Do economic policy uncertainty and environment-related technologies help in limiting ecological footprint?

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Abstract

Economic policies related to energy and the environment are found uncertain in developing economies. Renewable energy sources are gradually increasing in energy structure (ES) with the adoption of environment-related technologies (ERT). However, least attention is paid to investigating the nexus of economic policy uncertainty (EPU), ERT, ES, and ecological footprint (EF). Therefore, this study is an effort to examine the EPU, ERT, ES, and interaction of EPU and ERT on EF for BRICS economies under the umbrella of the STIRPAT model. By using the data from 1992 to 2020, findings are estimated through “cross-sectional dependence (CD test); CIPS and CADF unit root test; Westerlund’s co-integration; and CS-ARDL, AMG, and CCEMG.” Findings unveiled the negative role of EPU on EF. Furthermore, the role of RE and ERT is positive and substantial in decreasing the environmental degradation in BRICS. Therefore, the BRICS economies are suggested to be consistent on economic policies to catch the positive impact of ERT. Findings are robust to the policy implications.

Keywords Economic policy uncertainty · Energy structure · Environment-related technologies · Ecological footprint · BRICS

JEL classifications O44 · Q56 · Q50

Introduction

The uncertainty associated with fiscal and monetary policies that affect the environment leads to economic policy uncertainty (Pirgaip and Dinçergök 2020). Due to global uncertainties, the economic and political stability is affected in every country of the world and vice versa, e.g., international markets are substantially influenced by the second

Gulf War in 2003 (Guidolin and la Ferrara 2010; Rigobon et al. 2005). Moreover, the COVID-19 created economic uncertainty around the globe (Baker et al. 2020). EPU may have environmental consequences in addition to economic consequences EPU, for example, encourages industries to use environmentally unfavorable manufacturing practices, resulting in environmental degradation (Amin and Dogan 2021). Furthermore, an increased EPU may reduce RE sources and environment-related technologies’ (ERT) investments, and consequently, the environment may suffer.

To pay for the deprived revenue tempted by EPU, production industries employ low-cost energy sources in their manufacturing processes. As such industries’ earnings increase, they invest in environment-related technologies in production processes (ERT), resulting in a better environment. The investment in ERTs can help to reduce environmental degradation (Danish and Ulucak 2020; Hussain and Dogan 2021). Furthermore, a better income level promotes RE sources, and that helps in reducing carbon emissions (Danish et al. 2019; Hussain et al. 2020a, b; Mahmood et al. 2019). It would be interesting to study the ERT, ES, and EF nexus in the presence of EPU.

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Despite the relevance of the EPU–environment nexus, there are just a few studies in the literature that examine this nexus. The majority of these studies focus only on single-country analysis, i.e., China and the USA (Amin and Dogan 2021; Danish and Ulucak 2020). A few studies examine the EPU–environment nexus in a panel of G-7 (Pirgaip and Dinçergök, 2020). However, they only used panel causality to estimate the results, which may be unable to reflect the whole story. This is why BRICS’ panel is a notable group among the world’s developing countries, and it is widely highlighted in the literature (Danish and Ulucak 2020; Hasanov et al. 2021; Wang et al. 2018). The findings imply that measures promoting reduced traditional energy sources and EF, as well as the use of renewable sources, should be implemented in BRICS nations to help mitigate the impact of EPU.

Based on this premise, this study is adding value to the existing literature of EPU–environment in the following ways: *firstly*, to the best knowledge of the authors, this study is first to investigate the effect of EPU, ES, and ERT on EF in BRICS by using the data from 1992 to 2020. *Secondly*, this study uses the most suitable econometric estimations, i.e., “CD test for cross-sectional dependence; CIPS and CADF unit root tests to check stationarity; Pedroni, Koa, Fisher, and Westerlund’s co-integration; CS-ARDL, AMG, and CCEMG” techniques. These estimations can handle the problems of panel data. The rest of the paper contains a literature review section in nexus form, theoretical background, methodology, empirical results and discussions, and conclusions with policy implications.

Literature review

To understand the hypothesized linkage of considered factors, the literature is categorized into nexus in the following ways:

Firstly, the energy–environment nexus is discussed to reach a rationale. In this nexus, Rahmane et al. (2021) looked at the role played by renewable energy in the protection of the Algerian ecological footprint from 1990 to 2017. They noted a two-way causal relationship between the two aforementioned variables in their sample. They observed the ineffectiveness of RE in reducing EF. They cited the less utilization of renewable energy sources for this ineffectualness. They stressed the high usage of renewable energy for mitigating environmental degradation. Likewise, Usman and Hammar (2021) checked the effect of renewable energy consumption on the ecological footprint of the “Asia–Pacific Economic Cooperation” countries for the period 1990 to 2017. Moreover, Akif and Sinha, (2020) found that an overall increase in RE reduces the EF in their study of 24 OECD countries. Similarly, Nathaniel et al. (2020) investigated the impact of renewable energy on the ecological footprint

of CIVETS countries from 1990 to 2014. They noted that though renewable energy enhances environmental quality and reduces ecological footprints, this effect is insignificant. They believed that CIVETS countries need to invest more in RE sources to increase environmental quality. Furthermore, in an important study by Ulucak and Khan (2020), it is concluded that RE decreases EF in their sample of BRICS countries. So, the positive role of RE in protecting the environment and its quality is observed in this study. They arrived at these conclusions by applying fully modified ordinary least squares and dynamic ordinary least squares for 1992 to 2016. They also seconded the commitment of BRICS countries in achieving sustainable development goals by renewable energy technologies. Alola et al. (2019) explored the dynamic impact of RE on the EF of 16 European Union countries from 1997 to 2014. They highlighted the RE usage in protecting the environment. Based on these arguments, it is further recommended that ES should be examined in the presence of uncertain economic policies in the BRICS.

Secondly, the EPU–environment nexus’ literature is investigated to draw conclusive remarks for the BRICS’s economic policies. There is a wealth of literature on the relationship between EPU and CO₂ emission (Danish et al. 2020a; Pirgaip and Dinçergök 2020; Yu et al. 2021; Zakari et al. 2021). However, there are a handful of studies using EF as a measure of environmental quality. For example, Anser et al. (2021) investigated the effect of economic policy uncertainty on the EF of five emerging states from 1995 to 2015. They concluded that EPU lessens environmental degradation in their study. They were of the view that EPU reduces the use of energy and other pollution-based materials. This in turn had a positive effect on EF. On similar grounds, Chu and Le (2021) explored the effect of EPU on the EF of G7 countries for the period from 1997 to 2015. They concluded that high economic policy uncertainty causes economic slow-down and forces organizations to use cheap and harmful sources of energy. They spend less on measures to combat environmental protection. They were of the view that economic policy uncertainty reduces the ecological footprint. In another study, explored the impact of economic policy uncertainty on the ecological footprint of the top ten income producer countries from tourism from 1995 to 2015. They found that EPU enhances the EF in their sample. According to the root cause, the reason for this negative impact lies in uncertain trade and stock market activities. They were also of the view that during uncertain times, there is less emphasis on environmental protection measures. Therefore, it is interesting to further investigate the role of EPU–environment nexus by considering the role of ERT in the BRICS economies.

Thirdly, literature is scarce on the impact of environmental technologies and ecological footprint. The impact of technological development on the EF and carbon emission of big emerging countries from 1995 to 2016 using

second-generation panel data techniques is examined (Destek and Manga 2021). Moreover, Hussain and Dogan (2021) checked the effect of environmental technologies on the ecological footprint in BRICS for the period 1992 to 2016. They observed that the increase in investment in ERT reduces environmental degradation. They advocated the positive role of ERT in the reduction of EF consumption per capita. However, they stressed the need for more investment in reducing EF levels in BRICS. On this premise in the light of controversial literature, further investigation of the phenomenon is necessary. Therefore, this study is reinvestigating the nexus in BRICS economies. Interestingly, the role of EPU, ES, and ERT on EF is examined, which was silent in the literature. So, this study is adding a little knowledge to the existing literature. The theoretical base and the methodology section provided the theoretical and empirical evidence in the following sections.

Theoretical background and model construction

The Stochastic Impacts by Regression (STIRPAT) model is an important model which is commonly employed for problem-solving. In literature, the STIRPAT procedure is used in numerous studies to estimate the influence of different factors on carbon emissions, in Europe, the long- and short-run impact of energy, economic, and social factors on the environment (Chen et al. 2021; Ghazali and Ali 2019; Hussain et al. 2020a, b; Pham et al. 2020). Moreover, many studies followed the above-mentioned model to validate the linkage of environmental proxies with income level, population, and other relevant factors (Amin and Dogan 2021). Therefore, EPU, ES, ERT, and EF are assumed to be connected by controlling the population and income level in BRICS. Based on the recognized population, affluence, and technology–STIRPAT–theory framework, we offer the following model:

$$EF = \alpha_0 + \beta_1 Y + \beta_2 P + \beta_3 ES + \beta_4 ERT + \beta_5 EPU + \mu \quad (1)$$

where *EF* is an abbreviation used for ecological footprint measured as ecological footprints consumption per capita and *Y* represents the income level measured as GDP. *P* is

the total population of a country every year. *ES* is used for energy structure which is a share of renewable energy in the total energy consumption. *ERT* is representing an investment in the production and processing of goods and services by using environment-related technologies which are sustainable technologies used in the production and processing of goods without harming the environment. *EPU* is economic policy uncertainty, and as per the literature support, the role of *EPU* is proposed to be negative toward environmental degradation. The annual data from 1992 to 2020 is used to estimate the proposed model for the BRICS economies. Furthermore, the measurements and sources of every variable are briefed in Table 1.

Econometric methodology

Based on the panel data requirements and diagnostics, the second-generation econometric techniques are suitable estimates for the proposed linkages: cross-sectional dependence test and correlation. After the CSD test (Pesaran 2015), it is necessary to identify the stationarity of the variables. For this purpose, the CADF (Pesaran 2007) and CIPS tests are selected which are capable of managing the CSD problem. Subsequently, co-integration estimation is used (Kao 1999; Pedroni 2001; Westerlund 2007). Eventually, the CSD problem is dealt with using a newly CS-ARDL technique (Chudik et al. 2015; Ghazali and Ali 2019). The benefit of using the “cross-sectional autoregressive distributed lag” estimation is that it can handle the problem of cross-sectional dependence and endogeneity (Hussain et al. 2020a, b; Khan et al. 2020). The model for “cross-section augmented autoregressive distributive lag (CS-ARDL)” is as follows:

$$\Delta E_{it} = A_{it} + \sum_{l=1}^q \phi_{il} \Delta E_{i,t-l} + \sum_{l=0}^q \phi_{il}^* M_{i,t-l} + \sum_{l=0}^q \partial_{il}^* \bar{X}_{i,t-l} + \mu_{it} \quad (2)$$

where $\bar{X}_i$, $\Delta \bar{E}_{it}$, and $\Delta \bar{M}_{it}$ are for the averages of cross-sections of dependent and independent variables. Furthermore, the robustness of results is also checked by using the, “augmented mean group” (AMG) and “common correlated effect mean group” (CCEMG) estimators; these techniques are equally well-suited to manage CSD and heterogeneity

Table 1 Variables' details

Abrev	Indicator name	Measurement	Source
EF	Ecological footprint	Consumption per capita	GFN
Y	GDP	US dollar	WDI
P	Population	Total population	WDI
ES	Energy structure	The share of renewable energy consumption in total energy	EIA
ERT	Environment-related technologies	Investment in ERT	OECD stats
EPU	Economic policy uncertainty	Bakers' 2016 measurement scale of EPU	Economic policy uncertainty index

problems (Eberhardt and Bond 2009; Hussain and Dogan 2021; Hussain and Khan 2021).

Empirical results and discussions

To follow the recommended procedure, the results start with basic statistics (correlation and CD test). In the first part of Table 2, correlation results are given. According to the results, all the considered factors, i.e., Y, P, ES, ERT, and EPU, are significantly correlated with ecological footprints. In the last part of Table 2, the results of cross-sectional dependence (CD test) are given. The results report the problem of the cross-sectional issue in the panel data. It means that the data is showing the inter-dependence of cross-sections. It may be due to the similar characteristics of BRICS economies.

In the presence of “cross-sectional dependence problem” in the data, the next procedure is to examine the unit root problem. The results of CIPS and CADF unit root tests’ results are

reported in Table 3. These second-generation unit root estimations are recommended for panel data with CD problems (Danish and Ulucak 2020; Hasanov et al. 2021). According to the reported results, the variable which is not stationary at the level, after taking the first difference, becomes stationary. Overall, all the variables are stationary, which is a necessary condition for the applied estimations (CS-ARDL, AMG, CCEMG).

After the confirmation of stationarity, the next suitable step is to check the co-integration among the sampled variables. For the pursuit of this goal, first- and second-generation co-integration (Kao 1999; Pedroni 1999, 2004; Westerglund 2007) tests are applied, and the results are reported in Table 4. According to the results, EF, Y, P, ERT, ES, and EPU are co-integrated. The results are confirmed by all the estimations. It is an indication of the robustness of the results. It means that the said variable has a long-run relationship (Ali et al. 2021; Hussain et al. 2020a, b).

After confirmation of the co-integration by the first- and second-generation co-integration techniques, the next suitable step is to estimate the short- and long-run association of the

Table 2 Correlation and CD test

Variables	LNEF	LNy	LNP	LNES	LNERT	LNPU
LNEF	1					
LNy	0.5761	1				
LNP	−0.7059	0.2820	1			
LNES	0.4654	0.6879	0.2406	1		
LNERT	0.5575	0.6097	−0.43233	0.2743	1	
LNPU	0.2589	0.4012	−0.02266	0.4442	0.0058	1
CD test	−3.1386*** (0.00)	14.0077*** (0.00)	2.3820*** (0.01)	9.4216*** (0.05)	−1.9471* (0.09)	7.7960*** (0.00)

The authors own calculations. In the case of CD test, *P* values are reported in parenthesis, and ***, **, and * represents 1%, 5%, and 10% levels of significance

Table 3 Unit root tests

Variables	CIPS		CADF					
			Without trend			With trend		
	Without trend	With trend	T-bar	Z-t-tilde-bar	<i>P</i> value	T-bar	Z-t-tilde-bar	<i>P</i> value
LNEF	−1.46	−2.88	−2.90	−2.62	0.004*	−2.97	−2.73	0.054*
ΔLNEF	−4.87	−5.42	−3.31	−3.57	0.000*	3.02	−1.72	0.042*
LNy	−1.25	−0.87	−0.08	3.87	1.000	−1.41	2.16	0.985
ΔLNy	−5.57	−5.28	−2.38	−1.42	0.076*	−2.54	−0.56	0.028*
LNP	−2.65	−1.31	−2.61	−1.97	0.024*	−3.19	−2.12	0.017*
ΔLNP	−2.98	−3.69	−1.44	0.73	0.009*	−2.97	−1.59	0.055*
LNES	−1.20	−2.60	−1.53	0.51	0.69	−2.15	0.37	0.644
ΔLNES	−5.73	−6.16	−4.57	−6.48	0.000*	−4.38	−4.97	0.000*
LNERT	−2.25	−2.15	−1.98	−0.51	0.302	−1.67	1.53	0.937
ΔLNERT	−5.64	−6.16	−4.77	−6.94	0.000*	−5.35	−7.32	0.000*
LNPU	−1.72	−2.24	−2.031	−0.62	0.26	−2.19	0.28	0.611
ΔLNPU	−5.67	−5.84	−4.49	−6.31	0.000*	−4.49	−5.26	0.000*

* is the level of significance

Table 4 Pedroni, Kao, and Fisher co-integration analysis

Pedroni test				Kao residual		Johansen Fisher		
		Statistic	Weighted stat	T-stat	Prob	No of co-integration	Trace	Max eigen test
Within-dimension	Panel v	0.7515 (0.22)	−0.4322 (0.63)	−1.8401 ***	0.0003	None	177.2 *** (0.00)	77.84 *** (0.00)
	Panel rho	−0.606 (0.26)	−0.1786 (0.43)			At most 1	113.8 *** (0.00)	62.10 *** (0.00)
	Panel PP	−5.2189 *** (0.00)	−4.2627 *** (0.00)			At most 2	65.65 *** (0.00)	29.13 *** (0.00)
	Panel ADF	−2.2965 *** (0.01)	−4.7051 *** (0.00)			At most 3	43.49 *** (0.00)	25.23 *** (0.00)
Between-dimension	Group rho	0.4820 (0.61)				At most 4	28.23 *** (0.00)	19.42 ** (0.03)
	Group PP	−4.6666 *** (0.00)				At most 5	27.74 *** (0.00)	27.74 *** (0.00)
	Group ADF	−4.1626 *** (0.01)						
Westerlund co-integration test								
Statistics		Value	Z value	P value	Robust P value			
Gt		−7.058	−6.873	0.06	0.00 ***			
Ga		−3.222	3.213	1.00	0.10 *			
Pt		−8.419	−3.617	0.03	0.00 ***			
Pa		−4.679	2.145	0.98	0.06 *			

***, **, and * represent 1%, 5%, and 10% levels of significance

factors of the model. The results of CS-ARDL, AMG, and CCEMG are reported in Table 5. The income level Y is statistically significant with a positive coefficient (0.415) in the long run. It means that a 1% change in income level can change the ecological footprints by 0.415% in the BRICS economies in the long run. In other words, with an increasing level of GDP in these economies, the level of environmental degradation is increasing. These results are supported by literature (Danish

et al. 2020a; Ghazali and Ali 2019; Haldar and Sethi 2022; Hussain et al. 2020a, b). It is observed that in growing economies like the BRICS, the income level is a major contributor to environmental degradation. The next independent variable is population, which is not significantly affecting the ecological footprint in CS-ARDL and AMG results. However, with a positive coefficient, P is indicating the significant linkage of the P with EF in CCEMG results. These results are aligned

Table 5 Augmented mean group (AMG), common correlated effect means group (CCEMG), and CS-ARDL

Dependent variable	Ecological footprint					
	AMG		CCEMG		CS-ARDL	
	Coefficient	Prob	Coefficient	Prob	Coefficient	Prob
Long-run coefficients						
LNY	0.7641 **	0.0400	0.5371 ***	0.0012	0.4159 **	0.0243
LNP	0.7272	0.6700	0.2850 *	0.0900	0.5533	0.1121
LNES	−0.0667 **	0.0500	−0.0392 ***	0.0081	−0.0416 *	0.0628
LNERT	−0.2371 **	0.0300	−0.2741 ***	0.0021	−0.0135 **	0.0451
LNEPU	0.1502 *	0.0730	0.1159 *	0.0243	0.2122 *	0.0812
Short-run coefficients						
D(LNY)					1.2825	0.233
D(LNP)					0.9247 *	0.092
D(LNES)					−0.1040	0.842
D(LERT)					−0.0234 *	0.0651
D(LNEPU)					0.1543	0.247

*, **, and *** represent 10%, 5%, and 1% levels of significance

with the literature (Amin and Dogan 2021; Pham et al. 2020). It means that the population is substantially increasing the level of ecological footprint in BRICS.

Energy structure is negatively affecting the EF significantly. The coefficient is -0.041 , which means that a 1% increase in renewable energy can decrease the level of EF by 0.041% in the BRICS. These results are verified by the AMG and CCEMG. It is notable here that the increasing share of renewables in the total energy structure can help to reduce environmental degradation. In easy words, with the investment in renewable resources of energy, sustainable development can be achieved in the BRICS region. These results are also endorsed by the previous studies (Adedoyin et al. 2021a, b; Amin and Dogan 2021; Danish et al. 2017).

The coefficient of ERT is found negative and significant with a coefficient of 0.013. It refers to the fact that a 1% increase in the investment of ERTs can help to decrease the EF by 0.013% in the long run in the BRICS economies. This result is also supported by AMG and CCEMG, declaring it robust. This phenomenon is leading to logic that an increase in the investment in production and processing of environment-related technologies can help to decrease the dangerous emissions in the environment and ultimately the ecological footprint in the long run. These results are also supported by Danish and Ulucak (2020); Hussain and Dogan (2021); and Hussain and Khan (2021).

In the case of EPU, the results report the positive and significant effect of EPU on EF. In the coefficient empirical value of 0.212, it indicates the deteriorating role of EPU toward EF. Empirically, 1% change in EPU is increasing EF by 0.212% in the BRICS in the long run. Moreover, this outcome is also endorsed by the AMG and CCEMG. It led to the phenomenon that uncertain economic policies are detrimental to the environment. This outcome is also supported by the literature of individual country analysis (Amin and Dogan 2021; Danish et al. 2020a; Godil et al. 2020). The results of pair-wise causality are reported in Table 6. Bidirectional causality is reported in Y, P, and EF. It means the income level, population, and environmental degradation are having bidirectional linkage and affect each other. On the other hand, unidirectional causality was reported among ERT and EF, ES and EF, EPU, and EF. It refers to the indication that ERT, ES, and EPU are affecting EF; however, EF is not causing any effect on these factors. Furthermore, no causality is reported in Y and ERT, ES, and P.

Conclusion and policy implications

In this study, the effect of economic policy uncertainty is tested on ecological footprints under the STIRPAT model along with the energy structure and investment in environment-related technologies. The latest available annual data from 1992 to 2020 is used to test the hypothesized nexus by

Table 6 Pair-wise causality test

Null hypothesis	W-stat	Z bar-stat	Prob
LNy does not homogeneously cause LNEF	9.26852	6.49854	8.E-11
LNEF does not cause LNy	6.21453	3.69081	0.0002
LNP does not cause LNEF	9.37159	6.59330	4.E-11
LNEF does not cause LNP	10.2686	7.41796	1.E-13
LNES does not cause LNEF	1.89600	-0.27948	0.7799
LNEF does not cause LNES	5.06482	2.63381	0.0084
LNERT does not cause LNEF	5.68402	3.20308	0.0014
LNEF does not cause LNERT	2.46549	0.24408	0.8072
LNepu does not cause LNEF	2.76861	0.52276	0.6011
LNEF does not cause LNepu	6.56487	4.01290	6.E-05
LNP does not cause LNy	6.25244	3.72567	0.0002
LNy does not cause LNP	7.24839	4.64130	3.E-06
LNES does not cause LNy	3.17612	0.89741	0.3695
LNy does not cause LNES	4.22328	1.86013	0.0629
LNERT does not cause LNy	2.01416	-0.17086	0.8643
LNy does not cause LNERT	3.02149	0.75525	0.4501
LNepu does not cause LNy	3.62497	1.31006	0.1902
LNy does not cause LNepu	6.17603	3.65542	0.0003
LNES does not cause LNP	3.55949	1.24986	0.2113
LNP does not cause LNES	3.26444	0.97861	0.3278
LNERT does not cause LNP	3.88902	1.55282	0.1205
LNP does not cause LNERT	6.76828	4.19991	3.E-05
LNepu does not cause LNP	7.34343	4.72868	2.E-06
LNP does not cause LNepu	3.69438	1.37388	0.1695
LNERT does not cause LNP	3.88902	1.55282	0.0905
LNP does not cause LNERT	6.76828	4.19991	3.E-05
LNepu does not cause LNP	7.34343	4.72868	2.E-06
LNP does not cause LNepu	3.69438	1.37388	0.1695
LNERT does not cause LNES	2.70046	0.46011	0.6454
LNES does not cause LNERT	1.52706	-0.61867	0.5361
LNepu does not cause LNES	2.73643	0.49318	0.6219
LNES does not cause LNepu	6.28704	3.75747	0.0002
LNepu does not cause LNERT	1.01619	-1.08835	0.2764
LNERT does not cause LNepu	1.88872	-0.28618	0.7747

Bold values are insignificant

applying CD test; CIPS and CADF unit roots tests; first- and second-generation co-integration tests (Kao 1999; Pedroni 1999, 2004; Westerlund 2007); and CS-ARDL, AMG, and CCEMG estimations. Findings unveil the supportive role of ES and ERT in limiting the environmental degradation in BRICS. However, the EPU is found to be harmful to the environment. Furthermore, unidirectional causality is also evident in ES, ERT, and EPU toward EF.

Based on the empirical findings, some important policy implications can be suggested. *Firstly*, energy structure remains a major contributor toward reducing the ecological footprint. Therefore, the replacement of traditional energy

sources with renewable energy sources may help to reduce the level of environmental degradation in the BRICS. *Secondly*, the ERT is found to substantially reduce the EF. The BRICS may increase investment in the production and processing of ERTs to realize the benefit. They may subsidize the industrial production that opts for the ERTs to enhance sustainable growth. In this way, the BRICS can move toward sustainable development. *Thirdly*, the BRICS countries' policymakers should pay attention to minimizing EPU, because EPU is substantially increasing the level of EF. By controlling the EPU, the goal of a sustainable environment can be eased. Therefore, to implement the ERTs, the BRICS need an immediate plan that may help to reduce the economic policy uncertainty.

This study also has some limitations, which may lead to new research agenda. Due to limited data availability, this study is restricted to 29 years. Future studies may use longer data to other parts of the world which may bring a different outcome. Moreover, the economic policy of the high-income countries may behave differently. Therefore, the study of EPU and EF in high-income economies may bring more interesting results. Additionally, the role of EPU may reflect differences in different economies, so the country-level study of EPU may bring interesting results.

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Data availability The data used in this paper can be provided on demand.

Declarations

Ethics approval and consent to participate The authors are hereby ready to give their consent on ethical approval for the participation in this paper.

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