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Exploring the energy–economy–environment paradox through Yin–Yang harmony cognition☆

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ABSTRACT

Adopting a symbiotic perspective, this study aimed to examine the paradoxical interrelationship of the energy–economy–environment nexus through the novel lens of Yin–Yang cognitive harmony. With a broad sample of countries (6 African lions, 5 Asian tigers, 3 NAFTA countries, and 10 top European Union economies), we applied the cointegration and fully modified ordinary least squares techniques to evaluate the short- and long-term relationships between energy consumption, economic growth and carbon dioxide (CO_2) emissions for the period 1980–2012. The results were heterogeneous across countries, but a curvilinear (inverted U-shaped) relationship between total economic growth and CO_2 emissions in conformity with the environmental Kuznets curve was confirmed in many cases. However, there was no evidence that economic growth resulting from energy consumption has been responsible for CO_2 reduction, which suggests a 'trilemma' – that is, a challenge in balancing energy production, economic growth and environmental degradation. From a behavioural economic perspective, this paper draws on the Kuznets hypothesis and Jevon's paradox by adopting a paradoxical frame to characterise the complex energy–growth–environment interaction as a balanced, symbiotic coexistence. It thus provides novel insights into the energy–growth–environment trilemma through an unconventional perspective based on Yin–Yang cognitive harmony (Fig. 1, see the Appendix).

1. Introduction

Air pollution results from a complex mixture of microscopic particles suspended in the air, which are known as atmospheric aerosols. They are produced by combustion, mainly from factories and vehicles, and as a side effect of agricultural activities. Excess amounts of greenhouse gases (GHGs) such as water vapor, nitrous oxide (N2O), carbon dioxide (CO_2), methane (CH4) and chlorofluorocarbons (CFCs) in the atmosphere are the main cause of global climate change [1]. Increasing studies across disciplines highlight the direct, devastating effects of air pollution on health, notably adverse cardiovascular and respiratory disorders, as well as other consequences of dramatic climate change [2–4]. Organisations, governments and scholars across time and space have demonstrated a passion for finding sustainable solutions to these alarming problems facing our planet.

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Alongside international pacts on environmental protection, scholars have also been concerned with ways to use energy to achieve economic development while maintaining environmental integrity since this trio (energy, the economy and the environment) generally produces conflicting results [4–6]. Theoretical analysis of this conflicting but interdependent interaction gave rise to the environmental Kuznets curve (EKC) hypothesis as an important framework for the comparative discussion of economic growth and environmental protection [7]. According to the EKC hypothesis, in the initial stage of a country's economic growth, environmental degradation rises, but at a given level of increasing growth, this degradation gradually falls [7,8]. Graphically, the EKC hypothesis manifests as a curvilinear relationship (an inverted U-shaped curve) between economic growth and environmental degradation (Fig. 1). Theoretical and empirical studies of pollutants such as SO_2, CO and water vapor largely validate the EKC concept [1,5,7]. However, the literature is still ambiguous about the EKC interpretation of CO_2, 'one of the most significant GHGs responsible for climate changes' [8]. Moreover, the EKC hypothesis does not correspond with the level of development in every country. In other words, the environmental degradation phenomenon can be interpreted by the EKC hypothesis within a given biased scope, but environmental issues at the global level might be far too extended and complex for such an interpretation [9,10].

Energy consumption has been an important parameter in economic growth frameworks, as it is an equally major contributor to the environmental challenge. In many cases, countries adopt energy efficiency strategies that consist of limiting energy consumption to reduce GHG emissions [11]. Governments invest great effort in promoting economic growth through the efficient use of energy and pollution control. However, a consequent 'rebound effect' – an increase in energy consumption behaviour following measures that mandate efficient energy use – is inevitable when additional measures are not put in place to prevent this effect [12,13]. This phenomenon is illustrated by Jevon's paradox of the extreme rebound effect. To ensure energy efficiency, Jevon's paradox points to the need for additional support policies and measures to save energy and curb GHG emissions [12,14].

This paper posits that when the energy consumption–economic growth–environmental degradation trilemma is extended to the global scale, it constitutes a paradoxical formation that exceeds the interpretive scope of the EKC hypothesis and Jevon's paradox [13]. Therefore, this study proposes Yin–Yang (阴阳) harmony cognition as a dynamic frame for [15,16] (1) interpreting the energy–-growth–environment paradox, (2) forecasting the results of the energy–growth–environment project and (3) providing a productive resolution by portraying this trio as a symbiotic coexistence.

To clearly position the ongoing discussions, this paper aims to empirically establish the following.

(1) The complexity of the energy–growth–environment trio exceeds the interpretive scope of the EKC hypothesis and Jevon's paradox.
(2) The Yin–Yang framework can blend energy consumption, economic growth and environmental degradation into a harmonious symbiosis as a solution to the alarming climate devastation.

This paper contributes a novel perspective to the climate change literature, addressing the longstanding energy–-growth–environment trilemma from an unconventional, cognitive understanding (i.e. Yin–Yang cognitive harmony). Unlike the common methodology for evaluating the environmental problem and interpreting it using conventional methods (i.e. the EKC hypothesis and Jevon's paradox), this work suggests a unique framework (Yin–Yang) for adequately forecasting, interpreting and proposing possible solutions to the paradox [15,17]. Practically, our findings make valuable psychological and behavioural economic contributions to the ever-alarming climate change debate.

The paper is structured as follows: Section 2 provides the theoretical foundations of Yin–Yang harmonisation and frames the paradox formed by energy consumption, economic growth and environmental degradation. Section 3 describes the methodology used, Section 4 explores the results and Section 5 tackles the discussion. Section 6 provides the conclusion, and finally, Section 7 presents the limitations of the study and future research directions.

2. Literature review

A host of studies have investigated the interaction between energy consumption and carbon emissions and its implications for economic development and environmental preservation [18–20]. These studies have approached the growth–energy–environment nexus from different perspectives and with reference to varying causes [7,15,16]. The literature on economic growth and energy consumption can be traced as far back as [21], which studied the relationship between energy and gross national product. Some scholars have focused on investigating the relationship between economic growth and energy consumption [1,2], while others go beyond the interaction at face value to evaluate its implications for the environment. For instance Ref. [22], explored the determinants of environmental degradation in 44 selected sub-Saharan African countries using a generalised method of moments technique to explore how ICT modulates the effects of CO_2 emissions on inclusive development. The study found that ICT can be used to reduce the negative effects of CO_2 emissions on such development. That is, ICT policy thresholds should be modulated to meet environmental sustainability targets in the selected African bloc.

The EKC hypothesis is founded on the assertion that economic development increases environmental degradation up to a given threshold, beyond which there emerges a possibility of environmental recovery. Many empirical investigations of the EKC analysis use linear polynomial regression [7,23]. EKC analyses have revealed a U-shaped relationship with one turning point, an N-shaped relationship with two points and an M-shaped relationship with three points, depending on the dataset under study. Therefore, the results of specific interpretations may be analyzed subsequently to determine the best-fitting recommendations. Chin and Rowley [24] investigated the relationship between gross domestic product (GDP) and CO_2 emissions in China from 1975 to 2005 and found that the relation between CO_2 emissions and economic growth assumed an inverted U shape under the EKC hypothesis. Using a dataset on the

USA covering 1980–2014, Halliru and Loganathan [25] studied the EKC hypothesis using the variables CO_2 emissions, GDP, GDP squared (GDPsq) and renewable and non-renewable energy consumption. They found that the EKC hypothesis was not valid; there was no turning point in the energy–growth–environment relation. According to their results, increased production will not stop the USA's growth and will eventually lead to environmental collapse. Studying the situation in Bangladesh [26], used cointegration and the ARDL framework for 1980–2015. Their findings revealed a manifestation of the EKC hypothesis, showing that Bangladesh is a developing country in the development phase of the relationship between economic growth and CO_2 emissions. Study [26] also revealed manifestations of the EKC hypothesis in South Asian countries such as India, Bhutan, Bangladesh and Sri Lanka.

Meanwhile, the literature has recently been littered with references to renewable energy as the ultimate remedy for environmental protection [25,27]. While most studies focus on technological and chemical solutions [28], few scholars have investigated the use of natural or ideological approaches [29]. In fact, there is limited research on natural approaches to the energy–growth–environment dilemma [30]. Following [31], who proposed deploying Yin–Yang, a natural Oriental ideology, as a solution in competitive conflicts and conflicting business models, this paper explores the use of Yin–Yang harmony to address the energy–growth–environment paradox.

3. Theoretical foundations

3.1. The complexity of the energy consumption–economic growth–carbon emission nexus: beyond EKC interpretations

Traditionally, the initial phase of a new economic activity is characterised by much attention to developmental transformation, to the point that development seems to be disassociated from environmental protection initiatives. The literature provides evidence of a direct correlation between economic growth and carbon emissions [1,2,7,8]. [7,8] confirm that, in the initial stage, economic growth is a major source of carbon emissions; however, at a certain maximal level of developmental achievement, growth should no longer be pursued at all costs. At a certain threshold of economic growth, additional environmental degradation becomes more costly than attaining the next level of development, so economic achievement should then be utilised for the effective implementation of environmental protection measures. The rapport between economic growth and carbon emissions shows a curvilinear relationship (an inverted U curve), which is captured in the EKC hypothesis [8], named after Kuznets' work in 1955. The EKC hypothesis suggests that economic growth is actually an effective long-term remedy for environmental degradation and deterioration instead of a threat [7].

[4,6] modelled the interim relationship between energy, economic growth and environmental depletion using an intertemporal general equilibrium framework. According to the authors, this relationship seems to be dynamic because, while resources yield immediate economic benefits, their negative impact on the environment may be observed in the long run. Apart from the works on the direct link between these three variables of interest, the economic analysis of sustainable development and environmental policy has gained new impetus from endogenous growth theory [2]. Recently [9,10], provided theoretical surveys of the channels of transmission through which environmental policy and economic growth interact. Furthermore, most present research focuses on the output–energy or output–pollution nexuses [16,17]. developed a more rigorous econometric framework that includes carbon emissions, energy usage, income and international trade, and they discovered bidirectional Granger causation between carbon emissions and income, both in the short and long terms. According to these findings, neither carbon emissions nor energy use contribute to economic development. Many studies have demonstrated that the EKC hypothesis may not hold at all times and in all instances [11,17,18]. Therefore, we hypothesised the following.

Hypothesis 1 (H1). The EKC hypothesis does not adequately explain the relationship between energy consumption, economic growth and environmental degradation at the global level.

3.2. Applying Jevon's paradox to energy efficiency in the energy–growth–environment nexus

Energy efficiency improvements are a critical component of many governments' strategies to decrease energy usage and combat global warming. This is based on the notion that increasing energy efficiency leads to decreased energy use and, as a result, decreased GHG emissions [11,17]. These efficiency improvements, enabled in part by technological innovations, have also contributed to economic growth while lowering resource consumption and environmental pollution. However, a rebound effect occurs in the form of an increase in energy use after a gain in energy efficiency; this is Jevon's paradox [12–14]. This indicates that boosting energy efficiency without supplementary measures does not always result in energy savings or emission reductions, and in any case, energy consumption reductions are not proportional to the efficiency increase [18,20]. Energy efficiency measures must be considered in a larger context that defines their function within energy policy and includes other steps to mitigate the rebound impact. Energy efficiency strategies that result in a stronger direct rebound impact require additional policy factors concerning energy costs, consumer behaviour and legal tools [19,21].

As clearly demonstrated above, a holistic analysis of the energy–growth–environment nexus draws on a paradoxical complexity [11] that expands beyond Jevon's interpretation [21]. A proper repositioning of the energy–growth–environment discussion within a global scope shows that the paradox of using energy production to achieve economic growth without causing harm to the environment is much more complex than Jevon's interpretation suggests. Following this logic, we hypothesised the following.

Hypothesis 2 (H2). A holistic interpretation of the complexity of energy efficiency lies beyond the interpretive scope of Jevon's paradox.

3.3. *The Yin–Yang cognitive framework's harmonisation capability in the energy–growth–environment paradox*

Natural paradox resolution cognitive concepts have a long theoretical history. According to Eastern philosophers such as Lao Tzu and Confucius, the world is a mystical interplay of interdependent contradictions [22]. In Western thought, Aristotle and Hegel defined paradoxes as irrational puzzles or double binds that are difficult to resolve [23]. Both Socrates' elenctic method and Yin–Yang paradox harmonisation are classical instruments employed to blend opposing but complementary elements into a symbiotic coexistence that is essential for natural balance [23]. However, while the Greek philosophical method of elenchus (ἔλεγχος) focuses on metonymic and metaphorical models for interlocution, the Yin–Yang cognitive framework formed the philosophic basis of traditional Chinese medicine and governance [16,22,23]. The Yin–Yang concept, materialised by the Taijing (太极) symbol, became the embodiment of the core thought of a famous Chinese divination manual, 'Yijing' (易经), and was adopted as one of the Confucian Classics in the Han dynasty (202 BCE to 8 AD) [15,22]. The notion of Yin–Yang harmony encompasses the essence of everything, whether physical or intangible. Yin symbolises soft power, passive energy and feminine qualities, while Yang represents hard strength, positive force and masculine aspects [22,23]. As correlatives of a broader whole, Yin and Yang are aspectual and relational, and they must be defined in terms of one another. Both allude to a prolonged conflict between interdependent aspects of a phenomenon that persists concurrently and synergistically across time, and their methods of expression may seem illogical or unreasonable at times. From this perspective, we adopted Yin–Yang harmonizing cognition to interpret the energy consumption–economic growth–environmental degradation paradox, thus balancing resource exploration, energy production and economic growth with maximal ecological preservation in an interdependent, coexisting symbiosis [23,24,31].

To the best of our knowledge, while energy–growth–environment complexity has been widely researched, it has never been approached with a cognitive resolution perspective [23,24]. We proposed to use Yin–Yang harmony cognition to address the long-standing problem of environmental degradation from a cognitive perspective by encompassing the energy–growth–environment relationship within a balanced, symbiotic coexistence (Fig. 2; see the Appendix). Therefore, we hypothesised the following.

Hypothesis 3 (H3). The Yin–Yang harmony cognitive framework encompasses the paradoxical relationship between energy consumption, economic growth and environmental degradation within a symbiotic coexistence, even at the global level.

4. Data and methodology

4.1. *Method and empirical model*

Prior to the cognitive analysis, it was necessary to empirically assess the association between economic growth, energy use and environmental degradation. We used panel data for 24 selected countries across the globe from 1980 to 2012. The data was gathered from World Population Review (2022) and World Bank Databank and according to data availability, the selected countries for this research include 10 European countries, 6 African countries, 4 Asian countries, and 3 within the North American Free Trade Agreement (NAFTA). Countries were selected based on the level of global emissions of pollutants and the availability of data. Table 1

Table 1
List of countries and their CO_2 emissions.

Numbers	Countries	CO_2 Emissions (Mt)	Region
1	China	11680.42	Asia
2	United States	4535.3	America/NAFTA
3	Russia	1674.23	Europe
4	Germany	636.88	Europe
5	South Korea	621.47	Asia
6	Canada	542.79	America/NAFTA
7	South Africa	435.13	Africa
8	Mexico	407.7	America/NAFTA
9	Turkey	405.2	Europe
10	United Kingdom	313.73	Europe
11	Italy	297.35	Europe
12	Poland	292.35	Europe
13	Taiwan	280.56	Asia
14	France	279.99	Europe
15	Spain	214.85	Europe
16	Netherlands	144.69	Europe
17	Nigeria	126.92	Africa
18	Singapore	56.13	Asia
19	Switzerland	35.3	Europe
20	Hong Kong	32.43	Asia
21	Ethiopia	17.01	Africa
22	Ghana	16.52	Africa
23	Kenya	16.41	Africa
24	Mozambique	9.94	Africa

Note: Compiled by authors using data from the World Population Review (https://worldpopulationreview).

(See Appendix) presents in detail the data of CO_2 emission measurements of these countries and their respective regions. The regression analysis was conducted using the Fully Modified Ordinary Least Squared (FMOLS) technique. Since OLS estimation is known to lead to biases due to the overestimation or underestimation of the regression coefficients, the study employed the Quantile Regression technique as a robust regression estimator (see Table 2).

4.2. Empirical model

The formulation of the empirical model for this study was derived from the model in Ref. [27], which stated that environmental degradation is a result of the influence of factors such as foreign direct investment, energy consumption, human capital, GDP and biocapacity. This study thus expresses environmental degradation as a function of these factors. The simple, implicit form of the model is correspondingly stated as follows:

$$CO2 = f\{GDP, ENU, FDI, TRADE, POP\} \tag{1}$$

where 'CO2' denotes environmental degradation, which is proxied as carbon 2 emissions; 'ENU' denotes energy use; 'FDI' represents foreign direct investment; 'TRADE' represents trade openness; and 'POP' denotes population.

To assess the impact of economic factors and energy use on environmental degradation, Equation (1) is explicitly stated in a linear stochastic form to derive Equation (2). Hence, Equation (2) is given as follows:

$$CO2i,t = \beta 0 + \beta 1GDPi,t + \beta 2ENUi,t + \beta 3FDIi,t + \beta 4TRADEi,t + \beta 5POPi,t + \mu i,t \tag{2}$$

where 'μi,t' represents the stochastic error term.

In order to test for the U-shaped and the N-shaped relationships for different levels of economic growth and pollution, equations (3)–(6) are formulated using the linear, quadratic, and cubic form of GDP and ENU from equation (2). Hence equations (3)–(6) are given as:

$$CO2i,t = \beta 0 + \beta 1GDPi,t + \beta 2GDP2i,t + \beta 3ENUi,t + \beta 4FDIi,t + \beta 5TRADEi,t + \beta 6POPi,t + \mu i,t \tag{3}$$

$$CO2i,t = \beta 0 + \beta 1GDPi,t + \beta 2GDP2i,t + \beta 3GDP3i,t + \beta 4ENUi,t + \beta 5FDIi,t + \beta 6TRADEi,t + \beta 7POPi,t + \mu i,t \tag{4}$$

$$CO2i,t = \beta 0 + \beta 1GDPi,t + \beta 2ENUi,t + \beta 3ENU2i,t + \beta 4FDIi,t + \beta 5TRADEi,t + \beta 6POPi,t + \mu i,t \tag{5}$$

$$CO2i,t = \beta 0 + \beta 1GDPi,t + \beta 2ENUi,t + \beta 3ENU2i,t + \beta 4ENU3i,t + \beta 5FDIi,t + \beta 6TRADEi,t + \beta 7POPi,t + \mu i,t \tag{6}$$

To estimate the quantile regression, Equations (7) and (8) were formulated as follows:

$$QCO2i,t\ (\delta / \chi i,t) = \beta 0(\delta) + \beta 1(\delta)\ GDPi,t + \beta 2(\delta)\ GDP2i,t + \beta 3(\delta)\ GDP3i,t + \beta 4(\delta)\ ENUi,t + \beta 5(\delta)\ FDIi,t + \beta 6(\delta)\ TRADEi,t + \beta 7(\delta)\ POPi,t + \mu i,t \tag{7}$$

$$QCO2i,t\ (\delta / \chi i,t) = \beta 0(\delta) + \beta 1(\delta)\ GDPi,t + \beta 2(\delta)\ ENUi,t + \beta 3(\delta)\ ENU2i,t + \beta 4(\delta)\ ENU3i,t + \beta 5(\delta)\ FDIi,t + \beta 6(\delta)\ TRADEi,t + \beta 7(\delta)\ POPi,t + \mu i,t \tag{8}$$

where 'QCO2i,t (δ/χi,t)' is used to represent the δth quantile condition of the response variable, and 'χi,t' is used to represent the vector of explanatory and control variables for each of the countries. β1 to β7 are used to represent the slopes of the explanatory and control variables.

Table 2
Variable definitions and sources.

Variable	Definition	Source
CO_2	This represents total carbon dioxide emissions, excluding land use and forestry. The data were used in logged form.	World Bank Development Indicators (WDI 2021)
GDP	This represents the gross domestic product. It is the sum of the gross value contributed by all resident producers in the economy, excluding the subsidies not added to the value of the product. This variable was used in logged form.	World Bank Development Indicators (WDI 2021)
ENU	This refers to energy use. It indicates the use of primary energy before its transformation to other end-use fuels. The data were used in logged form.	World Bank Development Indicators (WDI 2021)
FDI	This is a proxy for foreign direct investment. It represents the total net inflows of foreign direct investment. The data were used in logged form.	World Bank Development Indicators (WDI 2021)
TRADE	This represents the ratio of the sum of merchandised exports and imports in addition to GDP, all in current US dollars.	World Bank Development Indicators (WDI 2021)
POP	This represents total population. It consists of all residents, regardless of legal status or citizenship.	World Bank Development Indicators (WDI 2021)

5. Data analysis and empirical results

5.1. Data analysis

Before the empirical analysis, we carried out various diagnostic tests to check whether there were conditions in the available data that might influence the validity of the empirical results. Hence, panel unit and correlation tests were carried out to evaluate the stationarity of and relationship between the study variables, respectively [32].

For the sensitivity analysis, we used a first-generation unit root test to check for stationarity among the variables [33]. However, according to Ref. [34], there is a possibility of cross-sectional dependence in data on countries that have similar economic networks or the presence of unobserved factors. Hence, to ensure valid results, we employed the cross-sectional dependence test, which is a second-generation dependence test. Unaddressed CD in data may generate inconsistency as well as overestimation or underestimation of the regression results [26]. For a cross-sectional dependence test, the null hypothesis is cross-sectional independence. All variables were significant at the 1% level; thus, the null hypothesis indicating the presence of cross-sectional independence was rejected. The descriptive statistics are shown in Table 3.

5.2. Panel unit root test

Table 4 shows the results for the first-generation panel unit test. We used Lin, Levin and Chu, Im Pesaran and augmented Dicker–Fuller tests to check the stationarity of the data [34]. As shown in Table 4, only GDP was found to be stationary at level. CO2, ENU, FDI, TRADE and POP were found stationary at first difference.

Table 5 presents the results of the second-generation test conducted using CIPS and CADF. While GDP, ENU, POP and TRADE are stationary at first difference, CIPS, CO2 and FDI are stationarity at level. With CADF, the results reveal that GDP, POP and FDI are stationary at level, while CO2, ENU and TRADE are stationary at first difference order (see Table 6).

5.3. Empirical results

To test the relationship between energy use, economic growth and environmental degradation, we used fully modified ordinary least squares regression, the results of which are shown in Table 3. As shown in Table 9 (see Model (1) in the Appendix), we regressed GDP, ENU, FDI, TRADE and POP on CO2. Based on Model (1), GDP and POP were significant at the 1% level, whereas FDI was significant at 5%. FDI showed a positive coefficient, which indicates that a 1% increase in foreign direct investment leads to a 2.3255% increase in CO_2. This means that an increase in foreign direct investment leads to a 1% increase in population leads to a 168.2026% increase in environmental degradation. GDP, though significant, showed a negative relationship with environmental degradation. This result is in line with the findings of [7,8,35,36,37,38]. This means that 1% in economic growth leads to a 36.3784% decrease in environmental degradation. This is in contrast to the results of [11,32,39,40,41]. ENU was found to be significant, with a positive coefficient. This indicates that 1% in energy use leads to a 75.5046% increase in environmental degradation.

Model (2) assessed the EKC hypothesis and the rebound relationship using GDP and squared GDP, finding that GDP and squared GDP had significant positive and negative relationships, respectively, which confirms the validity of the EKC and rebound hypotheses. Energy had a significant and positive relationship with environmental degradation. In Model (3), we included GDP, squared GDP and cubed GDP in the regression, and all three were significant. However, GDP and GDP3 had positive coefficients, while GDP2 had a negative coefficient. This indicates an N-shaped curve, which refutes the EKC and rebound effect hypotheses. Model (4) assessed the relationship between ENU and ENU2, finding that they had significantly positive and negative relationships with CO2, respectively, which confirms the EKC hypothesis and inverted U shape. In the regression in Model (5), we included ENU, ENU2 and ENU3, which were significant at 1%. ENU2 had a positive coefficient, while ENU and ENU3 had negative relationships with CO2. This result indicates an inverted N-shaped curve, which refutes the EKC and rebound hypotheses. This is in line with the findings of [42,43,44] (see Table 7).

In the cointegration test, the null hypothesis of no cointegration was decisively rejected at the 5% level (Table 8). Hence, there was cointegration among all the parameters employed in estimating the effect of environmental degradation on economic growth and energy use. This enabled us to use the FMOLS estimator to establish a long-term relationship between the variables (Table 9) (see Fig. 4).

Table 3
Cross-sectional dependence test.

Parameter	CO_2	ENU	GDP	FDI	TRADE
Breusch–Pagan LM	2406.651*	1943.888*	5661.065*	3898.940*	2191.370*
Pesaran scaled LM	107.1856*	84.60506*	265.9847*	180.0019*	96.68094*
Bias-corrected scaled LM	106.8575*	84.27694*	265.6566*	179.6737*	96.35281*
Pesaran CD	6.385009*	1.491936	74.75910*	61.14696*	37.17900*

Note: Compiled by the authors. *, ** and *** denote the 1%, 5% and 10% significance levels, respectively.

Table 4
Panel unit root tests.

Variable	CO2	ENU	GDP	FDI	TRADE	POP
Levels						
LLC	0.61458	−1.21059	−2.90013**	−1.23933	1.68699	−7.3592*
IPS	2.37857	0.63297	2.33058	1.36304	2.34150	−1.6108
ADF - Fisher Chi-square	32.3220	44.9120*	52.5844	25.6192	31.0474	151.139*
First difference						
LLC	−13.4747*	−10.9749*	−12.0466*	−13.1559*	−13.2230*	−3.9636
IPS	−15.5863*	−12.1434*	−12.2598*	−18.2320*	−12.9959*	−9.8338*
ADF - Fisher Chi-square	296.528*	224.593*	226.621*	348.864*	243.997*	−7.5454*

Table 5
Second-generation panel unit root tests.

Variable	CIPS		CADF	
	I (0)	I (1)	I (0)	I (1)
GDP	−1.849	−4.047*	−2.368***	
CO2	−2.054**		−1.649	−4.467**
ENU	−1.744	−5.037*	−1.553	−4.002*
POP	−1.420	−2.194**	−2.988*	
TRADE	−2.020	−4.604**	−2.049	−3.358*
FDI	−3.521**		−2.679**	

Note: * and ** represent the 1% and 5% significance levels, respectfully.
Correlation analysis.

Table 6
Correlation test.

Variable	CO_2	GDP	GDP2	GDP3	ENU	ENU2	ENU3	FDI	TRADE	POP
$CO_2$1	1.00000									
GDP	0.91358*	1.00000								
	58.92832									
GDP2	0.9098*	0.990*	1.00000							
	57.4776	571.506								
GDP3	0.904052	0.99580	0.999*	1.00000						
	55.47930	285.0998	570.7127							
ENU	0.80667*	0.786770	0.783679	0.778672	1.00000					
	35.80189	33.43362	33.09213	32.55240						
ENU2	0.782351	0.777537	0.775797	0.772203	0.998451	1.00000				
	34.43078	32.43229	32.24966	31.87828	570.7611					
ENU3	0.782351	0.766447	0.766077	0.763922	0.993777	0.998430	1.0000			
	32.94738	31.29917	31.26266	31.05101	234.106	467.4700				
FDI	0.697356	0.815548	0.814422	0.811317	0.574903	0.567771	0.559157	1.0000		
	25.52095	36.96558	36.81389	36.40170	18.42966	18.09125	17.69053			
TRADE	−0.13881	−0.10939	−0.12015	−0.13030	0.216541	0.218771	0.219469	−0.12525	1.0000	
	−3.67657	−2.88666	−3.17452	−3.44723	5.817861	5.880750	5.900477	−3.31136		
POP	0.572944	0.482214	0.493815	0.504762	0.104832	0.102915	0.102081	0.370235	−0.6234	1.0000
	18.33611	14.43790	14.89552	15.33697	2.7650***	2.7138***	2.692***	10.45405	−20.91265	

Descriptive analysis.

6. Robustness test

For the robustness test Table 10, and Figs. 5 and 6 (See Appendix) show the results of the quantile regression. The findings revealed a mixed result for the GDP–CO_2 emissions nexus in different quantiles, as indicated in panel A. In the lower quantiles, we did not find a significant relationship between GDP and CO_2 emissions, but in the upper quantiles, there was a significant, positive relationship. This means that at an early stage of country development, economic growth increases environmental degradation. To empirically validate the EKC hypothesis, we analyzed the coefficients of the squared of CO2. Above the 0.50 quantile, GDP has a significant negative impact on CO_2, which implies that a determined increase in economic growth reduces environmental degradation. Therefore, there is evidence that the EKC and rebound hypotheses are applicable in this study within the chosen period. However, at the high-mass stage of development, GDP^3 increases CO_2 emissions above the 0.25 quantile. This suggests that the pollution-haven hypothesis applies to these countries.

As shown in panel B of Tables 10 and in the initial stage of energy use, ENU has a positive and significant impact on CO_2 emissions at all quantile levels, except 0.95. ENU2 has a significantly negative relationship with CO_2 in all quantiles except 0.95, which indicates

Table 7
Summary statistics.

Variable	CO_2	GDP	GDP2	GDP3	ENU	ENU2	ENU3	FDI	TRADE	POP
$CO_2$1	1.00000									
GDP	0.91358*	1.00000								
	58.92832									
GDP2	0.9098*	0.990*	1.00000							
	57.4776	571.506								
GDP3	0.904052	0.99580	0.999*	1.00000						
	55.47930	285.0998	570.7127							
ENU	0.80667*	0.786770	0.783679	0.778672	1.00000					
	35.80189	33.43362	33.09213	32.55240						
ENU2	0.782351	0.777537	0.775797	0.772203	0.998451	1.00000				
	34.43078	32.43229	32.24966	31.87828	570.7611					
ENU3	0.782351	0.766447	0.766077	0.763922	0.993777	0.998430	1.0000			
	32.94738	31.29917	31.26266	31.05101	234.106	467.4700				
FDI	0.697356	0.815548	0.814422	0.811317	0.574903	0.567771	0.559157	1.0000		
	25.52095	36.96558	36.81389	36.40170	18.42966	18.09125	17.69053			
TRADE	−0.13881	−0.10939	−0.12015	−0.13030	0.216541	0.218771	0.219469	−0.12525	1.0000	
	−3.67657	−2.88666	−3.17452	−3.44723	5.817861	5.880750	5.900477	−3.31136		
POP	0.572944	0.482214	0.493815	0.504762	0.104832	0.102915	0.102081	0.370235	−0.6234	1.0000
	18.33611	14.43790	14.89552	15.33697	2.7650***	2.7138***	2.692***	10.45405	−20.91265	

Note: Compiled by the authors.

Table 8
Johansen–Fisher panel cointegration test.

Hypothesised No. of CE(s)	Fisher Stat. (from trace test)	Prob.	Fisher Stat. (from max-Eigen test)	Prob.
None	765.5	0.0000	515.5	0.0000
At most 1	310.6	0.0000	171.4	0.0000
At most 2	174.6	0.0000	94.47	0.0000
At most 3	107.9	0.0000	70.47	0.0039
At most 4	70.62	0.0037	69.30	0.0050
At most 5	44.84	0.3538	44.84	0.3538

Table 9
FMOLS regression results.

Variable	Estimation model				
	Model 1	Model 2	Model 3	Model 4	Model 5
GDP	−0.363784* (−5.874203)	3.049125* (6.210574)	13.79872** (2.829907)	−0.287261* (−4.324656)	−0.225511* (−3.615094)
GDP^2		−0.145665* (−7.026081)	−1.115834** (−2.531416)		
GDP^3			0.029063** (2.193787)		
FDI	0.023255** (2.120480)	0.024138** (2.451028)	0.021977** (2.270184)	0.016521 (1.483291)	0.015481 (1.494881)
TRADE	0.000613 (1.209392)	0.000776*** (1.705370)	0.000722 (1.621111)	0.000454 (0.894525)	5.39E-05 (0.113200)
POP	1.682026* (11.52980)	1.209061* (8.112900)	1.192856* (8.172910)	1.627164* (11.07030)	1.466079* (10.54680)
ENU	0.755046* (8.231720)	0.760346* (9.229073)	0.789871* (9.695847)	2.890655** (2.952861)	−42.25788* (−5.182205)
ENU^2				−0.333912** (−2.203464)	13.98110* (5.445616)
ENU^3					−1.497518* (−5.602074)

Note: Compiled by authors. T-statistics are presented in parentheses, while *, ** and *** indicate the 1%, 5% and 10% significance levels, respectively.

a negative but insignificant relationship. This implies that as social development matures, a persistent increase in this development reduces environmental degradation. This supports the EKC and rebound hypotheses within the countries studied. However, in the high-mass stage of energy consumption, ENU3 had a significantly positive effect on CO_2 in all quantiles except 0.95, which was also positive but not significant. This implies that as social development matures, energy use increases environmental degradation.

7. Discussion: applying the Yin–Yang cognitive predisposition to the environmental paradox

The elaborate analysis of this study has confirmed a complex and paradoxical relationship between energy consumption, economic growth and environmental degradation. These results are consistent with earlier literature in that they differ among countries [11,42,43]. While the reduction of carbon emissions directly correlates with economic growth in some countries [8,35], others become pollution havens as they develop economically [33,34,45]. Per the outcome of the empirical analysis, we posit that the EKC hypothesis

Table 10
Quantile regression results.

Variable	Estimation quantiles				
	δ = 0.10	δ = 0.25	δ = 0.50	δ = 0.75	δ = 0.95
Panel A					
GDP	33.57890 (1.104929)	−1.023039 (−0.165114)	21.2864** (2.509249)	30.07772* (11.78402)	28.30327* (7.398944)
GDP^2	−2.700124 (−1.048828)	0.225823 -(0.430186)	−1.672214 (−2.303494)	−2.459604* (−11.10391)	−2.325839* (−6.814209)
GDP^3	0.072848 (1.008249)	−0.009513 (−0.645234)	0.04388** (2.131597)	0.066956* (10.49175)	0.063666* (6.332838)
FDI	−0.039100 (−1.478559)	−0.004117 (−0.382914)	−0.035076* (−3.760364)	−0.02033** (−1.906799)	−0.011024 (−1.262778)
TRADE	−3.24E-05 (−0.078009)	0.000342* (2.758550)	−1.49E-06 (−0.006137)	−0.000518 (−1.351848)	2.28E-05 (0.092787)
POP	0.841482* (11.64638)	0.919663* (26.36181)	0.999881* (32.65563)	0.925605* (14.68108)	0.747981* (12.54628)
ENU	1.122673* (7.749204)	0.978615* (28.37523)	0.940848* (32.67205)	1.032449* (28.91057)	1.094750* (22.16132)
Panel B					
GDP	0.134770 (0.660933)	0.030708 (0.630026)	0.081018* (2.835887)	0.163507* (2.624995)	0.057997 (0.865930)
ENU	108.9446* (9.009965)	49.03436* (4.997338)	34.27867* (5.894582)	20.03527* (2.606235)	15.41402 1.131010)
ENU^2	−31.46925* (−8.920252)	−13.41469* (−4.698610)	−9.223048* (−5.279419)	−5.07198** (−2.13782)	−4.046733 −0.946855
ENU^3	3.039692* (8.757318)	1.242734* (4.499046)	0.845500* (4.875810)	0.43900*** (1.808788)	0.372882 (0.845491)
FDI	0.011709 (0.956168)	0.011609 (1.129909)	−0.020733* (−3.410717)	−0.02970** (−2.066396)	−0.020130 (−1.001347)
TRADE	0.000336** (1.970608)	0.000125 (1.261378)	−1.20E-06 (−0.006637)	−0.000344 (−1.098335)	7.27E-05 (0.120765)
POP	0.927110* (5.565248)	1.063531* (32.86974)	1.013934* (35.79494)	0.891303* (13.61905)	0.883349* (5.108637)

Note: Compiled by the authors. T-statistics are presented in parentheses, while *, ** and *** represent the 1%, 5% and 10% significance levels, respectively.

and Jevon's paradox are adequate for a holistic interpretation of the energy–growth–environment trilemma (i.e. H1 and H2) [25,37,38,46]. We therefore propose that the Yin–Yang framework is an ideal cognitive instrument for dynamically interpreting and resolving the environmental paradox (i.e. H3).

In recent years, Yin–Yang harmony cognition has evolved as a feasible meta-theoretical method for deciphering general principles in management and organisation research [23,24,44,47]. Yin–Yang represents a permanent, paradoxical complementarity between interdependent and coevolving parts in anything that may operate with distinct variables or a process linkage in any open system [48,49]. Yin–Yang harmony cognition denotes a persistent mental process of reconciling contradictions within a specific system or context, which may be physical, abstract or virtual. Strategically, it suggests the use of nonlinear thinking styles and authority-bound, irenic approaches. Ultimately, it seeks 'temporarily balanced yet constantly changing' yet 'morally correct' solutions [50–52].

For a diversified collection of competing but complementary dynamics, such as the energy–growth–environment interaction, a Yin–Yang cognitive predisposition provides a different mindset of symbiotic coexistence among aspects of a natural contradiction. Because of basic cognitive divergences on the competitive conflict between energy, growth and the environment, additional synthetic and philosophical qualitative research is required to augment empirical constructions and theories of conflict management [15,16,46]. For the first time, we use Yin–Yang harmony cognition as a metatheory to induce strategic thinking about environmental protection. Adopting a Yin–Yang harmony mentality as an antecedent to the energy–growth–environment discussion creates a balanced platform for sustainable use of natural resources. Given the rising global energy demand and rate of carbon emissions, Yin–Yang harmony thinking should be considered to provide natural and practical remedies [46] to legitimate economic and environmental demands.

7.1. Theoretical implications

The EKC hypothesis and Jevon's paradox are theoretically well-rooted [7,8,53,54] models that have been supported in both spatial and temporal applications. They have been used in multifaceted studies to establish concepts that provide theoretically sound, holistic approaches to paradoxical dynamics [55–57]. This study extends the existing body of theoretical knowledge by applying the traditional notion of Yin–Yang (阴阳) as a complement to the Western concepts of the EKC hypothesis and Jevon's paradox. When established on the three-layered foundation of the Yin–Yang harmony (阴阳和谐) cognitive framework [44,47], the energy–development–environment trilemma is drawn into a balanced, coherent coexistence [41]. The foundational layer projects the picture of a permanent, contradictory complementarity running through interdependent but paradoxical elements. It manifests as a linkage between separate variables and reveals the relationships between parameters, even though their functions might assume a contradictory coexistence – like, in this case, that of energy consumption, economic growth and environmental degradation. The next layer is Yin–Yang harmony (阴阳和谐). It represents a persistent process of harmonisation that implies the permanent pursuit of a balanced and continuous yet evolving relationship between all tangible and intangible things. This layer is the organ responsible for maintaining balance throughout the energy consumption and economic growth processes while protecting environmental values. The top layer is Yin–Yang harmony cognition, which represents an amalgamation of scientific and art-based methods perceived from a hermeneutic perspective [44,47]. Given that economic and environmental subjects generally involve cognitive processes [58,59], the energy–growth–environment trilemma necessitates a systematic cognitive analysis of a unique meta-theoretical framework [60,61].

The three-layered foundation of Yin–Yang harmony cognition provides a thoroughly harmonious mindset with a strong emphasis on building symbiotic coexistence and establishing paragenetic intercourse rather than focusing on elements individually and addressing the environmental situation by handling one element at a time [62]. The inherent harmonizing pattern of the Yin–Yang cognitive process encourages people involved in the environmental decision-making process to make strategic concessions based on well-balanced intuitive knowledge and well-informed, mature rationality. This process creates a harmonised melting point for pursuing an energy exploration and economic growth agenda while protecting mother nature. Moreover, the rebalancing mechanism that Yin–Yang harmony cognition provides is not completely predictable because it follows the natural ecological cycle, with a rotation between eight annual seasons (see the Yin–Yang eight-trigram model in Fig. 6). Established on the foundation of the Yin–Yang three-layered structure, the eight-trigram model symbolises natural rotations and permutations among the eight annual seasons (e.g. spring, summer, autumn and winter and the transitional seasons in between) as well as the coexistence of the eight primordial forces in the universe (heaven, lakes, fire, thunder, wind, water, mountains and earth) [44,47]. Against this background, the Yin–Yang harmony mentality creates an intuitive predisposition for grasping a symbiotic coexistence among economic and environmental elements. The Yin–Yang mental predisposition, unlike the EKC hypothesis and Jevon's concept, provides a preventive dimension that controls for all possible misappropriation from the start and guarantees a continuous rebalancing of economic and environmental parameters in conformity with rotating and mutating natural elements. Just as it was applied in Chinese medicine during the Qin dynasty (c. 221–207 BCE) to harmonise adapted medical therapies and treatments in accordance with the eight trigram elements, the Yin–Yang harmony mental predisposition provides a model for balanced economic growth in a healthy environment [62]. This study uses the Yin–Yang harmony cognitive approach to frame a model that reflects the harmonious coexistence of the conflicting yet complementary economic and environmental dynamics in complete conformity with nature.

7.2. Practical implications

Continuing from the previous discussion, this section outlines the practicality of Yin–Yang harmony cognition based on the eight-trigram conception [63] and its implications for sustainable development. While the EKC hypothesis and Jevon's paradox preconise economic growth first before attending to the environment, someone following the Yin–Yang approach would deal with economic growth sustainably from the beginning [23,24]. Moreover, according to the EKC hypothesis and Jevon's paradox, all parameters are mechanically constant and do not reflect the seasonal mutations of natural elements [64–66]. However, the Yan-Yang harmony eight-trigram framework provides a platform for mutating economic demands and environmental needs in accordance with specific seasons and natural characteristics [67]. Fig. 7 reviews the application of the Yin–Yang harmony eight-trigram model to various natural phenomena in the literature [23,24,62]. Meanwhile, this study explores the importance of the eight different seasons and natural forces of Yin–Yang harmony for the practical understanding of energy consumption, economic demands and environmental implications.

1. Spring

Spring is represented by Thunder (Zhen; ☳) and is marked by the commencement of transformations and emergence from the soil. This strategic setting predicts proliferating, developing vegetation with great potential for environmental recovery. Dominant resources and capital access may profit readily from such a high-growth environment with less vulnerability to the uncertainties caused by an asymmetric environment. It is critical at this point to ward off the fallacy of seasonal environmental renewal. While someone with the Yin–Yang harmony mindset will evaluate the whole cycle in this case, the EKC hypothesis and Jevons' paradox may be deceived by the temporary recovery. Making use of a well-established cognitive tendency, the Yin–Yang philosophy provides a comprehensive, far-reaching understanding of developmental undertakings.

2. Spring–summer

This season, symbolised by Wind (Zun; ☴), is defined by a feeling of development and a maturity ready to shape, maintain and feed the awakened energy and assets that are now accessible. This strategic position reflects a developing but still unpredictable environment rife with untapped, hazardous chances and great development potential. However, the energy consumption threshold begins to fall at this point, since the government normally regulates the market to promote industrial and economic growth. The Yin–Yang framework, on the other hand, advocates alignment with one's context so that one is better positioned to seize opportunities to address present environmental concerns and effectively prepare for subsequent seasons. It is critical to pay special attention to specific metrics at this stage to detect the crucial complementary forces at work, such as wind energy.

3. Summer

Summer, with the image of Fire (Li; ☲), suggests a strong preference for brightness and warmth. This strategic position may be viewed as a gradually formed but more competitive environment with a low energy-consumption rate paired with a high economic development rate, high profit returns and an enhanced environmental fabric. New energy consumption outlets are enticed to join the market at this point. However, the Yin–Yang tendency emphasises putting greater effort into allocating resources efficiently to gain a comparative advantage through the efficient use of scarce resources. In other words, when rivalries intensify, it is critical to construct an endogeneity-based competitive strategy that aids in the proactive development of core competencies for establishing creative, strategic complementarities among conflicting elements.

4. Summer–autumn

Characterised by Earth (Kun; ☷), this season represents significant changes that bring out kindness and openness, although it is saturated with a great number of new entrants, most of which are ecologically unfavourable. Environmental demand at this stage is quite high, signalling a critical need for a process of re-evaluation and therefore an increased capacity for maximum preservation and waste prevention. The fundamental strategic skill is to strike a balance between preserving the complementary forces in play and finding new ones. This is the season in which the Yin–Yang advocate uses previously gained knowledge and capacities to recognise unique rivalries and cooperative elements in a given situation. In this sense, the Yin–Yang inclination requires more efficient and effective resource management.

5. Autumn

The picture of a Lake (Dui; ☱) represents this season, implying a developed and successful economy with a comprehensive development tendency. This is the season when environmental parameters are relatively steady and saturated with a balanced interplay between energy consumption, economic development and environmental improvement. At this point, it becomes especially sensible to pursue a conservative policy focused on energy security by more carefully and efficiently maintaining current resources and capabilities. In such a case, the framework emphasises the need for reserving cash and hedging for future seasons.

6. Autumn–winter

Heaven (Qian; ☰) is defined by low entrance barriers, uneven coexistence and interdependencies between incumbent environmental components and energy demand structures. Here, the possibility for development is limited, and a rise in economic inertia is likely to make the environment less appealing over time. At this point, the imbalance could be exacerbated by the levelling out of economic capabilities through increased energy use (as in the EKC hypothesis), resulting in a worse situation for the next season, but with a cognitive predisposition towards providing other forms of energy to prepare for the next season and avert the worst outcomes. The Yin–Yang philosophy emphasises the development of an exogeneity-driven approach that allows for rapid adaptation to the impending chill.

7. Winter

Winter, associated with Water (Kan, ☵), has a volatile climate fraught with complexity and uncertainty in which an economic crisis may be an urgent danger, often owing to increased energy demand. In the face of increased adversity, the magnitude and size of tensions and disputes between competitors significantly increase. Complementarity among components can only be discovered at this point by developing close symbioses. Survival, according to the Yin–Yang mindset, consists of exogeneity-based defensive measures to meet global swings, wherein resources can still be conserved to withstand tumultuous circumstances.

8. Winter–spring

This season, symbolised by a Mountain (Gen; ☶), represents the time of darkness before the morning. As such, it represents a stagnant, declining market in which practically everything has entered a slump. A lengthy duration may have produced a widespread dependency among components, resulting in a shared conclusion in which high levels of energy demand neglect environmental protection. At this point, the employment of regulations to prepare for a probable recession is predetermined. A conservative approach based on exogeneity enables survival in the face of impending economic and environmental crises.

Based on this explication, the Yin–Yang framework, in contrast to the EKC and energy rebound hypotheses, suggests that comprehensive energy consumption, economic demands and environmental conditions directly correlate with the yearly seasons and natural conditions. Correlatively, the parameters of the energy–growth–environment trilemma are regulated by seasonal rotations in nature. This demonstrates that the Yin–Yang framework is the most adequate model for achieving harmony within the trilemma [47].

8. Conclusion

In this study, we aimed to elaborate a paradoxical interrelationship within the energy–economy–environment nexus through Yin–Yang harmony cognition. For that purpose, we used a sample of 24 selected countries around the world for the period 1980–2012. We used the cointegration and FMOLS regression techniques to evaluate the development of short- and long-term causal relationships between these three variables. As expected, our analysis established a complex and paradoxical relationship between energy consumption, economic growth and environmental degradation more robust than that established by the EKC hypothesis or Jevon's paradox (i.e. H1 and H2) [68,69–73] due to the regulatory capacity of the Yin–Yang artillery to harmonise this paradoxical interaction (i.e. H3). Our results are consistent with earlier literature by revealing the mix results among countries [40,45,34,74]; while economic growth directly correlates with decreasing carbon emission in some countries [3,4,6,75]; others became a pollution heaven with economic development [5,7,76,77]. For the course, Ozokcu S, and Özdemir Ö [7] used panel data from high-income level OECD countries and emerging countries between 1980 and 2010 to show that the EKC hypothesis is not supported across the board. The authors applied the Driscoll-Kraay Standard Errors with two models to confirm other findings [9,10,77] to show an N-shape and an inverted N-shape relationship between GDP level and CO_2 emission in different countries. Thus, according to Refs. [7,76,77] carbon emission is not automatically solved by economic growth.

Echoing this, we are unable to give proof that industrialized nations can genuinely recover from environmental degradation [69, 78–80]. In light of these findings, it is obvious that the alarming environmental hazards facing our planet call for cognitive and behavioural redress across all levels of society [64–66]. In line with our results Ruzzenenti et al. [81], suggest going beyond the conventional wisdom of the rebound effect and the Jevons' paradox to find answers to the pollution problem. In the World Energy Council report [90], Olyver Wyman proposed a World energy trilemma index 2020 in an attempt to provide a formula for Energy consumption and economic development devoid of carbon emission. The moral trilemma imposed by the Energy-Growth-Environment discussion suggests broader and more inclusive solution frameworks [11,23,78]. As mentioned already this novel research adopts the Yin-Yang harmony cognitive [62,63,67] to readdress the energy-growth-degradation paradox [82,83]. The Yin-Yang mental predisposition supervises respect for environmental values [23,24,84], as well as the economic and demographic demands within each given geographical and time setting [22,44,85].

9. Policy recommendations

Based on these findings, we can therefore offer some policy recommendations. First of all, since thresholds and turning points on the Growth-Environment relation curve are specific to each country and situation, the basic recommendation for dealing with the carbon emission problem is for governments to invest in natural, sustainable approaches to economic growth that do not rely highly on hydrocarbons and fossil fuel. The carbon problem is a serious issue for the entire globe and many technical solutions have been proposed, but the statistics have not been encouraging. We recommend that natural means should also be explored extensively by using nature to heal nature through traditional concepts like the Yin-Yang harmony cognitive. These kinds of concepts can be applied alone or in combination with other conventional laws like Photosynthesis, which simply implies that the amount of carbon emitted in a specific environment must be strictly dependent on the size and nature of the vegetation in the environment. According to the Yin-Yang concept, the type of vegetation to be planted in a location must be dependent not only on the climate but also on the level of energy consumption and carbon emission, thus the type of human activities that could be allowed. Even though these natural solutions could be deployed to deplete the level of CO_2 in a specific location, it is highly recommended that for new consignments of energy exploration and consumption, natural concepts holding Energy-Growth-Environment in symbiosis are explored and concluded ways before the start of the project. Other approaches like preserving or creating wetlands are very effective for protecting the environment naturally. Naturally, these solutions require a long-term examination of a wide scope of interconnected elements like the climate, vegetation, landscape, soil, water bodies and human activities. Governments must also adopt preventative measures to deal with unpredictable circumstances of climate change.

10. Limitation and future research

In spite of the remarkable contribution of this study, obviously, there are still some aspects of the Carbon emission question to be investigated in future research. First, unlike this study sample composed of several countries future work would be done at the national level to examine how the Yin-Yang framework applies at that level. Secondly, future studies might explore how the Yin-Yang concept can reverse the sequels of climate change by identifying and evaluating the capacity of buffer parameters to be introduced into the ecological preservation equation. Thirdly, future research on the Energy-Growth-Environment can explore more natural and rational ideological concepts used to solve paradoxical situations in other fields.

Author contribution statement

George Kwame Agbanyo: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Charles Ofori: Performed the experiments; Analyzed and interpreted the data.

Gigamon Joseph Prah: Analyzed and interpreted the data; Wrote the paper.

Tachia Chin: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

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.

Appendix

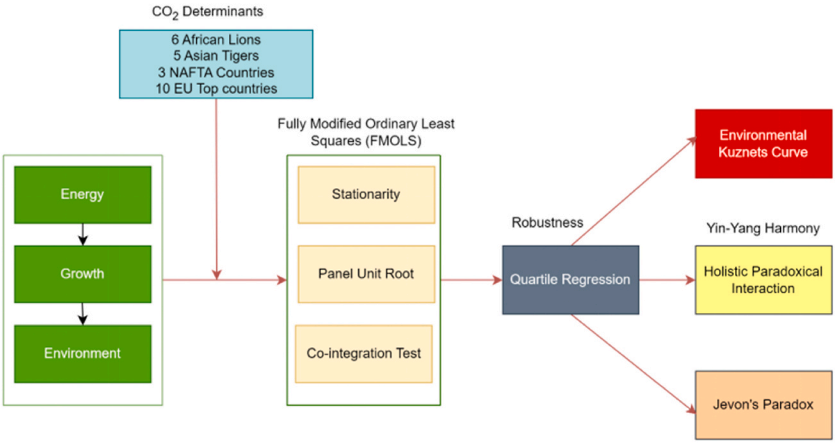

Fig. 1. Graphical abstract.

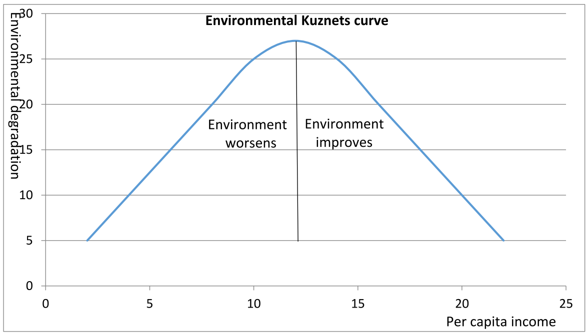

Fig. 2. Environmental Kuznets curve.

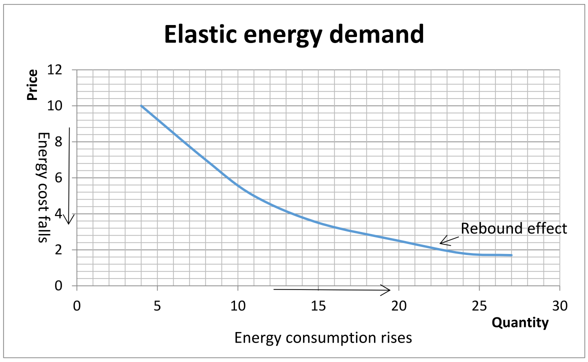

Fig. 3. A curve depicting Jevon's paradox.

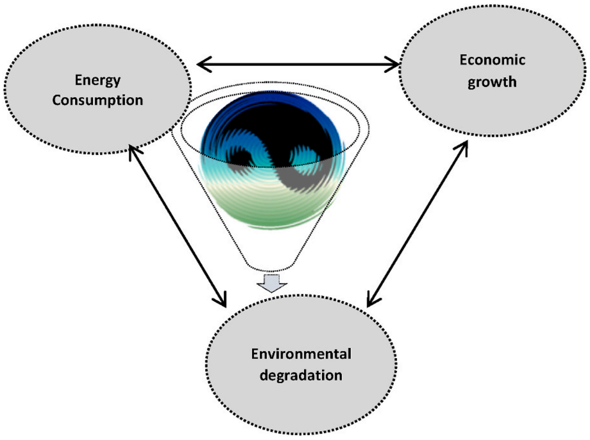

Fig. 4. Yin–Yang harmony.

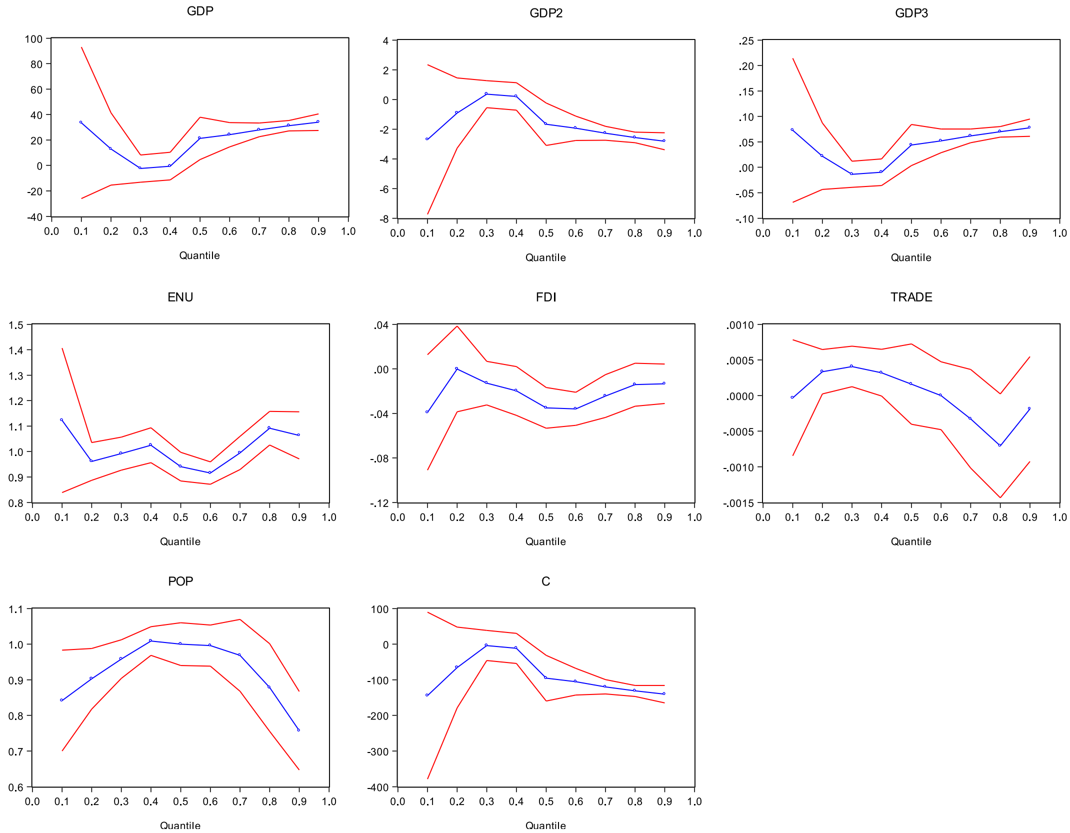

Fig. 5. Panel A Quantile estimation graph.

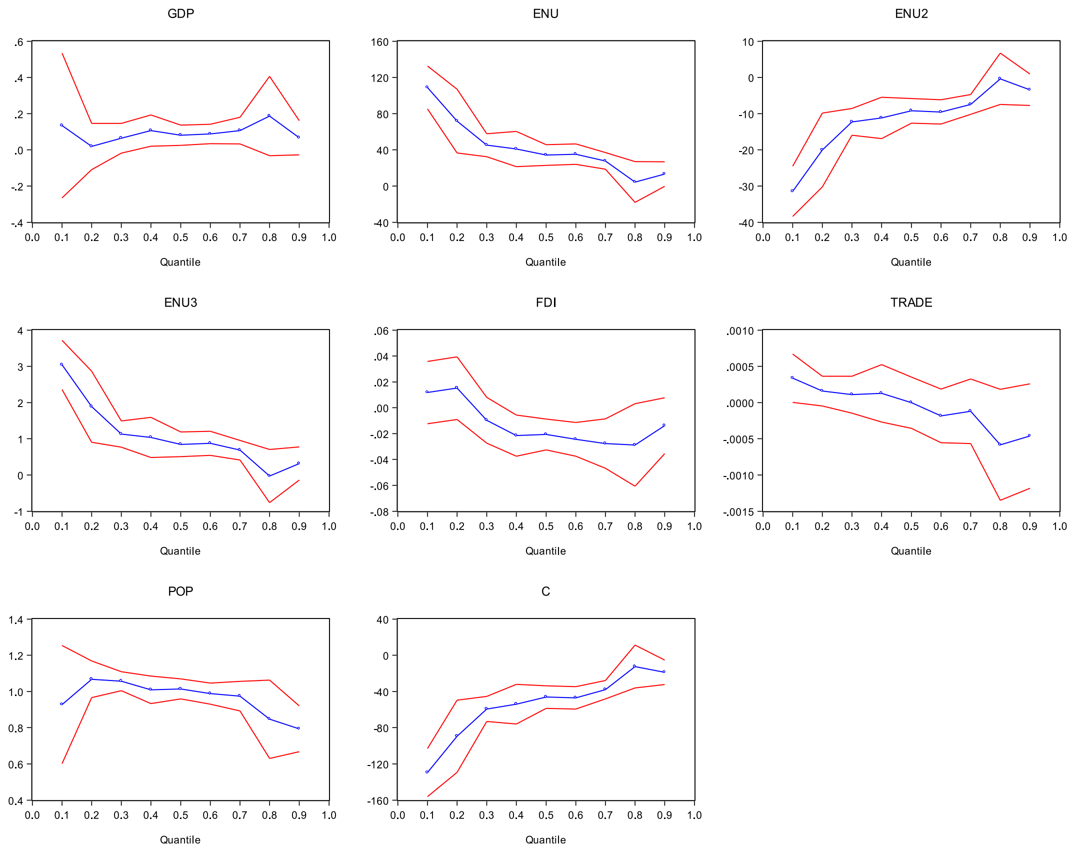

Fig. 6. Panel B Quantile estimation graph.

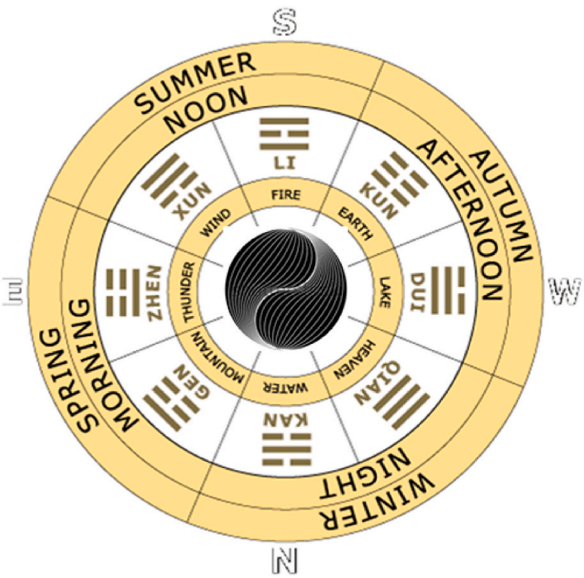

Fig. 7. The Yin–Yang eight-trigram model. Source: The Art Institute of Chicago.

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