and trade on CO_2 intensity. In the Eq. (1), t and ε demonstrate period and error terms. The data sets are from annual observations and cover the period of 1973–2014. Natural logarithms of all data were obtained for econometric estimation. Thus, the range difference of the data is reduced. Table 2 provides summary information about the data set, while Table 3 shows descriptive statistics.

When Eq. (1) is estimated, the possible results for the EKC hypothesis are as follows: (i) If $\beta_1 = \beta_2 = \beta_3 = 0$, there is no significant relationship between CO_2 intensity and income. (ii) If $\beta_1 > 0$ and $\beta_2 = \beta_3 = 0$, there is a monotonically increasing relationship between CO_2 intensity and income. (iii) If $\beta_1 < 0$ and $\beta_2 = \beta_3 = 0$, there is a monotonically decreasing relationship between CO_2 intensity and income. (iv) If $\beta_1 < 0$, $\beta_2 > 0$, and $\beta_3 = 0$, there is a U-shaped relationship between CO_2 intensity and income: (v) If $\beta_1 > 0$, $\beta_2 < 0$, and $\beta_3 = 0$, there is an inverse U-shaped relationship between CO_2 intensity and income (EKC is valid). (vi) If $\beta_1 > 0$, $\beta_2 < 0$, and $\beta_3 > 0$, there is an N-shaped relationship between CO_2 intensity and income. (vii) If $\beta_1 < 0$, $\beta_2 > 0$, and $\beta_3 < 0$, there is an inverted N-shaped relationship between CO_2 intensity and income. Finally, the possible consequences for the impact of the political regime on CO_2 intensity are (a) if $\beta_4 = 0$, there is no relationship between democracy (autocracy) and CO_2 intensity. (b) If $\beta_4 < 0$, then an increase in the level of democracy (a decrease in autocracy) has a reducing effect on CO_2 intensity. In this case, democracy is a better regime for the environmental quality. (c) If $\beta_4 > 0$, then an increase in the level of democracy (a decrease in autocracy) has an increasing effect on CO_2 intensity. In this case, autocracy is a better regime for the environmental quality.

Estimation of the regression coefficients that reveal the relationships between the variables is of great interest in the literature. For researchers, Gauss-Markov statistical properties, or best linear unbiased estimators, should achieve the

Table 1 Summary of the empirical literature on democracy-environmental nexus

Author (s)	Country	Period	Method	Pollution indicator	Result
Panayotou (1997)	30 developed and developing countries	1982–1994	Fixed effect (FE), random effect (RE)	SO2	The quality of institutions reduces environmental degradation in high and low-income countries.
Torras and Boyce (1998)	58 countries	1977–1991	Ordinary least squares (OLS)	Water and air pollution indicators	Political rights and civil liberties have a positive effect on the quality of the environment.
Bhattarai and Hammig (2001)	66 countries of Latin America, Africa, and Asia	1972–1991	FE, RE	Deforestation	Improvements in democracy significantly reduce deforestation.
Farzin and Bond (2006)	200 countries	1980–1998	FE	CO_2, NO_x, VOC, SO_2	Democratic regimes respond positively to the environmental demands of the people.
Li and Reuveny (2006)	143 countries	1961–1997	Two-way FE	CO_2, NO_2, organic pollution, deforestation	Democracy reduces all pollution indicators.
Culas (2007)	14 tropical developing countries	1972–1994	FE, RE, generalized least squares (GLS)	Deforestation	Institutional quality reduces environmental pollution.
Gallagher and Thacker (2008)	31 developing countries	1960–2001	FE	SO_2, CO_2	Democracy does not affect SO_2 and CO_2 emissions in the short-run but reduces them in the long-run.
Bernauer and Koubi (2009)	42 countries	1971–1996	FE, RE	SO_2	Democracy has a reducing effect on pollution emissions.
Buitenzorgy et al. (2011)	177 countries	1990–2000	OLS	Deforestation	Democracy has a reducing effect on deforestation.
Hosseini and Kaneko (2013)	129 countries	1980–2007	Seemingly unrelated regressions (SUR)	CO_2 intensity	Democracy has a reducing effect on CO_2 intensity.
You et al. (2015)	97 countries	1985–2005	Panel quantile regression	CO_2	The impact of democracy on CO_2 emissions is heterogeneous, or the effect varies from country to country.
Abid (2016)	Sub-Saharan Africa economies	1996–2010	Generalized method of moments (GMM)	CO_2	Democracy has a reducing effect on CO_2.
Charfeddine and Mrabet (2017)	15 MENA countries	1975–2007	Panel cointegration, dynamic OLS, fully modified OLS, causality	CO_2	Institutional developments do not have a reducing effect on environmental pollution.
Sulemana et al. (2017)	African and OECD countries	1990–2010	FE, RE	CO_2, PM_{10}	There is no significant relationship between institutional quality and CO_2 emission for African and OECD countries. Democracy has an increasing effect on PM_{10} in Africa.
Lv (2017)	19 emerging countries	1997–2010	Panel quantile regression	CO_2	The impact of democracy on CO_2 emissions is heterogeneous.
Adams and Klobodu (2017)	38 African countries	1970–2011	Panel cointegration, D-OLS	CO_2	Democracy and bureaucratic quality have a reducing effect on CO_2.
Adams and Klobodu (2018)	26 African countries	1985–2011	GMM	CO_2	Institutional variables do not have a significant effect on CO_2.
Joshi and Beck (2018)	22 OECD and 87 non-OECD countries	1995–2010	GMM	CO_2	The effect of democracy on CO_2 is heterogeneous, or the effect varies from country to country.

Table 1 (continued)

Author (s)	Country	Period	Method	Pollution indicator	Result
Wang et al. (2018)	G20 countries	2000–2014	Panel quantile regression	$PM_{2.5}$	Democracy increases $PM_{2.5}$ emissions in countries with high emissions. Democracy does not affect $PM_{2.5}$ emissions in countries with low emissions.
Adams and Acheampong (2019)	46 sub-Saharan African countries	1980–2015	GMM	CO_2	Democracy has a reducing effect on CO_2.
(Kim et al. (2019)	132 high- and low-income countries	2014–2016	RE	environmental quality index	Democracy affects increasing environmental quality in high-income countries. Democracy has no impact on environmental quality in low-income countries.
Usman et al. (2019)	India	1971–2014	Autoregressive distributed lag (ARDL)	CO_2	Democracy has no significant effect on carbon.
Le and Ozturk (2020)	Emerging Market and Developing Economies	1990–2014	Panel regression with cross-section dependence	CO_2	Governments' financial and governance activities increase carbon dioxide emissions.
(Usman et al. 2020)	South Africa	1971–2014	Bayer-Hanck cointegration, FM-OLS	CO_2	There is no significant relationship between democracy and CO2 emission.

following two conditions. First, each of the regression variables should be stationary in their level values, or their degree of integration should be zero [I (0)]. In this case, the regression results for parameter estimation are reliable. Second, if each of the variables is stationary at the first differences [I (1)], for the estimation parameters to be reliable, there must be a linear combination/cointegration relationship between the series. Otherwise, regression estimation is misleading, and conventional t, Wald, and F statistics can produce biased and ineffective results (Bilgili 2012). Therefore, in the first step of the analysis, it should be investigated whether the series is stationary or contains a unit root.

Traditional unit root tests developed by Dickey and Fuller (hereafter ADF 1981) and Phillips and Perron (hereafter PP 1988) are widely used in econometrics literature. For both tests, the null hypothesis that the series contains the unit root is investigated by the ADF and PP test statistics. If the test statistics are less than the critical values, the null hypothesis is rejected. According to unit root test results, if the series is stationary, regression parameters can be obtained by estimators such as the traditional OLS method. However, if the series is stationary at first differences rather than level values, then researchers should confirm the existence of the cointegration relationship before estimating the regression parameters. Otherwise, a spurious regression problem occurs.

Engle and Granger (1987), Johansen (1988), Johansen and Juselius (hereafter JJ 1990) and Pesaran et al. (2001) developed by cointegration methods are used extensively in the literature. These methods assume that long-term cointegration parameters do not change over time. However, there are many

Table 2 Summary information about the dataset

Abbreviation	Variable type	Definition	Source
lnCI	Dependent variable	CO_2 intensity (kg per kg of oil equivalent energy use)	World Bank
lnPR	Explanatory variable	Democracy index (average of political rights and civil liberties)	Freedom House
lnY	Explanatory variable	GDP per capita (constant 2010 US$)	World Bank
lnIND	Control variable	Industry (including construction), value added (% of GDP)	World Bank
lnTR	Control variable	Trade (% of GDP)	World Bank

Table 3 Descriptive statistics

	lnCI	lnPR	lnY	lnIND	lnTR
Mean	1.074	0.154	6.989	3.808	3.306
Median	1.105	0.153	6.961	3.817	3.495
Maximum	1.244	0.166	8.715	3.872	4.166
Minimum	0.814	0.142	5.553	3.714	2.079
Std. dev.	0.127	0.009	1.010	0.040	0.626
Jarque-Bera	3.910	3.144	2.805	2.682	3.416
(Probability)	0.141	0.207	0.245	0.265	0.187

structural elements such as economic crises, technological shocks, institutional developments, policy, and regime changes that may affect the long-run relationship between variables. These structural changes cause breaks in time series. Therefore, cointegration tests, which consider structural breaks in the estimation of long-run relationships, provide more robust results. To eliminate this assumption, Gregory and Hansen (1996) developed a method of cointegration, taking into account one structural break. Hatemi-J (2008) extended this method and put forward cointegration tests considering two structural breaks. Recently, Maki (2012) has developed a cointegration test that can estimate up to five structural breaks. For robust findings, this paper first performs the JJ cointegration test and then employs the structural breaks cointegration test of Maki (2012) because of the advantages estimating multiple breaks.

Maki (2012) calculates the possible breakpoints and t statistics for each period to test the null hypothesis that there is no cointegration relationship. The test procedure introduces 4 models for testing cointegration under the assumption of multiple breakpoints:

Model 0:

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \beta' X_t + \mu_t \quad (2)$$

Model 1:

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \gamma t + \beta' X_t + \mu_t \quad (3)$$

Model 2:

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \beta' x_t + \sum_{i=1}^{k} \beta_i' x_t D_{i,t} + \mu_t \quad (4)$$

Model 3:

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \gamma t + \sum_{i=1}^{k} \gamma_i t D_{i,t} + \beta_i' x_t + \sum_{i=1}^{k} \beta_i' x_t D_{i,t} + u_t \quad (5)$$

where t = 1, 2, …., T.y_t and $x_t = (x_t, \ldots, x_{mt})'$ are observable variables, and u_t indicates the error term. Equations (2–5) indicate level break (C), trend break (C/T), regime change (C/S), and trend break (C/T/S), respectively. For each model, it is decided that there is a cointegration relationship between the series if the calculated test statistics are greater than the critical values. Critical values are determined by Monte Carlo simulation, and Maki (2012) is reported in Table 1.

After confirming the cointegration relationship, the next step is to estimate the long-run regression coefficients. The dynamic least squares (D-OLS) method developed by Stock and Watson (1993) is an effective method for estimating long-run coefficients. The DOLS estimator is a dynamic method that includes lagged values of independent variables in the estimation model. It provides robust estimation in the presence of endogeneity and autocorrelation. A standard DOLS estimator is shown in the following equation:

$$y_t = \alpha_0 + \alpha_1 t + \alpha_2 x_t + \sum_{i=-q}^{q} \delta_i \Delta x_{t-i} + \varepsilon_t \quad (6)$$

In Eq. (6), Y, t, x, q, Δ, and ε represent the dependent variable, period, independent variable, lag length, first difference operator, and the error term, respectively. This paper also uses the OLS estimator, the FMOLS estimator developed by Phillips and Hansen (1990), and the canonical cointegration regression (CCR) estimator developed by Park (1992) as an alternative to DOLS estimates for robustness control.

Results and discussions

Unit root test results are reported in Table 4. According to the findings, there is a unit root in the level values of the variables. In other words, series are not stationary in level values. In this case, the first differences of the variables are calculated and the unit root test is applied again. Accordingly, all of the variables are stationary in their first differences, i.e., I(1).

Table 4 Unit root test results

Variables		ADF		PP	
		Level	First difference	Level	First difference
lnCI		− 1.817	− 6.544[a]	− 1.733	− 6.433[a]
lnY		− 3.150	− 3.268[b]	− 3.031	− 4.215[a]
lnPR		− 2.312	− 6.154[a]	− 2.311	− 6.164[a]
lnIND		− 2.507	− 5.207[a]	− 2.322	− 5.268[a]
lnTR		− 1.119	− 5.595	− 1.269	− 5.5945[a]
Critical values	1%	− 4.198	− 4.205	− 4.198	− 4.205
	5%	− 3.523	− 3.526	− 3.523	− 3.526
	10%	− 3.192	− 3.194	− 3.192	− 3.194

[a] and [b] show statistical significance at the 1% and 10% level. Estimates of the intercept and trend model are reported

Table 5 Cointegration test without structural breaks

Trace test				Maximum eigenvalue test			
Null hypothesis	Alternative hypothesis	Test statistic	Critical value (5%)	Null hypothesis	Alternative hypothesis	Test statistic	Critical value (5%)
$r=0$	$r>0$	79.753*	69.818	$r=0$	$r=1$	33.969*	33.878
$r\leq 1$	$r>1$	46.083	47.851	$r=1$	$r=2$	20.410	27.584
$r\leq 2$	$r>2$	25.672	29.797	$r=2$	$r=3$	18.155	21.131
$r\leq 3$	$r>3$	7.517	15.494	$r=3$	$r=4$	7.317	14.264
$r\leq 4$	$r>4$	0.199	3.841	$r=4$	$r=5$	0.199	3.841

All model selection criteria show 1 as the lag length. r shows the number of the cointegrating vector. * indicates 5% statistical significance

Since the variables in the analysis are stationary in the first differences, the cointegration relationship between the variables should be confirmed before estimating the regression parameters. Firstly, this paper shows the JJ cointegration test results, which do not account for structural breaks in Table 5. According to JJ test results, both trace and maximum eigenvalue statistics confirm a long-run cointegration relationship between variables.

However, to make a more objective decision on the existence of a long-run relationship, this paper secondly follows the cointegration test developed by Maki (2012), which takes into account structural breaks. Table 6 shows the cointegration test results with structural breaks. According to the test results, three of the four models reject the null hypothesis that there is no cointegration relationship between the variables.

Maki (2012) cointegration test results indicate significant dates of structural change in China. The years 1979, 1983, and 1988 refer to Deng's rules. During this period, China started implementing many economic reforms, such as the free market and outward opening out. The main goal of this period was to transform China into a modern and developed socialist state. This transformation took into account modernization in the fields of industry, agriculture, national defense, science, and technology (Dernberger 1999). Also, the end of the 1980s was a period in which student movements were intensified apart from economic transformation. Although there was no change in the regime, these movements were an anchor indicator for democracy (Yang and Zhao 2015). Finally, 1998 and 2008 imply periods of the Asian Crisis (1997 and later) and the Global Financial Crisis, respectively.

Both the JJ and Maki (2012) cointegration tests demonstrate the existence of a long-run equilibrium relationship between carbon intensity, GDP per capita, democracy, industrialization, and trade in China for the period 1973–2014. The final step after confirming the cointegration relationship is the estimation of the long-run regression coefficients. Table 7 shows the estimation results of D-OLS and other alternative methods.

Table 6 Cointegration test with structural breaks

Model	Test stat.	Critical values*			Break dates
		1%	5%	10%	
C	− 6.832[a]	− 6.501	− 5.992	− 5.714	1983; 1988; 2008
C/T	− 6.753[a]	− 6.741	− 6.214	− 5.974	1983; 1988; 2008
C/S	− 7.753[b]	− 8.336	− 7.803	− 7.481	1988; 1998; 2008
C/T/S	− 6.256	− 8.865	− 8.254	− 7.977	1979, 1998; 2008

* Critical values are obtained from Table 1 in Maki (2012). [a] and [b] show statistical significance at the 1% and 10% level

Table 7 Long-run parameter estimation without structural breaks

Regressor	D-OLS	FM-OLS	CCR	OLS
β_1	7.034* (5.08)	6.692* (6.39)	6.594* (6.46)	7.034* (6.80)
β_2	− 0.959* (− 4.86)	− 0.961* (− 6.12)	− 0.901* (− 6.13)	− 0.961* (− 6.51)
β_3	0.043* (4.70)	0.041* (5.83)	0.040* (5.86)	0.043* (6.235)
β_4	− 0.232** (− 2.38)	− 0.194* (− 2.86)	− 0.186** (− 2.36)	− 0.323* (− 3.08)
β_5	0.355** (2.25)	0.310** (2.59)	0.307* (2.74)	0.359* (3.01)
β_6	0.037* (1.23)	0.053*** (1.91)	0.052*** (1.89)	0.040*** (1.71)
Constant	− 16.471* (− 4.93)	− 16.908* (− 6.60)	− 16.668* (− 6.28)	− 17.984* (− 6.95)
First turning point	1.330$	1.090$	1.400$	1.240$
Second turning point	26.900$	29.700$	23.860$	26.000$
Diagnostic				
R^2	0.945	0.944	0.941	0.948
Adj. R^2	0.933	0.937	0.936	0.939
S.E. of regression	0.025	0.025	0.025	0.024
Durbin-Watson	1.886	1.884	1.913	1.903

*, **, and *** indicate statistical significance at the 1%, 5%, and 10% level, respectively. The value in parentheses is the t-statistic

Estimation results without structural breaks are as follows:

(1) Since $\beta_1 > 0$, $\beta_2 < 0$, and $\beta_3 > 0$, there is an N-shaped EKC relationship between CO_2 intensity and GDP per capita in China. An N-shaped EKC relationship indicates a relationship between pollution and income, first increasing, then decreasing, and then increasing again. The turning points for China are then calculated.[1] The first turning point where pollution begins to decrease is in the range of about 1.100–1.400 USD. The second turning point in which pollution starts to increase again is calculated in the range of approximately 23.000–30.000 USD.

The possible cause of this situation is that the scale effect exceeds the technical effect and that after the emergence of technical aging, economic growth starts to increase the level of environmental pollution again (Balsalobre et al. 2015; Sinha et al. 2017). In other words, the scale effect in China is more dominant than the structural and technological effects in the long run.

(2) All estimators show that an increase in political rights and civil liberties (democracy) has a diminishing effect on CO_2 intensity. That is, an authoritarian regime decreases the quality of the environment. This finding supports the theoretical outputs that the increase in the level of democracy improves environmental quality (Deacon 2000; Li and Reuveny 2006; Mak Arvin and Lew 2011; Payne 1995; Schultz and Crockett 1990).

Today, China is an autocratic country based on a free market economy (Freedom house 2018). Despite the weak democracy score, with reforms since 1976, China has demonstrated institutional development performance on elections, rule of law, and constitutional guarantee (Hasan et al. 2009). According to our findings, developments in this long-term institutional structure contribute to the improvement of environmental quality.

(3) Industrialization and trade have an increasing effect on CO_2 intensity. This result shows that the process of modernization and outward expansion in China increases environmental pollution.

Table 8 presents the estimated parameter results by considering the structural breaks in China. The structural break dates are founded on model 0 (C) results in Maki (2012). According to the test results, (1) there is an N-shaped relationship between GDP per capita and CO_2 intensity. The first turning point in which pollution begins to decrease is in the range of 1000–1500 USD, while the second turning point in which pollution starts to increase is 14.000–20.000 USD.

(2) Political rights and civil liberties have a reducing effect on environmental pollution. So, considering the structural breaks, it is concluded that the increase in the authoritarian regime level in China harms the quality of the environment. (3) The industrialization has an increasing effect on environmental pollution. While trade increases environmental pollution according to D-OLS and FM-OLS results, it does not have a significant impact on the environment according to CCR and OLS findings. Estimation findings are mostly consistent with each other.

Finally, the effect of structural changes in China on CO_2 intensity is as follows: (i) Opening-up and transition to a free market economy have an impact on increasing environmental pollution. (ii) According to all estimators, the parameter of the global financial crisis period is statistically insignificant. In other words, the global financial crisis has no significant effect on CO_2 intensity.

Table 8 Long-run parameter estimation with structural breaks

Regressor	D-OLS	FM-OLS	CCR	OLS
β_1	5.852* (6.22)	6.023* (7.81)	5.913* (7.80)	5.985* (5.41)
β_2	− 0.845* (− 6.63)	− 0.831* (− 7.11)	0.832* (− 7.48)	− 0.831* (− 5.61)
β_3	0.041* (6.44)	0.038* (8.02)	0.038* (7.80)	0.038* (5.63)
β_4	− 1.073* (− 3.29)	− 1.036* (− 4.90)	− 1.039* (− 4.38)	− 1.056* (− 2.86)
β_5	0.552* (5.43)	0.571* (6.48)	0.558* (6.45)	0.581* (4.72)
β_6	0.020*** (1.63)	0.018* (3.08)	0.013 (1.48)	0.012 (1.51)
D_1 (1983)	0.072* (3.35)	0.074* (5.07)	0.077* (4.06)	0.070* (2.92)
D_2 (1988)	0.046** (2.45)	0.037* (3.13)	0.037* (2.74)	0.042** (2.13)
D_3 (2008)	0.032 (1.06)	0.035 (1.55)	0.035 (1.37)	0.035 (1.52)
Constant	− 15.021 (− 6.46)	− 15.392 (− 7.93)	− 15.187 (− 7.60)	− 15.284* (− 5.62)
Diagnostic				
First turning point	1.200$	1.270$	1.010$	1.480$
Second turning point	19.900$	14.700$	18.000$	15.500$
R^2	0.942	0.930	0.940	0.931
Adj. R^2	0.925	0.911	0.921	0.917
S.E. of regression	0.020	0.020	0.020	0.020
Durbin-Watson	1.894	1.891	1.896	1.895

*, **, and *** indicate statistical significance at the 1%, 5%, and 10% level, respectively. The value in parentheses is the t-statistic

[1] The turning point formula for a cubic EKC model is as follows (Lorente and Alvarez-Herranz 2016):

$$Y_j = \frac{\beta 2 \pm \sqrt{\beta 2^2 - 3\beta 1 \beta 3}}{3\beta 3}, \ j = 1,2.$$

Y_1 and Y_2 are the first and second turning points, respectively. Exp (Y^*) is used to calculate the monetary value of the turning points.

Conclusion

At the end of the 1970s, China started the transition to a free-market economy without democracy. However, this process also manifested itself in institutional developments, including the political and legal environment. The transition to the market economy, globalization, and institutional developments has led, in part, to the improvement of political rights and civil liberties in China in the last 40 years. Considering the last 40 years of economic and institutional developments in China, this paper examines the impact of the political regime on environmental quality within the framework of the EKC model by employing the cointegration analysis. Analysis results show that political rights and civil liberties in China have a positive impact on environmental quality. Although China has an authoritarian political regime, this paper argues that policies towards institutional developments that increase political rights and civil liberties can make a significant contribution to environmental quality. Besides, this paper concludes that there is an N-shaped EKC relationship between GDP per capita and environmental pollution in China. This result may indicate that the scale effect in China is stronger than the structural and technological effects.

Although this paper contributes to the literature with its findings on China regarding the relationship between democracy (autocracy) and the environment, it has some limitations. First, we represented the level of democracy or autocracy with the index measured by the Freedom House. In future research, political regime measurement methods developed by Polity IV Project, V-Dem, and PRS Group may be used. Second, considering the current state of the Chinese economy, its global impact and leadership in greenhouse gas emissions, further research is needed on China regarding institutional quality-economic development and environmental quality relationships. Third, we considered the CO_2 intensity as an indicator of environmental pollution. However, the relationship between the political regime and the environment may be tested by indicators such as ecological footprint, water pollutants-wastewater, other greenhouse gases, deforestation, and biodiversity. Finally, the current literature focuses more on countries with a democratic regime. We especially focused on China, which has conditions for a free market economy but governed by autocracy. Therefore, future research may examine the relationship between the political regime and the environment, using linear and nonlinear methods such as causality tests, wavelet transform, and panel data tests, especially in other countries with authoritarian regimes.

References

Abid M (2016) Impact of economic, financial, and institutional factors on CO2 emissions: evidence from sub-Saharan Africa economies. Util Policy 41:85–94. https://doi.org/10.1016/j.jup.2016.06.009

Acemoglu D, Naidu S, Restrepo P, Robinson JA (2019) Democracy does cause growth. J Polit Econ 127:47–100. https://doi.org/10.1086/700936

Adams S, Acheampong AO (2019) Reducing carbon emissions: the role of renewable energy and democracy. J Clean Prod 240:118245. https://doi.org/10.1016/j.jclepro.2019.118245

Adams S, Klobodu EKM (2017) Urbanization, democracy, bureaucratic quality, and environmental degradation. J Policy Model 39:1035–1051. https://doi.org/10.1016/j.jpolmod.2017.04.006

Adams S, Klobodu EKM (2018) Financial development and environmental degradation: does political regime matter? J Clean Prod 197:1472–1479. https://doi.org/10.1016/j.jclepro.2018.06.252

Bai Y, Deng X, Jiang S, Zhao Z, Miao Y (2019) Relationship between climate change and low-carbon agricultural production: a case study in Hebei Province, China. Ecol Indic 105:438–447. https://doi.org/10.1016/j.ecolind.2018.04.003

Balsalobre D, Álvarez A, Cantos JM (2015) Public budgets for energy RD&D and the effects on energy intensity and pollution levels. Environ Sci Pollut Res 22:4881–4892. https://doi.org/10.1007/s11356-014-3121-3

Bernauer T, Koubi V (2009). Effects of political institutions on air quality. Ecol Econ 68(5):1355–1365

Bhattarai M, Hammig M (2001) Institutions and the environmental Kuznets curve for deforestation: a crosscountry analysis for Latin America, Africa and Asia. World Dev 29:995–1010. https://doi.org/10.1016/S0305-750X(01)00019-5

Bilgili F (2012) The impact of biomass consumption on CO2 emissions: cointegration analyses with regime shifts. Renew Sust Energ Rev 16:5349–5354. https://doi.org/10.1016/J.RSER.2012.04.021

Bilgili F, Koçak E, Bulut Ü (2016) The dynamic impact of renewable energy consumption on CO2 emissions: a revisited environmental Kuznets curve approach. Renew Sust Energ Rev 54. https://doi.org/10.1016/j.rser.2015.10.080

Buitenzorgy M, Mol APJ et al (2011) Does democracy lead to a better environment? Deforestation and the democratic transition peak. Environ Resour Econ 48:59–70. https://doi.org/10.1007/s10640-010-9397-y

Charfeddine L, Mrabet Z (2017) The impact of economic development and social-political factors on ecological footprint: a panel data analysis for 15 MENA countries. Renew Sust Energ Rev 76:138–154

Chen J, Yuan H, Tian X, Zhang Y, Shi F (2019) What determines the diversity of CO2 emission patterns in the Beijing-Tianjin-Hebei region of China? An analysis focusing on industrial structure change. J Clean Prod 228:1088–1098. https://doi.org/10.1016/j.jclepro.2019.04.267

Chou M (2015) The rise of China and the decline of democracy in Australia? Aust J Int Aff 69:637–644. https://doi.org/10.1080/10357718.2015.1081146

Congleton R (1992) Political institutions and pollution control. https://doi.org/10.2307/2109485

Culas RJ (2007) Deforestation and the environmental Kuznets curve: An institutional perspective. Ecological Economics 61(2–3): 429–437

Danish (2019) Moving toward sustainable development: the relationship between water productivity, natural resource rent, international trade, and carbon dioxide emissions. Sustain Dev sd 2007. https://doi.org/10.1002/sd.2007

Danish UR, Khan SU et al (2019) Mitigation pathways toward sustainable development: is there any trade-off between environmental regulation and carbon emissions reduction? Sustain Dev sd 2032. https://doi.org/10.1002/sd.2032

Dasgupta P, Mäler KG (1995) Chapter 39 poverty, institutions, and the environmental resource-base. Handb Dev Econ 3:2371–2463

Deacon RT (2000) The political economy of environmentdevelopment relationships: A preliminary framework Nota di Lavoro No. 3. 2000, Fondazione Eni Enrico Mattei (FEEM), Milano

Dernberger RF (1999) The People's Republic of China at 50: the economy. The China Quarterly 159: 606–615

Desai U (1998) Environment, economic growth, and government in developing countries. In: Desai U (ed) Ecological policy abd politics in developing countries: economic growth, democracy and environment, Primera edn. State University of New York Press, Albany, pp 1–45

Dickey DA, Fuller WA (1981) Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica 49:1057. https://doi.org/10.2307/1912517

Dogan E, Ulucak R, Kocak E, Isik C (2020) The use of ecological footprint in estimating the environmental Kuznets curve hypothesis for BRICST by considering cross-section dependence and heterogeneity. Sci Total Environ 723:138063. https://doi.org/10.1016/j.scitotenv.2020.138063

Doucouliagos H, Ulubaşoğlu MA (2008) Democracy and economic growth: a meta-analysis. Am J Polit Sci 52:61–83. https://doi.org/10.1111/j.1540-5907.2007.00299.x

Dryzek JS (1987) Rational ecology: environment and political economy. Ration Ecol Environ Polit Econ 18:70. https://doi.org/10.2307/2071946

Engle RF, Granger CWJ (1987) Co-integration and error correction: representation, estimation, and testing. Econometrica 55:251. https://doi.org/10.2307/1913236

Euchi J, Omri A, Al-Tit A (2018) The pillars of economic diversification in Saudi Arabia. World Rev Sci Technol Sustain Dev 14:330–343. https://doi.org/10.1504/WRSTSD.2018.095719

Farhani S, Balsalobre-Lorente D (2020) Comparing the role of coal to other energy resources in the environmental Kuznets curve of three large economies. Chin Econ 53:82–120. https://doi.org/10.1080/10971475.2019.1625519

Farzin YH, Bond CA (2006) Democracy and environmental quality. Journal of Development Economics 81(1): 213–235.

Foa RS (2018) Modernization and authoritarianism. J Democr 29:129–140. https://doi.org/10.1353/jod.2018.0050

Freedom House (2018) https://freedomhouse.org/country/china/freedom-world/2018 date of access: September 29, 2019

Gallagher KP, Thacker SC (2008) Democracy, income, and environmental quality PERI Working Papers 124

Gregory AW, Hansen BE (1996) Residual-based tests for cointegration in models with regime shifts. J Econ 70:99–126. https://doi.org/10.1016/0304-4076(69)41685-7

Hajko V, Sebri M, Al-Saidi M, Balsalobre-Lorente D (2018) The energy-growth nexus: history, development, and new challenges. In The economics andeconometrics of the energy-growth nexus. Academic Press, Cambridge, p 1–46

Haque F, Ntim CG (2018) Environmental policy, sustainable development, governance mechanisms and environmental performance. Bus Strateg Environ 27:415–435. https://doi.org/10.1002/bse.2007

Hasan I, Wachtel P, Zhou M (2009) Institutional development, financial deepening and economic growth: evidence from China. J Bank Financ 33:157–170. https://doi.org/10.1016/j.jbankfin.2007.11.016

Hasegawa T, Fujimori S, Takahashi K, Yokohata T, Masui T (2016) Economic implications of climate change impacts on human health through undernourishment. Clim Chang 136:189–202. https://doi.org/10.1007/s10584-016-1606-4

Hassan ST, Danish KSU-D et al (2019) Role of institutions in correcting environmental pollution: an empirical investigation. Sustain Cities Soc 53:101901. https://doi.org/10.1016/j.scs.2019.101901

Hatemi-J A (2008) Tests for cointegration with two unknown regime shifts with an application to financial market integration. Empir Econ 35:497–505. https://doi.org/10.1007/s00181-007-0175-9

Hatunoğlu H;Yılmaz GS (2018) SİYASET, EKONOMİ ve YÖNETİM ARAŞTIRMALARI DERGİSİ

Hosseini, HM, Kaneko S (2013) Can environmental quality spread through institutions? Energy Policy 56:312–321

International Energy Agency (IEA) (2018) World energy outlook

IPCC (2014) Climate change 2014: synthesis report. Contribution of working groups I, II, and III to the fifth assesment report of the intergovernmental panel on the climate change. Geneva, Switzerland

Jiang B, Bai Y, Wong CP, Xu X, Alatalo JM (2019) China's ecological civilization program–implementing ecological redline policy. Land Use Policy 81:111–114. https://doi.org/10.1016/j.landusepol.2018.10.031

Johansen S (1988) Statistical analysis of cointegration vectors. J Econ Dyn Control 12:231–254. https://doi.org/10.1016/0165-1889(88)90041-3

Johansen S, Juselius K (1990) Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. Oxf Bull Econ Stat 52:169–210. https://doi.org/10.1111/j.1468-0084.1990.mp52002003.x

Joshi P, Beck K (2018) Democracy and carbon dioxide emissions: assessing the interactions of political and economic freedom and the environmental Kuznets curve. Energy Res Soc Sci 39:46–54. https://doi.org/10.1016/j.erss.2017.10.020

Kim S, Baek J, Heo E (2019) A new look at the democracy-environment nexus: evidence from panel data for high- and low-income countries. Sustain 11. https://doi.org/10.3390/su11082353

Kinda SR (2016) Democratic institutions and environmental quality: effects and transmission channels. SSRN Electron J. https://doi.org/10.2139/ssrn.2714300

Koçak E, Şarkgüneşi A (2018) The impact of foreign direct investment on CO2 emissions in Turkey: new evidence from cointegration and bootstrap causality analysis. Environ Sci Pollut Res 25:790–804. https://doi.org/10.1007/s11356-017-0468-2

Koçak E, Ulucak ZŞ (2019) The effect of energy R&D expenditures on CO2 emission reduction: estimation of the STIRPAT model for OECD countries. Environ Sci Pollut Res 26:14328–14338. https://doi.org/10.1007/s11356-019-04712-2

Koçak E, Uzay N (2018) Democracy, economic freedoms and economic growth: an investigation on the role of institutions. Sosyoekonomi 81–102. https://doi.org/10.17233/sosyoekonomi.2018.02.05

Koçak E, Ulucak R, Dedeoğlu M, Ulucak ZŞ (2019) Is there a trade-off between sustainable society targets in sub-Saharan Africa? Sustain Cities Soc 51:101705. https://doi.org/10.1016/J.SCS.2019.101705

Lægreid OM, Povitkina M (2018) Do political institutions moderate the GDP-CO 2 relationship? Ecol Econ 145:441–450. https://doi.org/10.1016/j.ecolecon.2017.11.014

Le HP, Ozturk I (2020) The impacts of globalization, financial development, government expenditures, and institutional quality on CO2 emissions in the presence of environmental Kuznets curve. Environ Sci Pollut Res 27:1–18. https://doi.org/10.1007/s11356-020-08812-2

Li Q, Reuveny R (2006) Democracy and environmental degradation. Int Stud Q 50:935–956. https://doi.org/10.1111/j.1468-2478.2006.00432.x

Lorente DB, Alvarez-Herranz A (2016) An approach to the effect of energy innovation on environmental Kuznets curve: an introduction to inflection point the anthropogenic effect of energy, tourism and agricultural consumption view project 2012. El estado actual de la reforma laboral:historia, economía y treinta años de relaciones laborales View project

Lo K (2015) How authoritarian is the environmental governance of China? Environ Sci Pol 54:152–159

Lu W, Lu W (2019) Industrial water-use technical efficiency and potential reduction of CO 2 emissions : evidence from industry-level data of CO 2 emissions : evidence from industry-level data. Carbon Manag 10:513–522. https://doi.org/10.1080/17583004.2019.1661733

Lv Z (2017) The effect of democracy on CO2 emissions in emerging countries: does the level of income matter? Renew Sust Energ Rev 72:900–906. https://doi.org/10.1016/j.rser.2017.01.096
Mak Arvin B, Lew B (2011) Does democracy affect environmental quality in developing countries? Appl Econ 43:1151–1160. https://doi.org/10.1080/00036840802600277
Maki D (2012) Tests for cointegration allowing for an unknown number of breaks. Econ Model 29:2011–2015. https://doi.org/10.1016/J.ECONMOD.2012.04.022
Mamipour S, Yahoo M, Jalalvandi S (2019) An empirical analysis of the relationship between the environment, economy, and society: results of a PCA-VAR model for Iran. Ecol Indic 102:760–769. https://doi.org/10.1016/j.ecolind.2019.03.039
Marinelli M (2018) How to build a 'Beautiful China' in the Anthropocene. The political discourse and the intellectual debate on ecological civilization. J Chinese Polit Sci 23:365–386. https://doi.org/10.1007/s11366-018-9538-7
Mele M, Randazzo L (2019) A causal investigation on the determinants of CO2 in China. Int J Sustain Dev World Ecol 26:665–671. https://doi.org/10.1080/13504509.2019.1641567
Neumayer E (2002) Do democracies exhibit stronger international environmental commitment? A cross-country analysis. J Peace Res 39: 139–164. doi: https://doi.org/10.1177/0022343302039002001
Omri A, Euchi J, Hasaballah AH, Al-Tit A (2019) Determinants of environmental sustainability: evidence from Saudi Arabia. Sci Total Environ 657:1592–1601. https://doi.org/10.1016/j.scitotenv.2018.12.111
Panayotou T (1997) Demystifying the environmental Kuznets curve: turning a black box into a policy tool. Environment and development economics 465–484.
Park JY (1992) Canonical cointegrating regressions. Econometrica 60: 119. https://doi.org/10.2307/2951679
Payne RA (1995) Freedom and the environment. J Democr 6:41–55. https://doi.org/10.1353/jod.1995.0053
Pesaran MH, Shin Y, Smith RJ (2001) Bounds testing approaches to the analysis of level relationships. J Appl Econ 16:289–326. https://doi.org/10.1002/jae.616
Phillips PCB, Hansen BE (1990) Statistical inference in instrumental variables regression with I(1) processes. Rev Econ Stud 57:99. https://doi.org/10.2307/2297545
Phillips PCB, Perron P (1988) Testing for a unit root in time series regression. Biometrika 75:335–346. https://doi.org/10.1093/biomet/75.2.335
Povitkina M (2018) The limits of democracy in tackling climate change. Env Polit 27:411–432. https://doi.org/10.1080/09644016.2018.1444723
Sarkodie SA, Strezov V (2019) A review on environmental Kuznets curve hypothesis using bibliometric and meta-analysis. Sci Total Environ 649:128–145
Schultz CB, Crockett TR (1990) Economic development, democratization, and environmental protection in Eastern Europe. Bost Coll Environ Aff Law Rev 18:53
Scott CA, Pierce SA, Pasqualetti MJ, Jones AL, Montz BE, Hoover JH (2011) Policy and institutional dimensions of the water-energy nexus. Energy Policy 39:6622–6630. https://doi.org/10.1016/j.enpol.2011.08.013
Sinha A, Shahbaz M, Balsalobre D (2017) Exploring the relationship between energy usage segregation and environmental degradation in N-11 countries. J Clean Prod 168:1217–1229. https://doi.org/10.1016/j.jclepro.2017.09.071
Sinha A, Shahbaz M, Balsalobre D (2019) Data selection and environmental Kuznets curve models-environmental Kuznets curve models, data choice, data sources, missing data, balanced and unbalanced panels. In Environmental Kuznets Curve (EKC) Academic Press, Cambridge, p 65–83
Stock JH, Watson MW (1993) A simple estimator of cointegrating vectors in higher order integrated systems. Econometrica 61:783. https://doi.org/10.2307/2951763
Sulemana I, James HS, Rikoon JS (2017) Environmental Kuznets curves for air pollution in African and developed countries: exploring turning point incomes and the role of democracy. J Environ Econ Policy 6:134–152. https://doi.org/10.1080/21606544.2016.1231635
Teets J (2018) The power of policy networks in authoritarian regimes: changing environmental policy in China. Governance 31(1):125–141
Torras M, Boyce JK (1998) Income, inequality, and pollution: a reassessment of the environmental Kuznets curve. Ecol Econ 25:147–160. https://doi.org/10.1016/S0921-8009(97)00177-8
Ulucak R, Yücel AG, Koçak E (2019) The process of sustainability: from past to present. In Environmental Kuznets Curve (EKC) Academic Press, Cambridge, p 37–53
Ulucak R, Koçak E, Erdoğan S, Kassouri Y (2020) Investigating the non-linear effects of globalization on material consumption in the EU countries: evidence from PSTR estimation. Res Policy 67:101667. https://doi.org/10.1016/j.resourpol.2020.101667
Ur Rahman Z, Chongbo W, Ahmad M (2019) An (a)symmetric analysis of the pollution haven hypothesis in the context of Pakistan: a non-linear approach. Carbon Manag 10:227–239. https://doi.org/10.1080/17583004.2019.1577179
Usman O, Iorember PT, Olanipekun IO (2019) Revisiting the environmental Kuznets curve (EKC) hypothesis in India: the effects of energy consumption and democracy. Environ Sci Pollut Res 26: 13390–13400. https://doi.org/10.1007/s11356-019-04696-z
Usman O, Olanipekun IO, Iorember PT, Abu-Goodman M (2020) Modelling environmental degradation in South Africa: the effects of energy consumption, democracy, and globalization using innovation accounting tests. Environ Sci Pollut Res 27:8334–8349. https://doi.org/10.1007/s11356-019-06687-6
Wang N, Zhu H, Guo Y, Peng C (2018) The heterogeneous effect of democracy, political globalization, and urbanization on PM2.5 concentrations in G20 countries: evidence from panel quantile regression. J Clean Prod 194:54–68. https://doi.org/10.1016/j.jclepro.2018.05.092
Wang R, Qi R, Cheng J, Zhu Y, Lu P (2020) The behavior and cognition of ecological civilization among Chinese university students. J Clean Prod 243:118464. https://doi.org/10.1016/j.jclepro.2019.118464
Yang H, Zhao D (2015) Performance legitimacy, state autonomy and China's economic miracle. J Contemp China 24:64–82. https://doi.org/10.1080/10670564.2014.918403
Yılmaz B, Bonaparte N (2018) Why has China succeeded? Does China's success contradict Acemoğlu and Robinson's thesis in "Why nations fail?" "Let China sleep, for when China wakes, she will shake the world". IPC Working paper. https://ipc.sabanciuniv.edu/Content/Images/CKeditorImages/20200310-14032708.pdf. Accessed 26 Feb 2020
You WH, Zhu HM, Yu K, Peng C (2015) Democracy, financial openness, and global carbon dioxide emissions: heterogeneity across existing emission levels. World Dev 66:189–207. https://doi.org/10.1016/j.worlddev.2014.08.013
Zelli F, van Asselt H (2013) The institutional fragmentation of global environmental governance: causes, consequences, and responses. Glob Environ Polit 13:1–13
Zhang Y, Chen X, Wu Y et al (2019) Peaks of transportation CO_2 emissions of 119 countries for sustainable development: results from

carbon Kuznets curve. Sustain Dev sd 2008. https://doi.org/10.1002/sd.2008

Zhu H, Xia H, Guo Y, Peng C (2018) The heterogeneous effects of urbanization and income inequality on CO2 emissions in BRICS economies: evidence from panel quantile regression. Environ Sci Pollut Res 25:17176–17193. https://doi.org/10.1007/s11356-018-1900-y

Zmami M, Ben-Salha O (2020) An empirical analysis of the determinants of CO2 emissions in GCC countries. Int J Sustain Dev World Ecol: 1–12. https://doi.org/10.1080/13504509.2020.1715508