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The relationship between energy-resource depletion, climate change, health resources and the environmental Kuznets curve: Evidence from the panel of selected developed countries

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A B S T R A C T

The objective of the study is to examine the relationship between energy-resource depletion, climate change, health resources and the Environmental Kuznets Curve (EKC) under the financial constraint environment in the panel of selected developed countries, over the period of 2000–2013. The study employed panel Generalized Method of Moments (GMM) estimate for robust inferences. The results confirmed the existence of EKC hypothesis in the energy-resource depletion model i.e., inverted U-shaped relationship between energy-resource depletion and GDP per capita in the selected developed countries. The results of climate change model confirmed the U-shaped relationship of Perfluorocarbons (PFC) gas emission and Particulate Matter-2.5 micrometers ($PM_{2.5}$) emissions with the per capita income. The health resource model confirmed the existence of inverted U-shaped relationship of infant deaths and health expenditures per capita with the per capita income, while there is a U-shaped relationship between incidence of Tuberculosis (TB) and GDP per capita. The other results indicate that carbon dioxide (CO_2) emissions increase Sulfur Hexafluoride (SF_6) emissions and health expenditures; fossil fuel energy consumption increases PFC gas emissions and $PM_{2.5}$ emissions; energy demand increases $PM_{2.5}$ emissions and health expenditures; and financial dummy (D_{2008}) affected energy-resource depletion, $PM_{2.5}$ emissions, Greenhouse Gas (GHG) emissions index, infant deaths, and health expenditures per capita.

Contents

Abbreviations: EKC, environmental Kuznets curve; GMM, Generalized Method of Moments; PFC, Perfluorocarbons; $PM_{2.5}$, Particulate Matter (2.5 micrometers); TB, Tuberculosis; GDP, Gross Domestic Product; CO_2, carbon dioxide emissions; SF_6, Sulfur Hexafluoride; D_{2008}, dummy variable; GHG, greenhouse gas; SO_2, sulfur dioxide; PCA, principal component analysis; JB test, Jarque–Bera test; LM, Lagrange Multiplier; VIF, variance inflation factor; GNI, Gross National Income; PPP, Purchasing Power Parity; MENA, Middle East and North Africa; eHDI, emissions associated Human Development Index; EEA, European Environmental Agency

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1. Introduction

The relationship between energy-resource depletion and the growth trajectories is one of the focal points for the policy makers to device the long-term energy policies in order to balance the free flow of energy supply across the globe. In addition, climate change and health hazards are a more pronounced agenda in the environmental literature that became obvious to finance with the sustained economic growth and long-term developmental vision of the nations. This study investigated the relationship between energy-resource depletion, climatic factors and health resources under the framework of Environmental Kuznets Curve (EKC) that provided the set of regressors to explain these environmental-growth models in the panel of selected developed countries.

The EKC debate is almost covered since last three decades, while the starting point of this theory is based upon the original work of Kuznets [1] that described the different growth phases in relationship with the income inequality. Almost half of the century has passed away, but Kuznets' work is still alive in different forms i.e., the most debatable form of Kuznets' work is EKC which has still been showing conflicting results in different regional settings and in the cross-sectional panel of settings.

There are number of parallel studies available on the work of EKC in different environmental settings, however, these studies are like the two sides of the same coin that always stand opposite to each other. Asafu-Adjaye [2] examined the cause–effect relationship between energy demand and economic growth for four Asian developing countries and found the causality running from energy demand to economic growth in India and Indonesia, while there is a feedback relationship between energy and economic growth in Thailand and the Philippines. Bhattarai and Hammig [3] investigated the long-run relationship between deforestation and GDP per capita in Latin America, Africa and Asian continent. The results confirmed the inverted U-shaped relationship between GDP per capita and deforestation in all the three regions of the World. The study concludes that the deforestation process was significantly influenced by the institutional structure and economic policies of the continents, however, the progress in political reforms and good governance significantly reduced deforestation process. Fischer-Kowalski and Amann [4] analyzed both the IPAT (population led emission) model and EKC hypothesis in the context of industrial and developing countries. The result fail to explain the IPAT model and EKC hypothesis under different socio-economic factors, however, population growth and technology both increased the carbon share more than the GDP per capita in the selected panel of countries. Ehrhardt-Martinez et al. [5] investigated the deforestation–Kuznets curve in the cross-sectional panel of less developed countries and found a strong evidence of inverted U-shaped relationship between deforestation and economic development in the region. Halkos [6] employed two sophisticated panel econometric techniques including panel GMM technique by Arellano-Bond and random coefficient method, and evaluating EKC hypothesis with sulfur dioxide (SO_2) emissions in the panel of 73 OECD and non-EOCD countries, comprised the larger data set from 1960 to 1990 and found that there is an inverted U-shaped relationship between SO_2 emissions and GDP per capita by Arellano-Bond method, while in random coefficient panel technique, there is no visible sign of EKC with SO_2 emissions. Both the results are different from each other, while using the same data set with different econometric modeling techniques. Therefore, the EKC hypothesis considered is more sensitive with different econometric techniques, which should be cautioned with care while handling EKC modeling.

Jalil and Mahmud [7] investigated the relationship between air pollutant, energy demand, economic growth, and trade openness in the context of China, over the period of 1975–2005. The results confirmed the inverted U-shaped relationship between GDP per capita and per capita CO_2 emissions nationwide. The causality results confirmed the unidirectional causality running from economic growth to CO_2 emissions but not vice versa. Akbostanci [8] examined both the time series modeling technique (for country-wide) and panel data estimation technique for Turkish Province and found that there is monotonic increasing function between GDP per capita and per capita CO_2 emissions by using time series modeling, while the results of panel estimation confirmed the N-shaped relationship between (i) GDP per capita and SO_2 emissions and (ii) GDP per capita and PM_{10} emissions, respectively. Winchester and Reilly [9] argued that carbon price is a feasible solution to enlarged low carbon technologies and bioenergy across the globe. Gul et al. [10] examined the causal relationship between CO_2 emissions and energy demand by employing maximum entropy bootstrap approach in the context of Malaysia, over the period of 1975–2013. The results confirmed that energy consumption deteriorates environmental quality which further depicts in the result of Granger causality result where the causality runs from energy demand to per capita CO_2 emissions, but not vice versa. Qureshi et al. [11] investigated the long-run relationship between electric power shortages and specific growth factors in the context of World's largest regions and found that climatic variability possesses the largest variance in terms of inadequate electric power transmission. Khan et al. [12] investigated the relationship between water resources, resource rent, energy use and CO_2 emissions in the context of Pakistan and found that both the energy use and water resources significantly increase CO_2 emissions. The results of variance decomposition analysis indicate that natural resources rent has least contribution in influencing air pollution in a country. Saidi and Hammami [13] explored the long-run panel relationship between energy demand and income of the 58 countries from 1990 to 2012. The results show that the energy consumption is significantly associated with the increasing economic growth of the cost of air pollution in the region. Ozturk and Bilgili [14] highlighted the importance of biomass consumption and trade liberalization policies in the context of Africa's growth.

Menegaki and Tsagarakis [15] examined the panel relationship between GDP per capita, fossil fuel energy and renewable energy production in 33 European countries, over the period of 1999–2010. The study employed both the random effect panel model and Arellano Bond estimator and confirmed the U-shaped EKC relationship with the coal production and renewable energy production accordingly. Ahmed et al. [16] confirmed the existence of EKC hypothesis with the deforestation in the context of Pakistan. Al-Mulali and Ozturk [17] confirmed the significant and positive impact of energy associated emission that leads towards the ecological footprint in the MENA region. Tan et al. [18] examined the relationship between seven types of industrial pollution intensity and GDP per capita of 46 Chinese pilot cities, over the period of 1993–2012. The results confirmed the 'intensity EKC' hypothesis in which industrial pollution initially decreased with the increasing economic growth, while at the later stage of development this rate of decline is persistent and is continued in the next stages. According to Capellán-Pérez et al. [19], p. 397], *"The end of the era of cheap and abundant energy flows brings the issue of economic growth into question, stimulating research for alternatives as the de-growth proposal"*. Zhou et al. [20] emphasized the importance of biophysical factors including climate change in the EKC framework that explained 78% variations in environmental quality as compared to the only 37% variations found in the original EKC framework in China. Liddle [21] investigated the relationship between per capita GDP and transport related emissions and found the existence of EKC hypothesis in relationship between per capita GDP and emissions technology. Ozturk and Al-Mulali [22] although did not find the traces of EKC hypothesis for Cambodia, the interesting results related with the good governance and control of corruption that significantly preserve the natural flora of the country. Lamb and Rao [23] emphasized the emissions associated with the human development index (eHDI) i.e., human development is correlated with the energy use and GHG emissions, however, for balancing the basic need and health resources, there is a substantial requirement of energy reforms for human development progress. Liddle and Messinis [24] investigated the relationship between per capita SO_2 emissions and per capita GDP for 25 OECD countries, covering the period of 1950–2000. The results uncovered the inverted-Us and inverted-Vs for 19 out of 25 countries.

The above significant debates indicate the existence of EKC hypothesis with different socio-economic variables. The present study examined the interlinkages between energy-resource depletion, climate change and health resources with the EKC framework under the financial constraint environment, in the panel of nine developed countries, over the period of 2000–2013. The study has sub-objectives in order to device long-term sustainable policy framework for the region i.e.,

- To investigate the relationship between GDP per capita and energy-resource depletion including energy depletion, net forest depletion and natural resource depletion, under financial constraint environment with specific reference of inverted U-shaped relationships between them.
- To investigate the relationship between GDP per capita and climatic factors including PFC gas emission, PM2.5 emission and SF6 emission, under financial constraint environment with specific reference of inverted U-shaped relationships between them.
- To investigate the relationship between GDP per capita and health resources including incidence of tuberculosis, number of infant deaths and health expenditures per capita, under financial constraint environment with specific reference of inverted U-shaped relationships between them.

These objectives have been empirically evaluated by the simultaneous equations modeling technique including panel GMM estimator that addresses the possible endogeneity from the models.

2. Data source and methodological framework

The study examined the interrelationship between energy-resource depletion, climate change, health resources and the Environmental Kuznets Curve (EKC) in the panel of nine selected developed countries namely, Austria, Czech Republic, Estonia, Germany, Ireland, Lithuania, Poland, Slovenia, and Slovak Republic. The study used number of variables in order to assess the impact of income per capita (constant 2005 US $), carbon dioxide emission (metric tons per capita), Energy use (kg of oil equivalent per capita), and Fossil fuel energy consumption (% of total) on energy depletion (Adjusted savings: energy depletion (% of GNI)), Adjusted savings: natural resources depletion (% of GNI), Adjusted savings: net forest depletion (% of GNI), PFC gas emissions (thousand metric tons of CO_2 equivalent), $PM_{2.5}$ pollution – mean annual exposure (micrograms per cubic meter), SF_6 gas emissions (thousand metric tons of CO_2 equivalent); Incidence of tuberculosis (per 100,000 people), number of infant deaths and health expenditure per capita, PPP (constant 2011 international $), respectively. The unbalanced panel of data is used for the respective variables across the countries, which is available at *World Development Indicators* published by World Bank [25]. The data set of this study covers a period of 2000–2013, which illustrates some factual movements in the global economic recession and economic downturn, as the inflation-adjusted crude oil prices rose from US$25/barrel to US $30/barrel, and then enormously increased up to US$60/barrel from 1980 to 2003, 2006, and 2008 respectively, which constantly increased due to global financial crisis of 2008 [26]. European countries also faced a severe financial crisis that not only slowed down the economic growth of many European countries but also compromised with environmental and air pollution related sustainability issues. Thus, this study is conducted for this time period as a ready reference to evaluate the environmental sustainability issues under the constraint financial environment in a panel of developed countries.

The study constructed an index of GHG emissions which is the combination of PFC gas emissions, $PM_{2.5}$ – mean annual exposure of microorganisms, and SF_6 gas emissions, by using principal component analysis (PCA). PCA used for two main purposes, i.e., at first instance, the study filled the missing gaps in the GHG components by the constructed weighted index points rather than using forward and backward interpolation technique, latterly, the study averages the GHG components and constructed the overall index, that we called 'GHG index'. Table 1 shows the GHG index by PCA.

Table 1, Panel A, shows that among three factors, first factor has an eigenvalue greater than the value of unity, while the remaining two factors have a value less than unity. The proportional variation of factor-1 is explained about 71.60%, while factor-2 and factor-3 explained 25.66% and 2.74% respectively. Table 1, Panel B, shows the eigenvectors loading and found that principal component matrix-one (PC1) is suitable for the remaining PC2 and PC3 due to the negative vector loadings in them. The study simply averaged the PC1 vector loadings and divided them by their respective factors loading that are able to fill the missing gaps in the respective variables series i.e., PFCGAS, $PM_{2.5}$ and the SF_6. After that, the study constructed GHG index respectively. Finally, Table 1, Panel C, shows the correlation matrix between the respective variables. The correlation results show that both the $PM_{2.5}$ and SF_6 have a positive correlation with the PFCGAS, however, the SF_6 have a larger share in terms of magnitude to influence PFCGAS emission in a panel of countries. In addition, there is a positive correlation between SF_6 and $PM_{2.5}$ respectively.

There are number of possible reasons to selected these countries as a sample for this study, as these countries faced severe environment and sustainability issues, along with economic slowdown due to the effect of the global economic crisis. The Austrian economy severely faced eco-environmental problems that slow down the economic growth rate, and reached 0.7% in 2015, which is far low from the assigned targeted growth rate of 1.7% for the subsequent years [27]. The economy of Czech Republic concentrated on environment associated problems, which includes preservation of natural resources, improving ambient air quality, climate protection, ecosystem stability and environment cleanliness. These policies aid to facilitate the economy towards green development [28]. The economy of Estonia is flared with transportation and industrial emissions, which significantly affect the health and wealth of the country. The sound legislative environmental reforms may reduce the strain of air pollution across the countries [29]. WHO [30] discussed the environmental effects of health in Germany and emphasized the need of substantial policy reforms to reduce environmental health burdens in Germany and across the World. Ireland economy has a sustained economic growth and it has maintained the highest growth rate among all European countries with sound socio-economic and environmental balance to decrease air pollution, however, biodiversity and natural habitat still threatened with unpredictable climate change that required sustainable policy reforms as United Nations Kyoto protocol [31,32]. Lithuania has produced an average

Table 1
Principal components analysis for constructing GHG emissions index.

Panel A: Eigenvalues (sum=3, average=1)					
Number	Value	Difference	Proportion	Cumulative value	Cumulative proportion
1	2.148	1.378	0.716	2.148	0.716
2	0.769	0.687	0.256	2.917	0.972
3	0.082	–	0.027	3	1
Panel B: Eigenvectors (loadings)					
Variable	PC1	PC2	PC3		
PFCGAS	0.655	−0.211	−0.725		
$PM_{2.5}$	0.416	0.902	0.113		
SF_6	0.630	−0.376	0.679		
Panel C: Ordinary correlations					
	PFCGAS	PM2.5	SF6		
PFCGAS	1				
$PM_{2.5}$	0.432	1			
SF_6	0.907	0.308	1		

Note: PFCGAS indicates PFC gas emissions. PM2.5 indicates PM2.5 emissions, and SF6 indicates SF6 emissions.

GHG emissions amount to 4–5 t per capita, which is considerably lowest in European Union countries. The major economic sectors including energy that produced 61.7% GHG emissions are: agriculture sector contributed 21.4%, industry around 10.8%, and waste sector produced around 5.6% in 2010. Although, the policy reforms to reduce GHG emissions in considerably high priority in a country, however, the country still faces environmental challenges to maintain their ecological and biological standards [33,34]. The sustainable policy agenda for European countries including Poland, Slovenia, and Slovak Republic emphasizes the following green growth sustainable agenda to sustain ‘Europe 2020’ strategy for utilizing knowledge base, optimizing natural resource management, and protecting terrestrial base including biodiversity preservation and ecosystem balance for broad-based growth across the globe [35,36].

The EKC hypothesis is the old and gold theory which is related with the work of Kuznets who presented the novel relationship between GDP per capita & income inequality and found the inverted U-shaped relationship between the variables in the setting of cross-sectional panels of countries. Eq. (1) shows the mathematical and empirical reduced form of Kuznets' work i.e.,

$$\ln(Inequality)_{i,t} = \alpha_1 + \alpha_2 \ln(GDPPC)_{i,t} + \alpha_2 \ln(GDPPC)_{i,t}{}^2 + \alpha_3 \ln(z)_{i,t} + \varepsilon_{i,t} \quad (1)$$

where ‘*Inequality*’ indicates income inequality, *GDPPC* indicates GDP per capita, ‘*z*’ is the other regressor, ‘*i*’ indicates the cross-section identifiers, ‘*t*’ is the time period, and ε is the error term.

The Kuznets' school of thoughts identified different forms of the relationship between income inequality and per capita GDP i.e., (i) inverted U-shaped relationship, (ii) U-shaped relationship, (iii) no relationship between the variables, (iv) monotonic increasing function, and (v) monotonic decreasing function. After 35 years of Kuznets work, a number of scholars deduced another form of relationship which is in between the relationship between per capita CO_2 emissions and GDP per capita. The mutually agreed form of notion for this relationship is generally called ‘Environmental Kuznets Curve (EKC)’. The reduced form of EKC is presented in Eq. (2), i.e.,

$$\ln(CO_2/POP)_{i,t} = \alpha_1 + \alpha_2 \ln(GDPPC)_{i,t} + \alpha_2 \ln(GDPPC)_{i,t}{}^2 + \alpha_3 \ln(z)_{i,t} + \epsilon_{i,t} \quad (2)$$

where CO_2/POP represented per capita carbon dioxide emissions.

The EKC hypothesis emerged in the early 1990s, where the stakeholders and environmentalists both were keen to device environmental protection polices to protect the natural bonanza of the world. Some early studies on the EKC are conducted in different countries/panel settings including Selden and Song [37] used panel of cross-national data to reassess the EKC hypothesis; Hilton and Levinson [38] used panel of 40 countries with 20 years data set; Vincent [39] used Malaysian data set; Karp and Liu [40] used OECD countries data set for evaluating EKC hypothesis, etc.

With the passage of time, the EKC hypothesis has been transformed into cubic versions which showed the two new forms of EKC hypothesis i.e., N-shaped relationship and opposite to the N-shaped relationship [41]. The empirical illustration is shown in Eq. (3) i.e.,

$$\ln(CO_2/POP)_{i,t} = \alpha_1 + \alpha_2 \ln(GDPPC)_{i,t} + \alpha_2 \ln(GDPPC)_{i,t}{}^2 + \alpha_3 \ln(GDPPC)^3_{i,t} + \alpha_4 \ln(z)_{i,t} + \epsilon_{i,t} \quad (3)$$

where $(GDPPC)^3$indicates the cube of the GDPPC.

This study extended the concept of EKC hypothesis by using the number of variables as the ‘response’ variable including energy depletion, natural resource depletion, net forest depletion, SF_6 emissions, $PM_{2.5}$ emissions, PFC gas emissions, incidence of tuberculosis, infant deaths and health expenditures per capita. While, the study includes number of ‘regressors’ including CO_2 emissions per capita, GDP per capita, energy use, fossil fuel energy consumption, and financial dummy (D_{2008}). Conventionally, air pollutants including CO_2 emissions per capita are used as ‘response’ variables in the EKC framework, however, this study included CO_2 emissions as an explanatory variable due to its considerable impact on the energy-resource depletion, health factors and climatic variables accordingly. The study considered three models for evaluation i.e.,

2.1. Model-1: energy-resource depletion

$$\ln(ENRGDEP)_{i,t} = \alpha_1 + \alpha_2 \ln(GDPPC)_{i,t} + \alpha_2 \ln(GDPPC)_{i,t}{}^2 + \alpha_3 \ln(CO_2) + \alpha_4 \ln(ENRGUSE)_{i,t} + \alpha_5 \ln(FFUEL)_{i,t} + \alpha_6 D_{2008} + \epsilon_{i,t} \quad (1')$$

$$\ln(NFDEP)_{i,t} = \alpha_1 + \alpha_2 \ln(GDPPC)_{i,t} + \alpha_2 \ln(GDPPC)_{i,t}{}^2 + \alpha_3 \ln(CO_2) + \alpha_4 \ln(ENRGUSE)_{i,t} + \alpha_5 \ln(FFUEL)_{i,t} + \alpha_6 D_{2008} + \epsilon_{i,t} \quad (2')$$

$$\ln(NRDEP)_{i,t} = \alpha_1 + \alpha_2 \ln(GDPPC)_{i,t} + \alpha_2 \ln(GDPPC)_{i,t}{}^2 + \alpha_3 \ln(CO_2) + \alpha_4 \ln(ENRGUSE)_{i,t} + \alpha_5 \ln(FFUEL)_{i,t} + \alpha_6 D_{2008} + \epsilon_{i,t} \quad (3')$$

where *ENRGDEP* is the energy depletion, *NFDEP* is the net forest depletion, *NRDEP* is the natural resource depletion, D_{2008} indicates the financial crisis dummy i.e., 0 for 2000–2007 and 1 for 2008–2013, ‘*i*’ indicates the nine developed countries and ‘*t*’ is the time period from 2000 to 2013.

2.2. Model-11: climate change

$$\ln(PFCGAS)_{i,t} = \alpha_1 + \alpha_2 \ln(GDPPC)_{i,t} + \alpha_2 \ln(GDPPC)_{i,t}{}^2 + \alpha_3 \ln(CO_2) + \alpha_4 \ln(ENRGUSE)_{i,t} + \alpha_5 \ln(FFUEL)_{i,t} + \alpha_6 D_{2008} + \epsilon_{i,t} \quad (4')$$

$$\ln(PM2.5)_{i,t} = \alpha_1 + \alpha_2 \ln(GDPPC)_{i,t} + \alpha_2 \ln(GDPPC)_{i,t}{}^2 + \alpha_3 \ln(CO_2) + \alpha_4 \ln(ENRGUSE)_{i,t} + \alpha_5 \ln(FFUEL)_{i,t}$$

$$+\alpha_6 D_{2008}+\epsilon_{i,t} \quad (5')$$

$$\ln(SF6)_{i,t}=\alpha_1+\alpha_2\ln(GDPPC)_{i,t}+\alpha_2\ln(GDPPC)_{i,t}{}^2+\alpha_3\ln(CO_2)+\alpha_4\ln(ENRGUSE)_{i,t}+\alpha_5\ln(FFUEL)_{i,t}+\alpha_6 D_{2008}+\epsilon_{i,t} \quad (6')$$

$$\ln(GHGINDEX)_{i,t}=\alpha_1+\alpha_2\ln(GDPPC)_{i,t}+\alpha_2\ln(GDPPC)_{i,t}{}^2+\alpha_3\ln(CO_2)+\alpha_4\ln(ENRGUSE)_{i,t}+\alpha_5\ln(FFUEL)_{i,t}+\alpha_6 D_{2008}+\epsilon_{i,t} \quad (7')$$

where *PFCGAS* is the PFC gas emissions, *PM*2.5 is the PM2.5 emissions, *SF6* is the SF6 emission, and *GHGINDEX* is the Greenhouse gas emissions.

2.3. Model-111: health resources

$$\ln(INCTUB)_{i,t}=\alpha_1+\alpha_2\ln(GDPPC)_{i,t}+\alpha_2\ln(GDPPC)_{i,t}{}^2+\alpha_3\ln(CO_2)+\alpha_4\ln(ENRGUSE)_{i,t}+\alpha_5\ln(FFUEL)_{i,t}+\alpha_6 D_{2008}+\epsilon_{i,t} \quad (8')$$

$$\ln(INFDTH)_{i,t}=\alpha_1+\alpha_2\ln(GDPPC)_{i,t}+\alpha_2\ln(GDPPC)_{i,t}{}^2+\alpha_3\ln(CO_2)+\alpha_4\ln(ENRGUSE)_{i,t}+\alpha_5\ln(FFUEL)_{i,t}+\alpha_6 D_{2008}+\epsilon_{i,t} \quad (9')$$

$$\ln(HEXPPC)_{i,t}=\alpha_1+\alpha_2\ln(GDPPC)_{i,t}+\alpha_2\ln(GDPPC)_{i,t}{}^2+\alpha_3\ln(CO_2)+\alpha_4\ln(ENRGUSE)_{i,t}+\alpha_5\ln(FFUEL)_{i,t}+\alpha_6 D_{2008}+\epsilon_{i,t} \quad (10')$$

where *INCTUB* indicates the incidence of tuberculosis, *INFDTH* indicates the infant deaths, and *HEXPPC* is the health expenditures per capita.

The study formulated the following plausible hypothesis that required empirical testing to accept or reject the hypothesis in the panel of developed countries i.e.,

H1: There is an inverted U-shaped relationship between energy-resource depletion and GDP per capita under the financial constraint environment, ceteris paribus.
H2: There is an inverted U-shaped relationship between climatic factors and GDP per capita under the financial constraint environment, ceteris Paribus, and
H3: There is an inverted U-shaped relationship between health resources and GDP per capita under the financial constraint environment, ceteris Paribus.

The study estimated these three models having Eqs. (1′)–(10′) with the panel GMM technique. The rationale of using panel GMM technique is that it provides a sound theoretical and computational unified approach which efficiently estimated the linear and nonlinear regressions with endogenous regressors and non-spherical disturbances. Panel GMM technique is one of the popular techniques to addressed the endogeneity from the model. Panel GMM equation used the list of instrumental variables that facilitate to overcome the problem of simultaneity from the models. This study evaluated these three models by the respective instrumental lists which are considered as the first lagged of the explanatory variables.

The Panel GMM estimator involves greater complexity in estimation; therefore, it is required to pay special attention. We start with the possible assumption is that there are a number of '*L*' moment conditions with the '*K*' parameters that satisfied the 'β' value. Thus, if the moment conditions greater than or/and equal to parameter are estimated, we may write in a form i.e.,

$$E(m(y_i,\beta))=0 \quad (4')$$

In time series econometrics, the moment conditions are restricted and applied orthogonality condition between the error term of the estimated equations, and for instrumental list of the regressors i.e., 'z_i' i.e.,

$$E(z_t u_t(\beta))=0 \quad (5')$$

Conventionally, we replaced different moment conditions from Eq. (3) with their sample analog and obtained 'β' to solve moment equations i.e.,

$$m_T(\beta)=\frac{1}{T}\sum z_t u_t(\beta)=\frac{1}{T}z'u(\beta)=0 \quad (6')$$

However, if there are a number of moment conditions, then Eq. (5) may not presented the true estimates; then this system is called 'over-identified' system. To avoid this problem, we recast our econometric problem and choose 'β' with sample moment '$m_T(\beta)\cong 0$', and is shown in polynomial form i.e.,

$$J(\beta,W_T)=Tm_T(\beta)'W_T^{-1}m_T(\beta)=\frac{1}{T}u(\beta)'zW_T^{-1}z'u(\beta) \quad (7')$$

The GMM estimate thus defined as the 'β' that minimizes Eq. (7). GMM instrumental estimators should be kept same at least as many parameters in the given model that be would helpful to optimize objective function equal to zero, if instruments are greater than parameters, then the optimized function would be deviated from zero. The '*J*' statistics is used to test the 'over-identifying moment conditions' from a given model.

The study used the non-linear form of relationship between the studied variables and evaluated by panel GMM estimator in a following functional relationships i.e.,

$$\ln r_{it}=\beta_0+\beta_1\ln y_{it}+\beta_2\ln y_{it}^2+\beta_3\ln c_{it}+\beta_4\ln e_{it}+\beta_5\ln f_{it}+\beta_6 D_{2008}+z_{it}+\mu_{it} \quad (11')$$

where '*r*' shows energy-resource depletion, climate change and health resources; '*y*' shows GDP per capita, '*c*' shows carbon dioxide emissions, '*e*' shows energy use, '*f*' shows fossil fuel energy consumption, 'D_{2008}' shows financial dummy, '*i*' shows countries specification i.e., 9 countries, '*t*' shows time period from 1990 to 2013, '*z*' indicates instrumental list of the variables, and μ shows error term.

The study used software EViews (version-9) to estimate the GMM parameters. The results include some diagnostic settings in order to access the expression powers of the estimated coefficients including normality test, serial correlation test, heteroskedasticity test, and model stability tests.

3. Results

This section comprises descriptive statistics, correlation matrix and panel GMM estimates. Table 2 shows the descriptive statistics and correlation matrix. In Table 2 Panel A shows the descriptive statistics of the candidate variables including central tendency value, central dispersion value, maximum value, minimum value, skewness, and Kurtosis. These statistics are presented here for the ready reference.

Table 2, Panel B, shows the correlation between the variables. The results indicate the positive correlation between CO_2 emissions and energy depletion, while energy demand, fossil fuel and GDP per capita have a negative correlation with the energy depletion in the region. There is a negative correlation between net forest depletion (and natural resource depletion) and other variables including CO_2 emissions, GDP per capita, energy demand and fossil fuel energy consumption. Fossil fuel energy

Table 2
Descriptive statistics and correlation matrix.

	CO_2	ENRGDEP	ENRGUSE	FFUEL	GDPPC	GHGINDEX	HEXPPC	INCTUB	INFDTH	NFDEP	NRDEP
Panel A: Descriptive statistics											
Mean	8.784008	0.159268	3531.557	72.41715	21910.32	334.9285	2237.690	22.27222	743.0556	0.168944	0.362789
Maximum	13.77320	0.439164	4400.871	95.68148	50569.08	2555.210	4516.830	86.00000	2757.000	0.543732	0.941445
Minimum	4.211634	0.011713	2275.927	20.57486	7863.528	3.347613	823.8601	5.600000	55.00000	0.000000	0.048323
Std. dev.	2.482567	0.144860	667.8921	19.67031	14728.13	770.9375	1235.595	22.90278	944.6230	0.189709	0.279254
Skewness	0.035113	0.891607	−0.560316	−1.443668	0.744303	2.432699	0.580914	1.879705	1.303098	0.850863	0.951008
Kurtosis	2.865025	2.595341	2.075618	4.609078	1.958166	7.051436	2.010811	5.342942	2.881940	2.377520	2.684941
Panel B: Correlation matrix											
CO_2	1										
ENRGDEP	0.240	1									
ENRGUSE	0.714	−0.178	1								
FFUEL	−0.342	−0.189	−0.302	1							
GDPPC	0.154	−0.441	0.317	0.362	1						
GHGINDEX	0.087	−0.049	0.244	0.210	0.357	1					
HEXPPC	0.058	−0.414	0.396	0.321	0.897	0.490	1				
INCTUB	−0.465	0.282	−0.592	−0.338	−0.508	−0.270	−0.564	1			
INFDTH	−0.002	0.361	−0.138	0.476	0.058	0.767	0.159	−0.216	1		
NFDEP	−0.251	0.082	−0.274	−0.338	−0.582	−0.341	−0.494	0.164	−0.223	1	
NRDEP	−0.071	0.716	−0.425	−0.204	−0.653	−0.280	−0.588	0.244	0.170	0.716	1

Note: CO_2 is carbon dioxide emissions, ENRGDEP is energy depletion, ENRGUSE is energy use, FFUEL is fossil fuel energy consumption, GDPPC is GDP per capita, GHGINDEX is greenhouse gas index, HEXPPC is health expenditures per capita, INCTUB is incidence of tuberculosis, INFDTH is infant deaths, NFDEP is net forest depletion, and NRDEP is natural resource depletion.

Table 3
Results of Panel GMM for Model 1: energy-resource depletion.

Variables	Dependent variable: $\ln(ENRGDEP)_{i,t}$	Dependent variable: $\ln(NFDEP)_{i,t}$	Dependent variable: $\ln(NRDEP)_{i,t}$
Constant	−8.293	−22.885	−16.994
$\ln(ENRGDEP)_{i,t-1}$	0.914*	–	–
$\ln(NFDEP)_{i,t-1}$	–	0.829*	–
$\ln(NRDEP)_{i,t-1}$	–	–	0.842**
$\ln(GDPPC)_{i,t}$	20.976**	11.805*	18.553**
$\ln(GDPPC)^2_{i,t-1}$	−10.384**	−4.298*	−11.213*
$\ln(CO_2)_{i,t}$	0.609	−1.249*	−0.139
$\ln(ENRGUSE)_{i,t}$	0.381	1.523	0.573
$\ln(FFUEL)_{i,t}$	0.176	1.681	1.319
D_{2008}	0.771**	0.683**	0.870***
Statistical tests			
R-squared	0.517	0.699	0.712
Adjusted R-squared	0.477	0.601	0.656
Diagnostic tests			
Instrumental rank	8	8	8
J-statistic	0.000	2.13E−36	9.94E−37
JB test	2.101	1.991	2.564
LM test	0.667	1.110	0.999
Heteroskedasticity test	0.656	1.507	0.950
Ramsey RESET test	1.569	0.011	0.773

Note: Dependent variable of energy depletion: $\ln(ENRGDEP)_{i,t}$, Dependent variable of net forest depletion: $\ln(NFDEP)_{i,t}$, Dependent variable of natural resource depletion: $\ln(NRDEP)_{i,t}$. CO_2 is carbon dioxide emissions, *ENRGDEP* is energy depletion, *ENRGUSE* is energy use, *FFUEL* is fossil fuel energy consumption, *GDPPC* is GDP per capita, *GHGINDEX* is greenhouse gas index, *HEXPPC* is health expenditures per capita, *INCTUB* is incidence of tuberculosis, *INFDTH* is infant deaths, NFDEP is net forest depletion, and *NRDEP* is natural resource depletion. 'ln' shows natural logarithm. *J*-statistic shows Sarjan–Hansen *J*-statistic, JB test shows Jarque–Bera test, LM test shows Lagrange Multiplier serial correlation tests. *, ** and *** shows significant at 1%, 5% and 10% level.

consumption and GDP per capita increases the infant deaths in the panel of selected countries. There is negative correlation between incidence of TB and other factors including CO_2 emissions, GDP per capita, energy demand and fossil fuel energy demand. Energy demand, fossil fuel energy and GDP per capita significantly associated with the increase health expenditures per capita in the region. Finally, GHG index is increasing along with the increase in CO_2 emissions, energy demand, fossil fuel energy demand and GDP per capita across the countries. Table 3 shows the results of Panel GMM for Model-1.

The results of panel GMM for model-1 (i.e., energy-resource depletion model) shows that initial value of energy depletion, net forest depletion and natural resource depletion significantly explained with the nominal terms of their same variables which exhibit the 'convergence of resource depletion' in the region. The results further indicate the inverted U-shaped relationship between (i) energy depletion and GDP per capita, (ii) net forest depletion and GDP per capita, and (iii) natural resource depletion and GDP per capita in the selected developed countries. The results provoke the existence of 'energy-resource depletion Kuznets curve', 'forest depletion Kuznets curve', and 'natural resource depletion Kuznets curve' in the region. The results infer that at the given level of GDP per capita; the energy-resource factors initially depleted, however, at the later stages of development, these factors subsequently improved in the panel of developed countries. In energy-resource depletion model, carbon dioxide emission is the only variable which significantly decreases the net forest depletion, i.e., if there is one percent increase in CO_2 emissions, forest depletion decreases by 1.249 percentage points. This result shows the importance of forest resources in the panel of countries. Finally, the dummy variable (D_{2008}) is included to trace out the possible impact of financial crisis on energy-resource depletion model and it confirms that financial crisis has a positive impact on energy-resource depletion, which implies that the crisis badly affected the energy resource depletion under the financial constraint environment.

The statistical test of the models show the goodness of fit of the model, as energy depletion model explained 47.7% variation by explanatory variables, followed by 60.1% of net forest depletion model, and 65.6% of natural resource depletion model. The results of diagnostic test confirm that the prescribed instrumental lists are valid as Sargan–Hansen *J*-statistic accept the null hypothesis of 'valid instruments' in all the three models, and it subsequently prove the 'joint validity' of prescribed instruments that cannot be rejected. In all the three given models, our instrumental rank is 8, which are far less than the number of observations, so there is no evidence of weak instrument selection in the models. There is 'no normality' issue in all the three given models as Jarque–Bera (JB

Table 4
Results of Panel GMM for Model 11: climate change.

Variables	Dependent variable: ln $(PFCGAS)_{i,t}$	Dependent variable: ln $(PM2.5)_{i,t}$	Dependent variable: ln $(SF6)_{i,t}$	Dependent variable: ln $(GHGINDEX)_{i,t}$
Constant	−6.068	7.924	−4.244	−7.894
ln $(PFCGAS)_{i,t-1}$	−0.477*	–	–	–
ln $(PM2.5)_{i,t-1}$	–	−0.404*	–	–
ln $(SF6)_{i,t-1}$	–	–	−0.303*	–
ln $(GHGINDEX)_{i,t-1}$	–	–	–	−0.396*
ln $(GDPPC)_{i,t}$	−3.991**	−24.084**	18.003	1.220
ln $(GDPPC)^2{}_{i,t-1}$	2.101*	11.915**	−8.372	−0.366
ln $(CO_2)_{i,t}$	0.715	−0.780	2.294***	0.674
ln $(ENRGUSE)_{i,t}$	−0.551	1.271*	−2.293	−0.320
ln $(FFUEL)_{i,t}$	1.635**	1.991**	1.038	1.361**
D_{2008}	−0.851	0.611**	1.607	1.060**
Statistical tests				
R-squared	0.349	0.414	0.142	0.234
Adjusted R-squared	0.266	0.367	0.072	0.176
Diagnostic tests				
Instrumental rank	8	8	8	8
J-statistic	0.000	4.86E−38	2.58E−38	0.000
JB test	2.991	3.231	2.771	1.980
LM test	0.212	0.778	1.898	1.657
Heteroskedasticity test	1.230	0.925	0.446	0.725
Ramsey RESET test	2.101	0.211	1.991	0.101

Note: Dependent variable of PFC gas emissions: ln$(PFCGAS)_{i,t}$, Dependent variable of $PM_{2.5}$ emissions: ln$(PM2.5)_{i,t}$, Dependent variable of SF_6 emissions: ln$(SF6)_{i,t}$, Dependent variable of GHG index: ln$(GHGINDEX)_{i,t}$. CO_2 is carbon dioxide emissions, *ENRGDEP* is energy depletion, *ENRGUSE* is energy use, *FFUEL* is fossil fuel energy consumption, *GDPPC* is GDP per capita, *GHGINDEX* is greenhouse gas index, *HEXPPC* is health expenditures per capita, *INCTUB* is incidence of tuberculosis, *INFDTH* is infant deaths, *NFDEP* is net forest depletion, and *NRDEP* is natural resource depletion. 'ln' shows natural logarithm. *J*-statistic shows Sarjan–Hansen *J*-statistic, J.B. test shows Jarque–Bera test, LM test shows Lagrange Multiplier serial correlation tests. *, ** and *** shows significant at 1%, 5% and 10% level. '

test) statistic accepts the null hypothesis of 'no normality'. Further, there is no problem of autocorrelation in the given models, as "Breusch–Godfrey Serial Correlation LM Test" accepted the null hypothesis of no autocorrelation problem. The heteroskedasticity test is evaluated by 'Breusch–Pagan–Godfrey test', which indicates that there is no heteroskedasticity problem in all the three given models. Finally, the stability test is done by Ramsey RESET test, and it confirms that the given models get empirically stable over a period of time. Table 4 shows the results of panel GMM for climate change model.

The results of Table 4 show that the initial value of all the three factors of greenhouse gas emissions and GHG index including PFC gas emission, $PM_{2.5}$ emissions and SF_6 emissions have a negative relationship with the nominal terms of their same variables which implies that the previous reforms for reduction of greenhouse gas emissions significantly lessen the climate change from the region. The results confirmed the existence of U-shaped relationship between PFC gas emission and GDP per capita, i.e., at the initial stage of development, GDP per capita significantly decreases the PFC gas emission, however, at the later stages of development, there is observed a significant rise in the PFC gas emissions which required the sustainable policy framework to reduce the PFC gas emissions in the region. One of the possible reasons to escalate the PFC gas emission is the dependency of fossil fuel energy consumption that deteriorates the climate across the globe. Dummy variable for financial crisis does not confirm the statistical significant result on PFC gas emissions during the study time period.

The second climatic variables i.e., $PM_{2.5}$ emissions indicate the existence of U-shaped EKC between $PM_{2.5}$ emission and GDP per capita in the region. The results further confirm the volatility of fossil fuel energy consumption that considerably increases $PM_{2.5}$ emissions, as if there is 1% increase in the fossil fuel energy consumption, $PM_{2.5}$ emissions increases around 1.991 percentage points that shows more elastic relationship between them. The financial crisis and energy demand both have a positive and significant impact on increasing $PM_{2.5}$ emissions; therefore, it clarified the impact of energy demand and global financial crisis on climatic changes in the panel of developed countries.

In the third climatic variable i.e., SF_6 emissions indicate there is no/flat relationship between SF_6 emissions and GDP per capita in the region, as both the GDP per capita and square of GDP per capita insignificantly impact on SF_6 emissions, while CO_2 emissions significantly increase SF_6 emission i.e., if there is one percent increase in CO_2 emissions, SF_6 emission increases by 2.294 percentage points. The financial crisis' dummy variable does not trace out any significant association with SF_6 emissions during the study time period. The policy to reduce CO_2 emissions should mitigate the possible climate changes across the countries.

Finally, the study constructed the GHG index in order to assess the combined effect of PFC gas emission, $PM_{2.4}$ emissions and SF_6 emissions as a single weighted factor. The result failed to established an inverted U-shaped relationship between GHG index and GDP per capita, and found the flat relationship between them; however, fossil fuel energy consumption deteriorates the climate change across the countries. The financial dummy captured the significant impact on increasing GHG emission index, which clarifies the financial interventions in the climate change policy that deteriorates the environment across the countries. There is a substantial requirement of the policy framework in order to mitigate climate change under financial constraint environment in the region.

The statistical test of the climate change model shows the goodness-of fit statistics, as PFC gas emission model explained 26.6% variation by explanatory variables, followed by 36.71% of $PM_{2.5}$ emissions model, 7.2% of SF_6 emissions model, and 17.6% of GHG index emissions model. The results of diagnostic test confirm that the prescribed instrumental lists is valid; instrumental ranks are lower than the number of observations; no normality issue, no serial correlation problem; no visible heteroskedasticity problem; and model is empirically acceptable in all four given climate changes models. Table 5 shows the results of panel GMM for Model-111.

The results of Table 5 show that there is a U-shaped relationship between incidence of TB and per capita GDP, which implies that at initial level of economic development, incidence of TB was fairly low, while at later stage of economic development, prevalence of TB considerably increases at a rate of 0.180%, if there is one percent increase in square of per capita income. There is an inverse relationship between energy use and incidence of TB, which implies that along with increase energy usage, incidence of TB substantially decreases, that emphasize the importance of energy demand in healthcare facilities. Financial dummy reported statistically insignificant, therefore, we may not observe the possible impact on incidence of TB during the studied time period.

The relationship between infants death and per capita income is quiet visible and pertaining a clear shaped of inverted-U relationship between them, which shows the good sign of recovery in healthcare reforms when economy is accelerating and transforming in the growth maturity phase. However, both the fossil fuel energy consumption and financial dummy have a direct impact on infant death, which escalating infants' death in a serious node that required substantial policy intervention for reducing infants' death across the countries.

Finally, the study confirm the inverted U-shaped relationship between health expenditures per capita and per capita income, which shows the economic maturity in order to prevent health diseases and considerably reduces the health-related burdens in their later stages of economic development. The interesting result is that energy demand and CO_2 emissions both have a direct relationship with health expenditures per capita, while financial crisis further escalating the health expenditures under financial constraint environment.

The statistical test of the health resource model shows the goodness of fit statistics, as incidence of TB explained 90.6% variation by explanatory variables, followed by 99.7% of infant deaths model, and 93.9% of health expenditures model. The results of diagnostic test confirm that the Sargan–Hansen *J*-statistics validate the joint significance of instrumental validity, JB tests, autocorrelation tests, heteroskedasticity, and model stability, all tests show that there is no problem of normality issue, no autocorrelation problem, no heteroskedasticity problem and models are empirical stable. The policy to increase health care resources deem desirable to prevent from incidence of TB and infants death in the region. Table 6 shows the variance inflation factor for detecting possible multicollinearity in the given studied models.

The results show that energy-resource depletion model, climate change model, and health resource model, all models have no visible multicollinearity problem, as the variance inflation factor (VIF) values fall in the prescribed threshold level values in between 0 and 10. Therefore, we may safely conclude that the given estimated values are robust by several econometric diagnostic settings. Table 7 shows the summary of hypothesis results.

The results show that energy-resource depletion model confirm the inverted U-shaped relationship between (i) energy depletion, (ii) net forest depletion, and (iii) natural resource depletion with per capita income, while there is mixed results in the other two models i.e., climate change model and health resource model. The detailed description of the mixed results is presented inside the given table for ready reference.

Table 5
Results of Panel GMM for Model 111: health resources.

Variables	Dependent variable: ln $(INCTUB)_{i,t}$	Dependent variable: ln $(INFDTH)_{i,t}$	Dependent variable: ln $(HEXPPC)_{i,t}$
Constant	−3.463	−1.348**	−4.515
ln $(INCTUB)_{i,t-1}$	1.106*	–	–
ln $(INFDTH)_{i,t-1}$	–	0.991*	–
ln $(HEXPPC)_{i,t-1}$	–	–	0.816*
ln $(GDPPC)_{i,t}$	−0.415*	1.258**	0.828*
ln $(GDPPC)^2_{i,t-1}$	0.180*	−0.627**	−0.188*
ln $(CO_2)_{i,t}$	−0.174	0.030	0.253*
ln $(ENRGUSE)_{i,t}$	−0.943*	0.093	0.502*
ln $(FFUEL)_{i,t}$	−0.570*	0.104*	0.018
D_{2008}	0.007	0.043**	0.238*
Statistical tests			
R-squared	0.913	0.9976	0.944
Adjusted *R*-squared	0.906	0.9974	0.939
Diagnostic tests			
Instrumental rank	8	8	8
J-statistic	1.63E−37	2.46E−3S6	0.000
JB test	1.010	2.010	0.412
LM test	1.413	1.990	1.918
Heteroskedasticity	0.277	1.001	0.667
Ramsey RESET test	1.112	1.717	2.715

Note: Dependent variable of incidence of TB: ln$(INCTUB)_{i,t}$, Dependent variable of infant deaths: ln$(INFDTH)_{i,t}$, Dependent variable of health expenditures per capita: ln$(HEXPPC)_{i,t}$. CO_2 is carbon dioxide emissions, *ENRGDEP* is energy depletion, *ENRGUSE* is energy use, *FFUEL* is fossil fuel energy consumption, *GDPPC* is GDP per capita, *GHGINDEX* is greenhouse gas index, *HEXPPC* is health expenditures per capita, *INCTUB* is incidence of tuberculosis, *INFDTH* is infant death, *NFDEP* is net forest depletion, and *NRDEP* is natural resource depletion. 'ln' shows natural logarithm. *J*-statistic shows Sarjan–Hansen *J*-statistic, JB test shows Jarque–Bera test, LM test shows Lagrange Multiplier serial correlation tests. *, ** and *** shows significant at 1%, 5% and 10% level.

Table 6
Variance inflation factors.

Variables	Energy-resource depletion model			Climate change model				Health resources		
	$VIF_{ENRGDEP}$	VIF_{NFDEP}	VIF_{NRDEP}	VIF_{PFCGAS}	$VIF_{PM2.5}$	VIF_{SF6}	$VIF_{GHGINDEX}$	VIF_{INCTUB}	VIF_{INFDTH}	VIF_{HEXPPC}
ln $(GDPPC)_{i,t}$	1.212	1.907	3.432	2.998	4.443	3.332	2.776	5.545	5.543	4.655
ln $(GDPPC)^2_{i,t-1}$	2.123	1.333	2.321	3.121	5.231	2.098	1.098	6.232	6.121	1.675
ln $(CO_2)_{i,t}$	2.434	2.137	1.989	1.987	1.221	3.212	2.209	3.321	1.998	1.990
ln $(ENRGUSE)_{i,t}$	1.717	1.667	2.111	1.665	2.877	1.980	1.907	2.997	2.434	2.221
ln $(FFUEL)_{i,t}$	4.543	1.771	1.232	2.587	1.675	2.233	1.665	2.654	2.221	3.790
D_{2008}	1.770	2.564	1.676	1.776	2.323	1.600	2.324	2.505	1.990	1.121

Note: VIF indicates variance inflation factors, CO_2 is carbon dioxide emissions, ENRGDEP is energy depletion, ENRGUSE is energy use, FFUEL is fossil fuel energy consumption, GDPPC is GDP per capita, GHGINDEX is greenhouse gas index, HEXPPC is health expenditures per capita, INCTUB is incidence of tuberculosis, INFDTH is infant death, NFDEP is net forest depletion, NRDEP is natural resource depletion, ENRGDEP indicates energy depletion, NFDEP indicates net forest depletion, NRDEP indicates natural resource depletion, PFCGAS indicates PFC gas emissions, PM2.5 indicates PM2.5 emissions, SF6 indicates SF6 emissions, GHGINDEX indicates GHG index, INCTUB indicates incidence of tuberculosis, INFDTH indicates infant deaths, and HEXPPC indicates health expenditures per capita.

Table 7
Summary of the hypothesis results.

Hypothesis	Statement	Decision	Remarks
H1	There is an inverted U-shaped relationship between energy-resource depletion and income, ceteris paribus. 1. There is an inverted U-shaped relationship between energy depletion and income, ceteris paribus. 2. There is an inverted U-shaped relationship between net forest depletion and income, ceteris paribus. 3. There is an inverted U-shaped relationship between natural resource depletion and income, ceteris paribus.	Accept 1. Accept 2. Accept 3. Accept	Existence of EKC hypothesis in relationship with the energy-resource depletion.
H2	There is an inverted U-shaped relationship between climate change and income, ceteris paribus. 1. There is an inverted U-shaped relationship between PFC Gas emission and income, ceteris paribus. 2. There is an inverted U-shaped relationship between PM2.5 emission and income, ceteris paribus. 3. There is an inverted U-shaped relationship between SF6 emission and income, ceteris paribus.	Mixed results 1. Reject 2. Reject 3. Reject	Existence of U-shaped relationship between PFC gas emission and per capita income. Existence of U-shaped relationship between SF6 and per capita income. There is flat relationship between SF6 emissions and per capita income.
H3	There is an inverted U-shaped relationship between health resources and income, ceteris paribus. 1. There is an inverted U-shaped relationship between incidence of TB and income per capita, ceteris paribus. 2. There is an inverted U-shaped relationship between number of infant deaths and income per capita, ceteris paribus. 3. There is an inverted U-shaped relationship between health expenditures per capita and income, ceteris paribus.	Mixed results 1. Reject 2. Accept 3. Accept	There is a U-shaped relationship between incidence of T.B. and per capita income. Existence of EKC hypothesis between infant deaths and per capita income. Existence of EKC hypothesis in between health expenditures and per capita income.

4. Conclusions

This study covered the three main broader areas of environment-growth nexus in the panel of nine developed countries, over the period of 2000–2013. The study constructed three models including energy-resource depletion model, climate change model and health resource model to assess the energy-resource reforms, climate mitigation and increased health care resources in the region. The study employed panel GMM technique that addresses the problem of endogeneity from the given models. The following conclusion has been drawn from this exercise i.e.,

(i) Existence of EKC hypothesis in the energy-resource model.
(ii) There is U-shaped relationship between (i) PFC gas emissions, (ii) PM2.5 emissions, (iii) incidence of TB, and GDP per capita.
(iii) There is an inverted U-shaped relationship between (i) infant deaths, (ii) health expenditures, and GDP per capita.
(iv) There is no/flat relationship between (i) SF6 emissions, (ii) GHG emission index, and per capita income.
(v) CO_2 emissions considerably affected to increase the SF6 emissions and health expenditures per capita.
(vi) Energy demand increases health expenditures to reduce incidence of TB, while it further increases the concentration of PM2.5 emissions in a panel of countries.
(vii) Fossil fuel energy consumption escalates the PFC gas emissions, PM2.5 emissions, and infant health damages.
(viii) Global financial crisis affected energy-resource depletion, climate change, and health resources in a panel of selected developed countries.

The overall results emphasized the importance of healthcare resources, mitigating unpredictable climate change and preserve energy-resource base under the financial constraint environment, in order to formulate long-term policy for the region. On the basis of the key findings, the study proposed the short-term, medium-term and long-term policy recommendations i.e.,

1. Short-term policy implication: There is high time to take care about our natural resources which are influenced by the energy, environment and wealth of the countries. The quest for the renewable energy sources are still lagging behind in most of the developed and developing countries, however, the appropriate energy portfolios required substantial knowledge information regarding the environment and health effects for green growth. Biofuel energy consumption considered is the future energy resource with minimal environmental considerations; however, before devising any energy resource policies, substantial in depth knowledge about energy portfolios is required to preserve the global environment.
2. Medium-term policy implication: Climatic variability is affected by the economic growth, CO_2 emissions and conventional sources of energy including fossil fuel energy consumption that simultaneously deteriorates the natural flora of the World. Sound safety nets are required that facilitate to prevent the unpredictable climate change and its health hazards across the globe.
3. Long-term policy implication: Health is one of the fundamental human rights that should be available for all. The policy makers generally used the buzz word i.e., 'health for all'. This is the time to re-think existing healthcare policies in order to sustain the long-term health policies, especially for health-related matters which are affected by the CO_2 emissions, fossil fuel energy consumption and wealth of the countries.

Global financial crisis not only affected the socio-economic living of the countries, while it further affected the environmental and sustainability matters, which required strong policy intervention to compliance United Nation-Kyoto protocol to preserve our natural environment for 'green development'.

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