Does Environmental Kuznets Curve Hypothesis hold in the long run: A Case study of China

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Abstract: This study investigates the long run relationship between carbon emissions, gross domestic product and energy consumption by utilizing time series data of 1971-2013 for China. Specifically, the study focus on analyzing whether environmental Kuznets curve exists in the long run or not. For this purpose, the methodology of unit root tests based on Phillips-Perron (PP), the ARDL Cointegration, the Granger Causality test in a VAR, Impulse Response and Variance Decomposition of VAR model are employed. The quadratic linkage between gross domestic product and carbon emissions has been identified, validating the presence of long run as well as short run Environmental Kuznets Curve relationships. The results of Granger causality test infer one way causality runs from gross domestic product to carbon emissions. The results of Variance Decomposition and Impulse Response suggest that the gross domestic product and energy consumption are two important components of carbon emissions in the long run. Sensitivity analysis has been carried out in order to check the fluctuations in carbon emissions with respect of economic progress.

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1. Introduction

The world has passed into an era of outstandingly fast economic growth and progress, with swift economic development particularly in China, followed by India and several other low-income nations. The speeds of economic growth in beginning of 21th century have been even greater than the average in the 'Golden Age' of the 1950s and 1960s. Accordingly, the current epoch might be called 'Platinum Age' (Garnaut & huang, 2007). This extraordinary economic progress goes in conjunction with escalating resources utilize and pressure on the environment and ecosystem, as well as the rising of greenhouse gases and follow-on climate change.

During last two centuries, progressive economic growth has been found in a small number of countries, such as Japan, Oceania, North America and Western Europe (Maddison, 2001). But in the 3rd quarter of the 20th century, it long-drawn-out into several relatively less developed economies in East Asia. A new age instigated in the 4th quarter of 19th century, by means of rapid expansion of the advantageous methods of advanced economic development into the core of overcrowded nations located in Asia, for example Indonesia, India and China. National incomes are developing rapidly in a number of the less developed economies.

In the nonexistence of foremost displacement of established trends, a rapid expansion in economic activity is likely to keep on for a sizable period. The slow-down in the United-States and a few other advanced economies in previous one decade will trim down the mean total global growth for a short time, but is improbably to break the impetus of strong Chinese economy, developing-country and overall growth. The first two decades of 20th century will observe a huge absolute upsurge in yearly consumption and human output than was made in the entire history of our species, and then once more in the next ten years to 2030 (Garnaut R. , 2008).

This global economic growth is greatly relying on energy consumption. Increasing world-wide energy prices can be anticipated to trim down considerably the expansion in use of gasoline, but not inevitably the growth rate of the aggregate fossil-fuel emissions, because of the prevalent obtainability of coal. This is true for majority of nations that do not possess the rigorous greenhouse gas control policies at the ready, and definitely for China (Song & Woo, 2009).

China is in position to be the leading engine of the global economic growth in the next twenty years. China is also included in list of those countries that extremely reliant on coal for energy use. Hence, it has one of the highest proportions of CO2 emissions to energy consumption. In addition to this, China has already surpassed the United States as the most contributor in global carbon emissions (MNP, 2008). The combination of China rapidly growing economy, and its emissions of huge amount of CO2 means in the near years it will have an impact on emissions of greenhouse gas as compare to other economy.

Concerns relating to the impacts of environmental degradation on economic growth were in conflict with claims that rapid in economic progress would better the environment, the article of belief in relation to environmental quality as luxury good. Additionally, people are willing to pay more and more money on this good the wealthy they will (De Bruijn, 1999). Grossman et al., (1991) analyzed the different impact of wealth on environmental quality and observed an overturn U-shaped linkage between income and production of certain pollutant. Panayotou (1993) observed the relationship identifying as Environmental Kuznets Curve (EKC), later the same-shaped relationship between income inequality and per capita income was drawn by the famous Economists Simon Kuznets (Kuznets, 1995). Thus, the central theme behind EKC hypothesis is an inverted U-shaped linkage between variables on environment pollution and income per capita. It's further suggests that in the long run, development in national income will invalidate the environmental effect of the initial phases of economic development. The current study, originally, Environmental Kuznet Curve relationships for carbon emissions by including energy consumption factor for China, use data from 1971-2013, has been investigated.

The rest of article is divided into five parts. Part two describes the previous studies on EKC. In part three, an analytical framework, empirical model and data used have been discussed. Part four connects the study with empirical results. Conclusions have been drawn in part five.

2. Theory and Related literature

There are a lot of empirical studies that addressed testing of hypothesis for Environmental Kuznets curve. This hypothesis was established by Grossman and Krueger's (1991) investigate the environmental effects of the North American Free Trade Agreement (NAFTA) in 1990 and 1992. EKC hypothesis explain the relationship between environmental quality and economic growth. The EKC hypothesis asserts that at the early stage of economic development of the country, environmental degradation will go up until a definite turning point is attained, and environmental quality will instigate to get better as mounting earnings (Selden and Song, 1994). The environmental quality statistics after achieving maximum turning point, instigate to signify demolitions in pollution and environmental degradation. In several cases this nexus insinuates that the environmental pollution indicator is an inverted U-shaped curve of national income (Lieb, 2002; Stern, 2004; Selden and Song, 1994; Kuo et al. 2014). The general format of EKC is presented in Figure 1 (Yandle et al, 2002).

Figure 1 actually reviews an essentially dynamic process of alteration, as national income in an economy upsurges over time, initially, level of emissions rises, touches a peak topmost point and subsequently instigates declining in pursuit of a threshold level of income (Dinda, 2004). A range of shapes of EKC hypothesis is identified in different studies conducted for different countries. These most common form is quadratic as the follows:

$$Y_{it} = \phi_0 + \phi_1 X_{it} + \phi_2 \ln X_{it}^2 + \varepsilon_{it}, (1)$$

Whereas,

$i = 1,2, \ldots \ldots N$, countries

T=1,…T, time

$Y_{it} = CO_2$ emissions per capita

ϕ_0 = Estimated parameters

X_{it} = GDP per capita

ε_{it} = error term

EKC hypothesis is valid only if the coefficient of ϕ_1 is positive and ϕ_2 is negative. In the model, the quadratic term signifies the -shape structure.

The EKC theory suggests that up to some starting point of income per capita, environment become more be polluted as the economic activity increases in scale. Considering that income per capita rises beyond this point, consequently the adverse environmental effects trim down (Li & Reuveny, 2009).

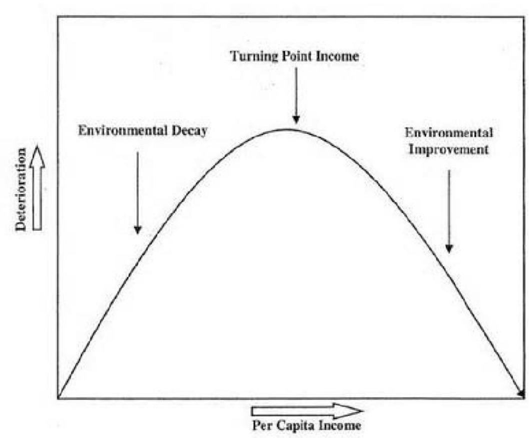

Figure 1: The environmental Kuznets curve

In the estimated model, if the coefficient of national income is statistically significant and parameter of quadratic version of national income is statistically insignificant, there are signals that display a few progresses with up surging national income. On the other hand, if the coefficient of national income is positive and statistically significant but the coefficient of quadratic term is statistically insignificant, these are indicators that point out some deterioration as earnings go up. It is conceivable that these indicators will exhibit the existence of EKC at higher per capita turning points. Moreover, if the coefficient of income is statistically significant and the quadratic term of income negative and statistically significant, then computed EKC has an extreme turning point per capita income level computed by ($Y^* = -\frac{\alpha_1}{2\alpha_3}$) (Neumayer, 2003; Neumayer, 2004).

Contrariwise, energy consumption is considered one of the important factor of carbon emissions as well as play an imperative role in the economic development of a country. There are several studies in which researchers investigate the relationship between carbon emissions, energy consumption and national income under context of EKC hypothesis. In the recent years, rapid economic progress along with energy consumption raised questions, for example whether there is a causal relationship between energy consumptions, increase in economic activity and environmental deterioration. In this regard, there are three classification of studies on the association between energy consumptions, income level and CO2 emissions. The main central point of first category is to investigate the relationship between factor of environmental contaminate and economic growth and explores the justification of the environmental Kuznets (1955) curve. The second category of the research scrutinizes the nexus between economic growth and energy consumption. The third category studies the dynamic association between economic growth, energy consumption, and environmental pollutants.

The Environmental Kuznets curve suggests that the nexus between different statistics of environmental degradation and income per capita is an inverted U-shaped function of income per capita (Stamation & Dritsakis, 2016). This curve also infers that the utilization of minerals deposit or the use of CO2 rising when GDP per capita improve. In this regard, Grossman and Krueger (1991), Ang (2007), and Acaravci and Ozturk (2010) attempted to examine the presence of Kuznets curve for diverse economies. Their findings were inconsistent and in various situation did not confirm the existence of the inverted U-shaped relationships.

In the second division of research which studies the linkage between economic growth and energy consumption are involved, among others, the studies of Kraft and Kraft (1978), Masih and Masih (1996), and Apergis and Payne (2009). All of them tried to investigate the trend of causality of the two aforementioned categories.

The last category which is an amalgamation of the first and second categories evaluates the dynamic association between economic growth, energy consumption, and environmental degradations. A number of latest studies in this group are Govindaraju and Tang (2013), Halkos and Tzeremes (2011), Akin (2014), Magazzino (2016), Dritsaki and Dritsaki (2014), and Ozturk and Uddin (2015). Their findings confirm the presence of causal nexus between energy consumption and CO2 emissions.

3. Model specification and Estimation procedure

3.1 Model Specification

This study utilizes the similar procedure employ by Halicioglu (2009) and Ghosh (2010). To test the validity of the EKC hypothesis in the long run, following double logarithm model is use:

$$\ln CE_t = \alpha_0 + \alpha_1 \ln EC_t + \alpha_2 \ln GDP_t + \alpha_3 \ln GDP_t^2 + \varepsilon_t \quad (2)$$

Where CE_t depicts carbon emission per capita, EC_t denotes Energy consumption per capita in kg of oil equivalent, GDP_t signify Gross domestic product in current US \$, GDP_t^2 shows square of gross domestic product, and ε_t represents error term.

The EKC hypothesis only holds when the sign of estimated coefficient of $\ln GDP_t$ is positive and $\ln GDP_t^2$ is negative. In addition to this, the both coefficients must be statistically significant. The turning point for gross domestic product is computed by using the following formula:

$$Y^* = -\frac{\alpha_1}{2\alpha_3} \quad (3)$$

If the value of Y is estimated in logs, in that case exponential of Y^* will provide the monetary value symbolize the uttermost of the EKC. indicated that in view of the fact that higher level consumption of energy cause a greater expansion in economic activity and ultimately accelerate carbon emission, the coefficient of $\ln EU_t$ is anticipated to be positive sign. (Saboori er. Al., 2016)

3.2 Estimation Procedure

The study uses time series data. In modern econometrics three chronological steps go along time series analysis. In the first step, time series data require testing for unit root with the purpose to obtain the order of integration. The existence of long run relationship between variables are consistent with the order of integration. In the second step, the test of cointegration is applied so to validate the long run association between variables. In the third and final step, different procedures are employed in order to estimate short run and long run unknown parameters of the true model.

Phillips-Perron (PP) unit root test developed by Phillips (1987) and Perron (1988) has been employed in order to confirm the consistency of our examination. In PP test of detecting unit root the null hypothesis is that the series are non-stationary and the decision regarding rejection or acceptance are based on the investigations of comparing t-ratio of the lagged term with the tabulated values. If we have a situation where t-ratio is less than the critical values of our null hypothesis is accepted. So if the null hypothesis is rejected and the series are stationary by the first difference, then the series is integrated of order one represented by I (1). Critical values for this t-statistic are given by the one-sided Mackinnon (1996). An important assumption of the DF test is that the error terms are independently and identically distributed. The ADF test adjusts the DF test to take care of possible serial correlation in the error terms by adding the lagged difference terms of the regress and. Phillips and Perron use nonparametric statistical methods to take care of the serial correlation in the error terms without adding lagged difference terms. Since the asymptotic distribution of the PP test is the same as the ADF test statistic, we will not pursue this topic here.

3.3. The ARDL Cointegration Framework

In order to estimate the long run association between variables of interest, most of the researcher utilized the Johansen cointegration technique in past studies. In reality this method is considered the most accurate procedure to employ for integrated of order one variables. However, lately some econometrician like Pesaran and Shin (1996); Pesaran and Pesaran (1997); Pesaran and Smith (1998) and Pesaran et al. (2001) conducted a series of studies and have developed an alternative method called "'Autoregressive Distributed Lag (ARDL)' bound test. It has been observed that ARDL comparatively more effective in small sample data sizes. As this thesis covers the time period 2005-2014, so the total observations for the study is 120. Once the lag of model is recognized then the ARDL allows the cointegration to be estimated by the OLS technique and this makes the ARDL procedure very simple. Another important feature of ARDL is that it is applicable whether the model is purely integrated of order zero or purely integrated of one or combination of integrated of order zero and integrated of order one.

Pesaran and Pesaran (1997) suggest that ARDL approach comprises two steps. The first step consists of F-test which determines the presence of long run association among desired variables. The second step of ARDL procedure consist of estimating the coefficients of the long run nexus and the coefficients of short run variables in the error correction representation of the ARDL model. By using the Error Correction term in ARDL, the speed of adjustment to equilibrium in the long run is estimated.

An ARDL depiction of Eq. (2) is constructed in following fashions:

$$\Delta CE_t = \beta_0 + \sum_{i=1}^{m} \beta_{1i}\Delta CM_{t-i} + \sum_{i=0}^{m} \beta_{2i}\Delta EC_{t-i} + \sum_{i=0}^{m} \beta_{3i}\Delta GDP_{t-i} + \sum_{i=0}^{m} \beta_{4i}\Delta GDP^2_{t-i} + \beta_5 CE_{t-i} + \beta_6 EC_{t-i} + \beta_7 GDP_{t-i} + \beta_8 GDP^2_{t-1} + \upsilon_t \quad (4)$$

Whereas all the dependent and independent variables have been previously specified. In above equation, the operator Δ indicates the first difference. υ_t represents the white noise error, β_0 is intercept while the parameters like β_{1i}, β_{2i}, β_{3i}, and β_{4i} show the short run dynamics of the model. While β_5, β_6, β_7, and β_8 show the long run multipliers in the ARDL model.

3.4. ARDL Bounds Testing Procedure

The ARDL Bound test methodology can be conducted in two steps. In first step equation (4) is estimated with the help of OLS. This is completed by performing F-test for the joint significance of the coefficients of lagged levels of the variables.

The null and alternative hypothesis are given as under:

$$H_0: \beta_5 = \beta_6 = \beta_7 = \beta_8 = 0$$
$$H_0: \beta_5 \neq \beta_6 \neq \beta_7 \neq \beta_8 \neq 0$$

When the regressors are I (d) where $0 \leq d \leq 1$ then the two asymptotic critical values of bounds provide a test for cointegration. It is noted that the values of lower bound anticipated that the independent variables are integrated of order zero, or I (0), whereas the values of upper bound values supposed that they are integrated of order one [I (1)]. The null hypothesis of no cointegration cannot be rejected if computed F-statistic falls below the lower bound value, I (0). The result is to be declared inconclusive in the case when the value of test statistic lies these two bound values.

When a long run association between economic variables have been constructed, Eq. (4) is computed by applying an appropriate lag selection criteria such as Schwarz Bayesian criterion (SBC) or Akaike information criterion (AIC). In the next step of ARDL cointegration procedure, a parameter stability test is possible to run to check the stability in the selected ARDL representation of the error correction model (ECM).

Error correction model (EMC) of Eq. (4) is constructed as follows:

$$\Delta CE_t = \gamma_0 + \sum_{i=1}^{m} \gamma_{1i}\Delta CE_{t-i} + \sum_{i=0}^{m} \gamma_{2i}\Delta EC_{t-i} + \sum_{i=0}^{m} \gamma_{3i}\Delta GDP_{t-i} + \sum_{i=0}^{m} \gamma_{4i}\Delta GDP^2_{t-i} + \lambda ECT_{t-1} + \mu_t \quad (5)$$

In eq. (5), λ signifies the speed of adjustment parameter and ECT_{t-1} indicates residuals that are taken from the estimated Eq. (2). The cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) are also employed to scrutinize the goodness of fit for auto regressive distribution model (Pesaran et al., 2001).

4. Empirical Findings:

4.1 Preliminary Analysis of Data

This study employ time series data covers the period 1971—2013 has been selected based on accessibility of the statistics for entire series. The data employ for estimation are carbon dioxide emission (CE_t) per capita, gross domestic product (GDP_t) in current US $ and energy consumption per capita in Kg of oil equivalent. All the data have been obtained from the World Bank website. All the variables are transformed into logarithms. Eviews 9.5 has been used to perform all empirical test. The data on carbon emissions, energy consumption and gross domestic product are presented in figure 1, 2 and 3, respectively.

It has been seen certain from figure 2, that all variables are nonstationary. Stationary series can be labelled as one series with a constant mean, constant variance and constant autocovariance for each lag during time. The Phillips-Perron (PP) Test is utilized to find out the stationary of time series of $CE_t, \ln EC_t, \ln GDP_t, \ln GDP_t^2$. The null hypothesis of random walk ($H_0: \mu = 0$) against the alternative hypothesis of a stationary process ($H_0: \mu < 0$) is tested. The results of unit root test based on the Phillips-Perron (PP) test is reported in the Table 1.

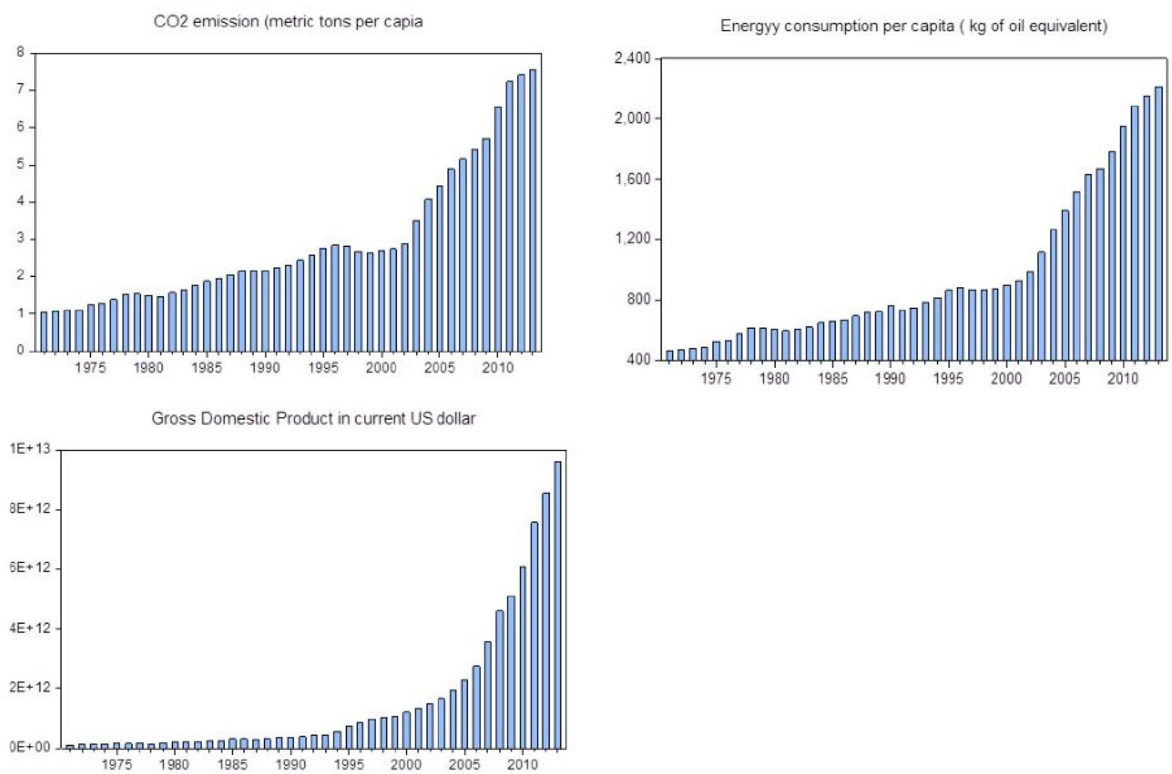

Figure 02: Graphical representations of carbon emission, energy consumption and GDP

The outputs of stationarity test divulge that at level with drift and trend, all the variables are non-stationary. Therefore, we cannot reject the null hypothesis of unit root at 5 percent level of significance. The same variables are also tested again at first difference and results show that all variables are stationary at first difference. Econometric theory suggests that if all the variables are non-stationary at level and become stationary at first differences, then these variables are integrated of order 1. While if the variables are stationary at level, then theses variables are integral of order zero. Hence technique of ARDL is employed to account for same order while estimating long run association among the independent variables and dependent variables.

To get rid of any serial correlation, the ARDL bound testing founded by Pesaran et al (2001) require correct lag size in variables. This lag size has been meticulously pick out by taking first difference of conditional error correction version of ARDL. Akaike information criteria is employed to obtain maximum lag. Table 2 depicts the results of Lag length selection criteria. The minimum value of AIC presents the maximum lag 5 is an appropriate lag length for estimate ARDL model. As to get reliable and unbiased results an appropriate lag order is necessary.

Table 1: Phillips-Perron (PP) unit root test

Variables	**T-Statistics**	**P value***
PP test at level with intercept		
ln CM_t	0.304289	0.9758
ln EC_t	0.974143	0.9955
ln GDP_t	2.489667	1.0000
ln GDP_t^2	2.654390	1.0000
PP test at first difference with intercept		
Δ ln CE_t	-3.810335	0.0058
Δ ln EC_t	-3.565168	0.0110
Δ ln GDP_t	-5.200094	0.0001
Δ ln GDP_t^2	-4.823599	0.0003

*Mackinnon (1996) one-sided p-values

Now the next step is to setup the existence of long run nexus among the independent and dependent variables of equation (3) by way of ARDL bound test. The output of bound test for cointegration is shown in Table 3.

The estimated value of F-Statistic is more than the tabulated upper bound value at 5 percent, 10 percent, 2.5 percent and 1 percent level of significance, hence the null hypothesis of no cointegration has been rejected at 5 percent level of significance. Hence, it validates that there exists a long run association among the variables include in the model.

Table 2: VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-9.776227	NA	2.43e-05	0.725065	0.897442	0.786395
1	230.6250	417.5390	1.81e-10	-11.08553	-10.22364*	-10.77888*
2	244.4415	21.08823	2.10e-10	-10.97060	-9.419206	-10.41863
3	255.7076	14.82385	2.91e-10	-10.72145	-8.480545	-9.924155
4	284.2229	31.51692*	1.76e-10*	-11.38015	-8.449735	-10.33753
5	302.4204	16.28199	2.09e-10	-11.49581*	-7.875884	-10.20787

*Lag order selected by the criterion. LR: Sequential modified LR test statistic (each test at 5% level), FPE

Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion.

Table 4 depicts the long run associations among variables. The results divulge that there exists a positive association between energy consumption and emissions of carbon dioxide. For instance, a 1 percent upsurge in energy consumption bring an increase in emission of carbon dioxide by 2.20 percent.

The coefficients of both GDP_t and GDP_t^2 prove the presence of inverted U- relationship between national income and Co2 emission inside China. The coefficients of both GDP_t and GDP_t^2 are 2.54 and -0.05, respectively and statistically highly significant.

Table 3: Bound test of cointegration

Test Statistic	Value	K
F-statistic	6.220013	3
Critical Value Bounds*		
Significance	**I0 Bound**	**I1 Bound**
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

*Pesaran et al., (2001) Critical values 0.08 percent.

As the model is double-log model, the computed coefficients can be interpreted as percentage change in carbon emissions as results of percentage change in energy consumption and gross domestic product. The results also divulge that a one percent boost in gross domestic product bring a 2.54 percent upsurge in carbon emissions. The statistically significant negative coefficients of GDP_t^2 infer that the national income rises consistently with the level of carbon emission. This result support the EKC hypothesis which stated that at the initial stage environmental pollution rises with income, but when income goes up to the stabilization point it declines.

Table 4: Long-Run coefficients of ARDL (1,5,4,0) Model Dependent Variable ln CE_t

Regressor	Coefficient	Standard error	t-ratio
Constant	-44.834704	6.803969	-6.589493
ln EU_t	2.197127	0.230430	9.534897
ln GDP_t	2.536923	0.466083	5.443073
ln GDP_t^2	-0.051345	0.009132	-5.622378

*Signify significance level at 5 percent

The turning point of gross domestic product turned out to be approximately USD 53.59 trillion (table 5), which is more than the highest value of gross domestic product in the sample in this paper. This outcome is consistent with those of (Cole, Rayner, & Bates, 1997) and (Grossman & Krueger, 1994).

Table 5: Estimated Turning Point

Coefficient of ln GDP_t	Coefficient of ln GDP_t^2	Turning Point
2.536923	-0.051345	53.59*

*trillion $ US

As all the variables are stationary at first difference, hence Granger-Causality test can be applying to study the casual association between GDP and Co2 emission. The results of Granger-Causality test are depicted in Table 6. The result signifies that in the long run GDP cause Co2 emission. This result also support some other studies that investigate the association between GDP and carbon emission, for instance Jalil and Mahmud (2009) and Zhang and Cheng (2009) for China, Shahbaz et al. (2010) for Pakistan and Ghosh (2010) for India.

Table 6: Granger causality test findings

Null hypothesis	F-statistic	p-value
ln GDP_t does not Granger Cause ln CE_t	3.80101	0.0318
ln CE_t does not Granger Cause ln GDP_t	1.11160	0.3401
ln GDP_t^2 does not Granger Cause ln CE_t	3.60575	0.0374
ln CE_t does not Granger Cause ln GDP_t^2	1.24678	0.2995

The short run relationships between variables are reported in Table 7. The results reveal that there exists a positive linkage between energy consumption and carbon emission. For instance, a one percent upsurge in use of energy leads an increase in carbon emission by 1.08 percent. Here the sign of both GDP_t and GDP_t^2 validate the EKC hypothesis in the short run. In addition to this, both variables are statistically significant at five percent level of significance respectively.

Table 7: Error Correction Representation of the selected ARDL (1, 5, 4, 0) Model Dependent variable Δ ln CE_t

Regressor	Coefficient	Standard error	t-ratio
Constant	-19.26552	6.068734	-3.174553
Δ ln EU_t	1.082803	0.123491	8.768259
Δ ln GDP_t	1.143982	0.353409	3.236994
Δ ln GDP_t^2	-0.022063	0.007114	-3.101362
$ECM_t(-1)$	-0.429701	0.115366	-3.724668

* shows level of significance at 5%, R-squared=0.998, F-Statistic=1744.544, Breusch-Godfrey Serial Correlation LM Test (Obs R squared) = 0.746136, Autoregressive Conditional Heteroscedasticity Test (Obs R squarer) = 1.013252, Ramsey RESET Test (F-Statistic) = 1.230035

The presence of cointegration associations among the variables entails the estimation of Error Correction Model (ECM) to understand the short run relationships between variables in the model. The coefficients of ECM also show the speed of adjustment to equilibrium when an economic shock is faced by an economy. The results of short run coefficients and error correction term are reported in Table 7. The model utilizes the first difference of the variables (shows short run variations).

It is noted that, after a temporary shock estimated short-run coefficients depict the conjunction to equilibrium in the long run. As keeping the views of econometric theory, the dynamic steadiness of the path of Co2 emission needs that the parameter on the ECT must be negative and significance on the statistically background. As in our estimated model, the coefficient of error correction term is negative and also statistically significance at the level of 5% significance.

The estimated coefficient of the ECM is 43 percent. This reveals that the nearby 43% of the disequilibrium in the preceding year following shocks to the system converge back to the long run equilibrium in the current year. By this ruling, it is deduced that to some extent disequilibrium within the CO2 emissions in the short run is hastily corrected and converged back to equilibrium in the long run.

In order to check whether our model is suffering from the problem of heteroscedasticity or not. For this purpose, the Autoregressive Conditional Heteroscedasticity (ARCH) Test has been employed. The result of ARCH test is represented in the Table 7. The Observed R Squared of the result reveal that the model is free of heteroscedasticity problem. So, the results show that, ARCH test depicts that there exists no heteroscedasticity in the residual terms of the model. Therefore, the null hypothesis of no heteroscedasticity has been accepted. For detection of auto correlation, we employ the Breusch-Godfrey serial correlation Lagrange Multiplier (LM) test. The value of observed R squared statistic test is 0.75. On the base of large chi-square probability value the model is considered free from the problem of serial correlation. As the null hypothesis of no serial correlation is accepted at 5% level of significance. Specification error is another important aspect of model diagnostic tests. To check the model specification error in model, Ramsey's Reset test has employed. From the table, it is clear that the value of F-statistic is 1.23. So, the null hypothesis of no model specification error has been accepted at 5% level of significance. Figure 3 depicts that the graph of CUSUM is significant at the five percent level of significance showing the stability of parameters.

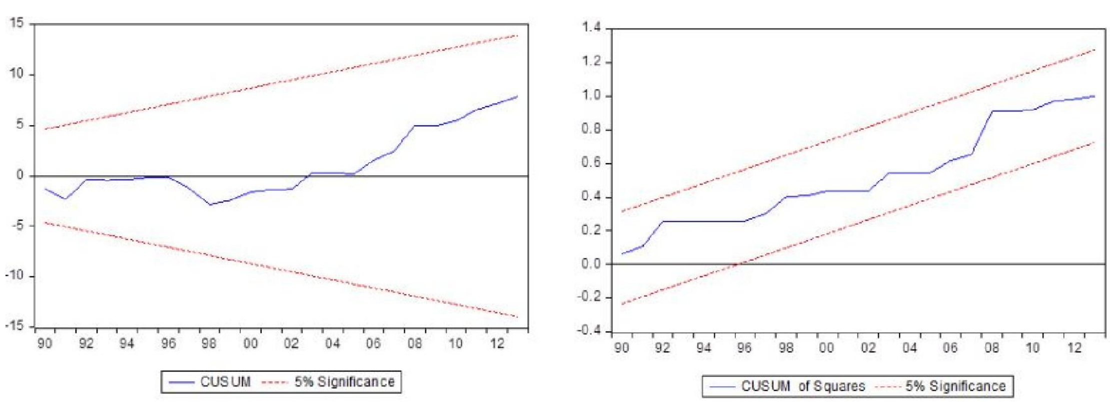

Figure 3: Parameters Stability test

4.2 Sensitivity Analysis

Sensitivity analysis studies shows that how variations in the assumptions of an economic model affect its predictions. It is a way to predict the outcome of a decision if a situation turns out to be different compared to the key prediction. In this study, sensitivity analysis is used to check (1) the variations between GDP and turning points, (2) the variation between GDP and CO2.

In order to calculate the consistency of the results acquired from the environmental degradation analysis, sensitivity analyses have therefore also been carried out for simulation 2 – variation in the following way: (1) increasing the values for estimated GDP elasticities by 5%, (2) decreasing values for estimated GDP elasticities by 5%.

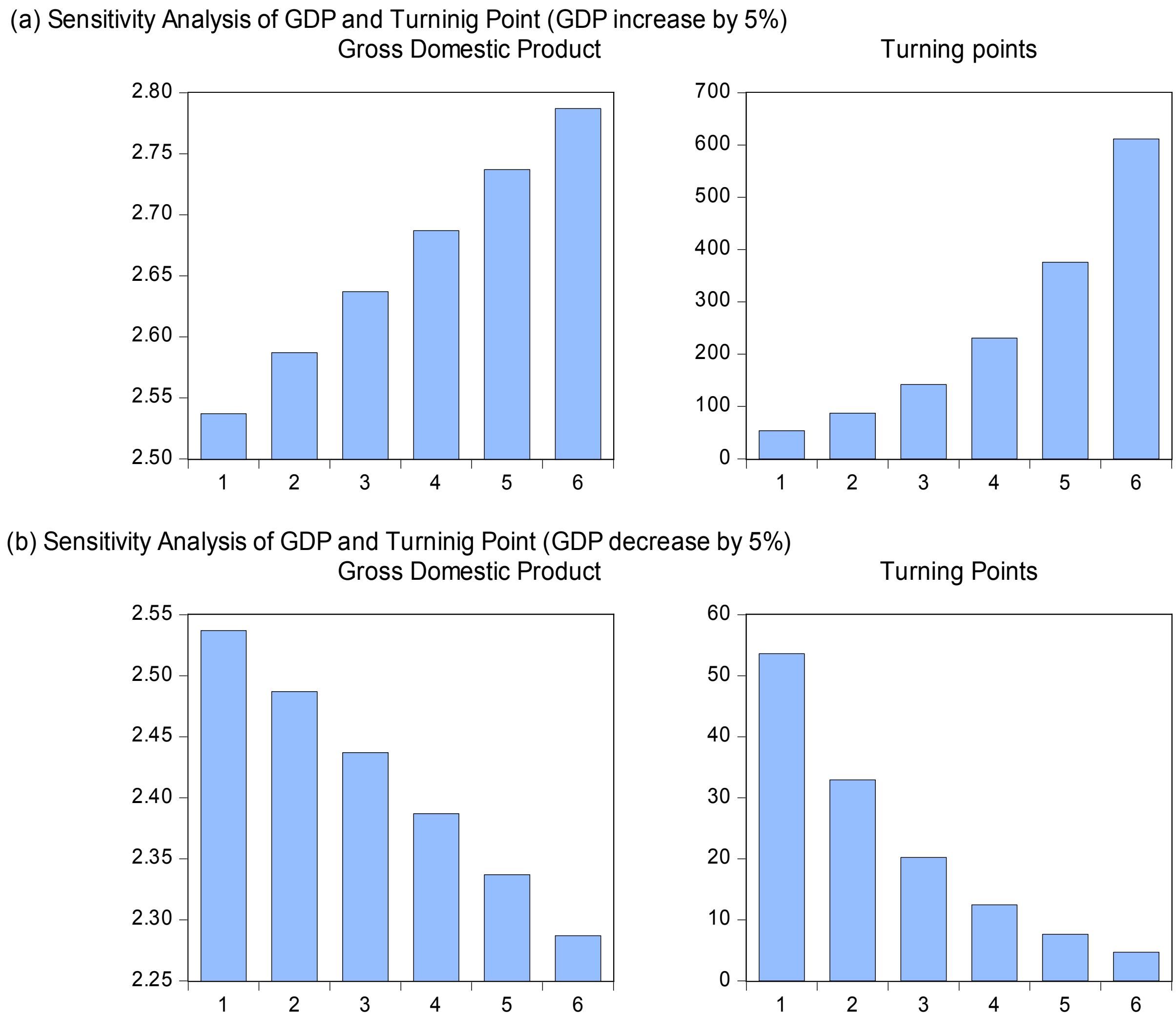

Figure 4: Sensitivity Analysis of GDP and turning points

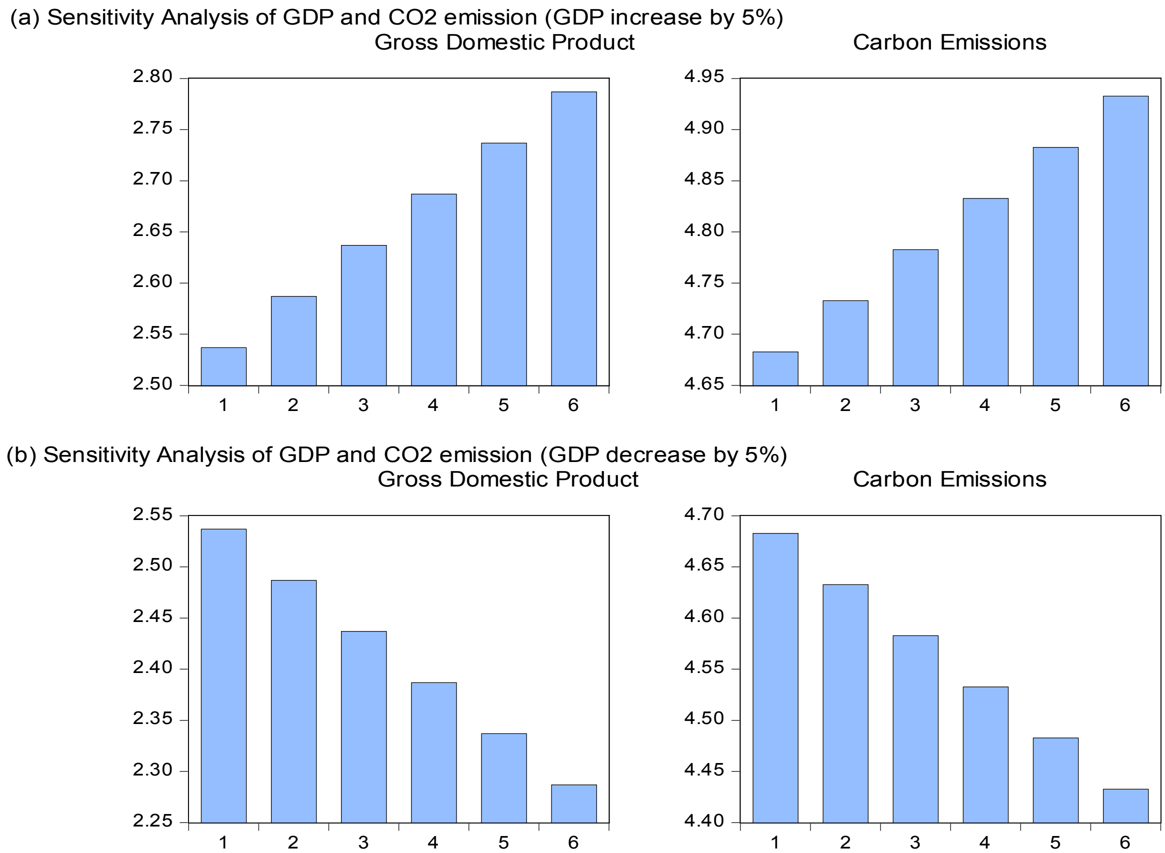

Figure 5: Sensitivity analysis of GDP and CO2 emissions

The simulation results from selected sensitivity tests of GDP and turning point is presented in figure 4. When the value for GDP increases by 5%, the turning point increased to 87 trillion US dollars. Again, further increase in GDP by 5% leads an increase in the value of turning point. On average five percent increase in GDP of China leads an increase of turning point by 250 trillion dollars. On the side, if GDP is decrease by five percent, turning point also decrease from 54 billion dollars to 33 trillion dollars. Once more decrease in GDP by five percent cause further decrease in turning point. On average five percent decrease in GDP cause reduction in turning point by 22 trillion US dollars. So, sensitivity analysis of GDP gives different scenarios of variation in GDP with respect to turning points. This results also reflects that GDP of China is sensitive in a sense that a greater variation in GDP bring a huge variation in turning points.

Figure 5 depicts the sensitivity analysis of GDP and CO2 emissions. From figure, it clear that five percent upsurge in GDP boost CO2 from 4.68 per capita to 4.73 per capita. If GDP further increase from 2.74 percent to 2.79 percent, ultimately CO2 emissions go up from 4.88 per capita to 4.93 per capita. On average five percent increase in GDP increase CO2 emissions by 8.81 per capita. On the other side five percent decrease in GDP trim down CO2 emissions from 4.68 per capita to 4.63 per capita. On average if GDP decrease by five present eventually CO2 emissions come down by 4.56 per capita. As GDP is one of the important factors of environmental degradations and this analysis validate that how variation in GDP is sensitive for causing environmental problems in China.

4.3 The Variance decomposition of VAR (1) Model

The variance decomposition of carbon emissions in 10 periods are presented in table 8. The results divulge that 100 percent of ln CM_t variance can be explained by current ln CM_t in the first period.

Table 8: Variance Decomposition of ln CM_t in 10 period

Period	SE	ln CM_t	ln EC_t	ln GDP_t
1	0.043074	100.0000	0.000000	0.000000
2	0.072361	98.12806	1.296644	0.575291
3	0.092783	97.72284	1.913128	0.364036
4	0.105886	96.77223	2.447103	0.780669
5	0.114714	94.32424	2.866408	2.809354
6	0.121688	90.18747	3.167947	6.644582
7	0.128150	84.88307	3.360334	11.75660
8	0.134604	79.17748	3.474817	17.34770
9	0.141141	73.67183	3.546791	22.78138
10	0.147731	68.67893	3.603094	27.71798

SE: Standard error

In the short run (period 3), impulse to CO2 emissions count for 97.72 percent variation of the fluctuations in CO2 emissions. On the other hand, shock to energy use and GDP cause fluctuations in carbon emissions by 1.91 percent and 0.36 percent, respectively. At the end of the tenth period (long run) the innovation to energy consumption and GDP bring a variation in carbon emissions by 3.60 percent and 27.72 percent, respectively. Hence, energy consumption and GDP are main two factors which bring a huge variation in carbon emissions in the long run.

Table 9 depicts variance decompositions of energy consumptions in ten periods. The results reflect that in the short period (period three) shock to energy consumption count for 28.12 percent variation of the fluctuations in CO2 emissions. While the contributions of GDP in variation of carbon emissions is 0.25 percent. While in the long run, innovation to energy consumption count for 24.63 percent ups and down of the variations in energy consumptions. While impulse to GDP bring a change in energy consumption by 38.66 percent.

Table 9: Variance Decomposition of ln EC_t in 10 period

Period	SE	ln CM_t	ln EC_t	ln GDP_t
1	0.030578	62.11170	37.88830	0.000000
2	0.050906	70.83446	29.09540	0.070143
3	0.065108	71.62605	28.12416	0.249790
4	0.074728	69.20667	28.71152	2.081810
5	0.082093	64.33434	29.26079	6.404872
6	0.088808	58.08040	29.11944	12.80016
7	0.095550	51.61807	28.31265	20.06928
8	0.102412	45.74406	27.13744	27.11850
9	0.109295	40.77205	25.86226	33.36569
10	0.116112	36.71158	24.63310	38.65532

SE: Standard error

Variance decomposition of gross domestic product is presented in table 10. The results reveal that in the short run, shock to GDP count for 89.07 percent variation of the fluctuations in GDP. On the other hand, innovation to carbon emissions and energy consumption cause fluctuations in GDP by 9.48 percent and 1.44 percent, respectively. While in the long run, the impulse to carbon emissions and energy consumption bring a variation in carbon emissions by 21.01 percent and 3.46 percent, respectively.

Table 10: Variance Decomposition of ln GDP_t in 10 period

Period	SE	ln CM_t	ln EC_t	ln GDP_t
1	0.086392	1.726945	0.037927	98.23513
2	0.122209	5.037684	0.942073	94.02024
3	0.149744	9.482951	1.443956	89.07309
4	0.173898	13.48331	1.908236	84.60845
5	0.196325	16.52716	2.296706	81.17613
6	0.217664	18.58379	2.620895	78.79531
7	0.238268	19.84681	2.888713	77.26448
8	0.258364	20.54847	3.111223	76.34031
9	0.278114	20.88727	3.298933	75.81380
10	0.297631	21.00894	3.460886	75.53017

SE: Standard error

4.4 The impulse-response functions of VAR (1) model

Consequently, the impulse-response functions of influence of variables by one standard deviation impulse on each other are charted for ten period limits in Figure 6 for VAR (1) model. It can be observed from the figures that one standard deviation innovation in energy consumption has a significant positive impact on carbon emissions, while that one standard deviation impulse in GDP has significant positive effect on carbon emissions.

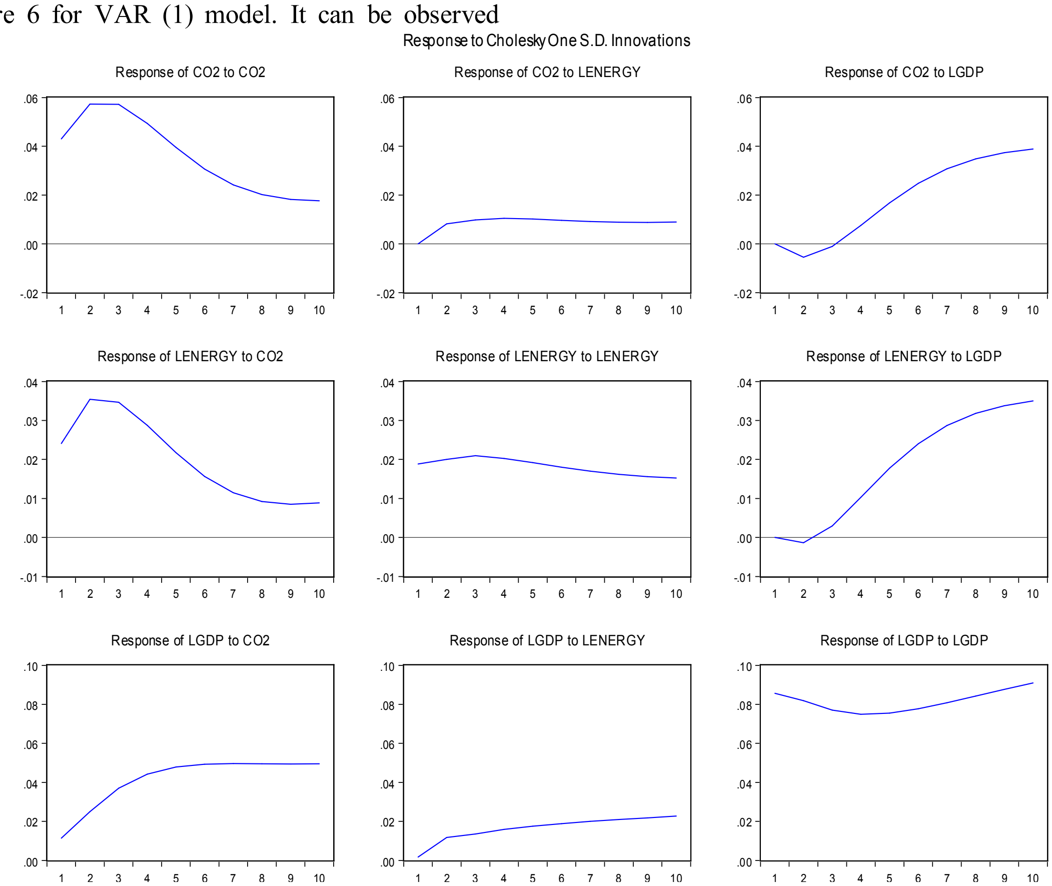

Figure 6: The impulse-response functions of vector Autoregression (1) model

5. Conclusions

This study goals to examine the long run relationships between carbon emissions, energy consumption and gross domestic product, and to assess the EKC hypothesis for China in 1971-2013. Firstly, the long run and short relationships between variables are scrutinized by econometric techniques. In this regard, the methodology employed in the study comprises of unit root tests based on Phillips-Perron (PP), the ARDL Cointegration, the Granger Causality test in a VAR, Impulse Response and Variance Decomposition of VAR model. In addition to this, sensitivity analysis is also used. The Phillips-Perron PP) unit root test depicts that all the variables are non-stationary al level but it turns to be stationary at first difference. The estimated outcomes conclude that there is a long-term nexus among gross domestic product, carbon emission and consumption of energy. The findings furthermore disclose the presence of short-term relation among gross domestic product, carbon emission and energy consumption. The paradigm utilized for testing EKC for China also mixed up one another variable that capture use energy consumption (EU). A positive relationship and significant impact of energy consumption on carbon mission have been traced. The findings of Granger's causality test propose that there is one way causality runs through gross domestic product to carbon emission. The sign of coefficient of Error Correction term is negative and statistically significant at one level of significance and hence proves the existence of long run nexus among variables. Additionally, the significant value of lagged error correction term depicts that variation in carbon emissions ahead of equilibrium are adjust by 43 percent within one year. The stability tests such as CUSUM and CUSUMQ procedure are employed on the ARDL model. In short, all the results confirm the existence of EKC both in the long run as well as short run. In the long run model. The sensitivity analysis divulge that increase or decrease in GDP bring a huge change fluctuations in carbon emissions.

The empirical results of this study are very significant for the environmental policy makers. For that reasons, the nations should unearth the substitute source of energy such as solar energy, natural gas etc. that there is an environmentally friendly. All the empirical results validate that in high economic growth causes to degradation of environment and ultimately diminution of natural resources regardless of expanding manner of living. The results of this study are imperative in the environmental policies. For that reason, it ought to acquire a sustainable economic growth by less carbon emissions and using less energy. Additionally, the environmental policy makers may incorporate exogenous impacts, for example overseas investments to work out energy policies, in addition to keep up economic growth for worldwide climate forewarning.

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