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Revisiting the concept of environmental Kuznets curve in period of energy disaster and deteriorating income: Empirical evidence from Japan

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HIGHLIGHTS

- EKC exist in Japan in spite of the country's energy disaster and deteriorating income.
- Energy consumption was found to be the major contributor to environmental degradation.
- Energy disasters are in themselves agents for the EKC to unfold immaterial of fortunes.
- Economic growth, exports and imports raises CO_2 by 16.24%, 23.89% and 44.18%.

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ABSTRACT

This study investigates the position of the Japanese environmental Kuznets curve in period of natural disaster and deteriorating income following the recent Fukushima energy crisis. The study aim to establish whether the EKC exist in period of energy disaster and deteriorating income. To ensure this, data from 1961 to 2012 was used while the Zivot-Andrew structural break test, the ARDL bounds test were applied, and these were validated using the innovation accounting test. The finding of the study established the existence of inverted-U shape, suggesting the presence of EKC despite the deteriorating income of the country. With the discovery of the existence of EKC in this study despite the dwindling productivity and revenue in Japan, this study challenged the EKC hypothesis and all existing studies on EKC, by establishing that natural disasters are in themselves strong causative agents for the EKC to unfold and it is immaterial whether the economic fortunes of a country is increasing or decreasing. The study further discovered energy consumption to be the major contributor of environmental degradation in Japan, while exports declines CO_2 emissions, but imports adds to environmental degradation. On the growth prospects of the Japanese economy after the crisis, the study discovered how energy consumption, exports, and imports contribute 33.55%, 1.027% and 7.126% to the country's economic growth respectively; in return a minimum of 16.24%, 23.89% and 44.18% of CO_2 emissions was discovered. The study proposed policy instruments that will help in realizing a balanced environment amidst efficient energy consumption and environmental management among others.

1. Introduction

Energy disaster arising from nuclear incidents are catastrophic phenomenon that afflict significant environmental and economic damages to a country's economic and social activities. The Fukushima Daiichi nuclear power facility, in the Futaba District of the Fukushima Prefecture in Japan, was severely damaged by a 9.0 magnitude earthquake and as a result of this, Japan lost considerable energy source, financial, physical and human capital. The scope of the physical destruction according to the Japanese Ministry of Economy (2011) wrought by this catastrophe was approximated to be between $195 billion and $305 billion. The latter amount comprising almost four times more than the costs of damages caused by Hurricane Katrina that was estimated to be $81 billion. This huge cost is said to be almost equaling Greece's GDP, and two times the New Zealand GDP (Nanto et al., 2011). Alternative valuation from the insured destructions was placed between $11 billion and $21 billion. Apart from that, other economic destruction from the Fukushima Daiichi nuclear energy disaster were found to overshoot to an estimated cost of $8 billion to $9.7 billion, making a combined total costs of approximately $20 billion

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to $30 billion (Rafindadi and Ozturk, 2016). In addition to that, property and insurance claims were placed at $50 billion, excluding losses from production and assertions that were associated with nuclear pollution. Subsequent to these financial disorders, data from the Japanese Ministry of Economy, Trade and Industry (2011) revealed that Japan's economy shrunk over two-quarters and had been in deep recession. In that instances, the Japanese, Ministry of Economy, Trade and Industry (2011) reported that the economic growth of the country in that period was anticipated to be almost zero and within an approximated scope of between minus 1% and plus 1%.

Japan being the third largest economy in the world, with its GDP previously put at $5.5 trillion thus giving it the opportunity to occupy 8.7% of the total global GDP, has its GDP suppressed by the Fukushima catastrophe to an approximated figure of 0.2% to 0.5% less from its GDP in 2011. Additional substantiation provided by the IHS Global Insight (2011) estimated that the economic growth of Japan was formerly expected to rise to a position of 0.5%, after the 2007/2008 financial crisis. However, the economic shocks that arose during the period of the financial crisis contributed greatly in displacing Japan from its No.2 position as the global economic giant after the United States of America to presently the third position after China. This development in addition with the Fukushima energy disaster combined to create a nostalgic economic phenomenon that saw Japan recording 0.0% of economic growth in March 2011. Similar development from the economic reconstruction in 2012 have shown that the Japanese economy further contracted by about 3.6%. In addition to that, and according to Morgan Stanley (2011), a short and deep recession was said to be inevitable in Japan following its economic shrink from 1% to 3% in 2011 and a reduction in the global growth of about 0.5% (Morgan Stanley MUFG, 2011). Apart from the preceding development, the Economy Watch (2014) further reported that the retail sales tax increase in many European countries led to a sharp contraction of the Japanese economy. Aggravating, the overall economic issues of Japan, Nanto et al. (2011) pointed out that after the Fukushima accident, a 2.5 trillion JPY (US 31 billion) trade loss was recorded, and that was for the first time since after the 1979 oil shock. This development was attributed to be due to a rise in the importation of fossil fuel which placed additional pressure on an economy that was already too weak.

Compounding, the overall effects of the Fukushima disaster and the nostalgic position Japan has seen itself during the recent period, was the escalation in public liability that was estimated to the tune of nearly 200% of the country's GDP. This situation caused stagnation to all sources of funds to the country thus, rendering economic reconstruction more intricate than previously considered. In this instance, it was asserted by Nanto et al. (2011) that Japan could not withstand an independent debt emergency comparable to that encountered by Greece.

The major concern of this study is that the energy and financial, economic losses that hit Japan in the two alternating periods of the 2007/2008 financial crisis and the energy disaster of March 11, 2011, has created considerable economic and financial implications for the country's economic growth prospects. Following this development, the present study ask: what is the position of the Japanese economic growth prospects as a result of the huge electricity shortage faced by the country? Apart from that, what is the position of the country's environmental Kuznets curve (EKC)? Could the EKC be said to exist considering the huge volume of radiation and amidst deteriorating income of the country? What policy instruments does exist that will help in realizing a balanced environment amidst efficient energy consumption and successful environmental management in Japan? In addition to that, it is noteworthy to mention that, the rise in fossil fuel utilization by Japan following the disaster has resulted in a considerable increase in the discharge of greenhouse gas thereby, leading to huge amount of CO_2 emissions that is very likely to exist, but the contentious issue that is of more concern to this study is the huge deteriorating income of the country. In this respect, this study aim to investigate the dynamic influence of the two alternating cases empirically, by uncovering the position of the Japanes EKC in period of falling income and energy crisis considering that the two are strong pillars that reduce production optimality possibilities.

2. Review of literature

The growing literature concerning the association between energy consumption, economic growth, and environmental degradation has been in existence for quite a long period. Notable researchers in this field include authors like, Kukla-Gryz (2009), Kohler (2013), Ozcan (2013), Cho et al. (2014), Robalino-López et al., (2014), Lau et al. (2014), Farhani et al. (2014), Al-mulali et al. (2015), Apergis and Ozturk (2015), Ozturk and Al-Mulali (2015), Tsurumi and Managi (2015), Marsiglio et al. (2015), Tutulmaz (2015), Yin et al. (2015), Jebli and Youssef (2015). These authors have studied the various position of the Environmental Kuznets Curve (EKC) on different countries, applying different methods of investigations and amidst varying economic circumstance. In addition to that, the position of EKC hypothesis was found to be a well-established concept that is common in the developed nation's and emerging market economies. This assertion can be traced in the studies of Ozturk and Acaravci (2013), Cho et al. (2014), Farhani et al., (2014), Apergis and Payne (2010), Al-mulali et al. (2015) and Ozturk and Al-Mulali (2015). To support their claims, the authors above used different indicators and ecological footprint ranging from economic growth, Trade openness CO_2 emission, urbanization, and the level of energy consumption to investigate the position of EKC in both panel and time series based studies. On the contrary none of these authors have investigated the position of the EKC in periods of energy disasters and deteriorating income.

The concepts of the EKC established that in any given country where economic growth increases, there is every possibility for a corresponding increase in CO_2 emission and other pollutants, meaning that an opportunity cost exists between the rise in income and rise in pollutants. This is in the sense that while an increase in national economic growth may be imminent, as a result, a corresponding increase in energy contaminants should also be expected at the primary stage; but following a particular extent from the income accrued or economic growth attained, the concepts of the EKC reassert that the degree of environmental contaminants will begin to decrease. This phenomenon, when plotted on a graph, will yield an inverted U-curve. Following this conceptual assertion, the legitimacy of EKC has been scrutinized by many researchers, both from the individual country point of view and also from a panel of countries. Foremost, the pioneering study of Krueger and Grossmann (1991) has consistently laid a sound theoretical structure of the EKC literature. From the positions of this authors, arguments series of researchers were challenged to re-examine the contribution of Krueger and Grossmann (1991). For instance, a study by Shafik and Bandyopadhyay (1992) and Holtz-Eakin and Selden (1995) have established that the quantity of CO_2 discharges is monotonically raised in line with per capita income. In contrast to that, the findings of Soytas et al. (2007) discover no causal association between income and the discharges of CO_2, as well as energy consumption in an analysis of the EKC study conducted by the authors using US data.

In another related development, and while using panel data Liu (2005) investigated the position of EKC for 24 Organizations for Economic Co-operation and Development (OECD) countries; the thrust of their investigation was to determine the effects of CO_2 emissions on these continental GDPs. The findings of the author established that the EKC for CO_2 is available at any given rise in economic growth in the respective case studies. Complementing the research findings of Liu (2005), Richmond and Kaufmann (2006) established that there is a restricted backing on the position of the EKC in the instance of OECD nations, but not in the instance of non-OECD nations. This finding challenged Ang (2007) to investigate the position of EKC in France. The findings of the author concluded that the EKC theory is fulfilled in France. The research findings by Ang (2007), Liu (2005) and Soytas et al. (2007) motivated Jalil and Mahmud (2009), in what is seen as a more recent research endeavor. The authors studied the position of EKC on the rising trend of the Chinese economy in the 21st century. This study was also regarded as the most interesting when compared to the rest of EKC studies because China's GDP was known to be rising significantly in the 21st century and has among others displaced Japan from its No 2 position after the U.S.A. In their research findings, the authors reported that there is no obvious substantiation of the EKC position in relation to CO_2 discharges in the case of China.

In another alternative development and while employing cross-national data, Song and Selden (1994), scrutinized the association linking economic growth as well as environmental degradation. They contemplated four air contaminants: nitrogen oxides, sulphur dioxide, carbon monoxide and particulate matter. Their research findings established an inverted-U association linking emission and per capita GDP. Cole et al. (1997) further reinvestigated the association linking per capita income and a broad variety of environmental signals. The authors employed cross-country panel data to assess the availability of the EKC. The outcome supported the existence of EKC for local air contaminants, even as signals that have a more international or indirect effects are either raised monotonically with revenues or otherwise. These results provide essential insight for the need to create sustainable environmental regulations in dealing with environmental contaminants. Expatiating on the outcome of the research findings established by Cole et al. (1997), de Bruyn et al. (1998) opined that the inverted U-shaped relationship linking economic growth and CO_2 discharges using panel data need not be generalized to a particular country. The authors in a further follow-up research established that the time sequences for air contaminants and CO_2 emissions are positively associated with economic growth and that decreasing discharges necessitate structural and technological alterations in the economy. They continue to argue that “sustainable growth” infers a level of economic growth that does not exacerbate pollution. Anxieties concerning climate change arising from CO_2 emissions have resulted in some analysts scrutinizing the association connecting energy consumption and/or carbon discharges, and economic activities, for instance. Halicioglu (2009), Apergis and Payne (2009) and Holtz-Eakin and Selden (1995) initially investigated the connection linking economic growth and CO_2 emission. Approximations taken from international panel data of 130 countries imply a reducing marginal inclination to release (MPE) CO_2 as GDP per capita increases. The result of the association displayed a monotonic relationship as opposed to inverted-U.

The contributions of this study are:

- To determine the position of the environmental Kuznets curve EKC for Japan on its current deteriorating economic performance and deteriorating income in period of the Fukushima energy disaster. This perspective is against the direction of past studies that focus more on the position of EKC in a situation of rising income and economic performance. Apart from the foregoing development, the study will also identify policy instruments that will help in realizing a balanced environment amidst efficient energy consumption and successful environmental management in Japan. In addition to that the study will also assess the outlook of the Japanese economic growth prospects following the consequences of the environmental disaster. To ensure this, the study applied the most parsimonious unit root test that provides the econometric accuracy of dealing with structural breaks which is common in time series data. In addition to that, the Ng-Perron unit root test as applied in this study was validated using the Zivot and Andrew (1992) structural break unit root test. This is to identify possible structural breaks in the series considering the aftermath of the crisis that affected the Japanese economy. Apart from that the ARDL bounds testing approach to cointegration in the presence of structural break was applied in the determination of the long-run and short-run dynamics. The serial advantages of the ARDL model, as implemented in this study, were outlined in the method and material section of the study.

3. Method and materials

As against the practice of estimating the position of EKC in periods of rising income and economic performance, the present study wishes to investigate if the environmental Kuznets curve (EKC) exist in a period of energy disaster and deteriorating income as per the prevailing situation in Japan. To ensure robust result for this analysis, the study incorporated the variable of energy consumption, exports and imports considering their key influence on the Japanese economic growth, in addition to that the CO_2 emissions variable was also included. Following this development, the Japanese times series data from 1961 to 2012 was used. The data was obtained from the World Development Indicators WDI (2013). The data collected was on real GDP, electricity consumption (kg of oil equivalent) per capita, exports per capita, real imports per capita and CO_2 emissions (metric tons) per capita. The model specification as used in the study is given below following Rafindadi and Ozturk (2015), Rafindadi and Ozturk (2016) and Lean and Smyth (2010). The model is specified as follows:

$$C_t = f(Y_t, Y_t^2, E_t, EX_t, IM_t) \quad (1)$$

In the model above, the study transformed the series into natural log and the empirical model specification is as follows:

$$\ln C_t = \beta_1 + \beta_2 \ln Y_t + \beta_3 \ln Y_t^2 + \beta_4 \ln E_t + \beta_5 \ln EX_t + \beta_6 \ln IM_t + \mu_i \quad (2)$$

where, C refers to CO_2 emissions per capita, $Y(Y^2)$ refers to real GDP (square of real GDP) per capita, EX stands for real exports per capita and IM is the real imports per capita. The term ln is natural log and finally μ is the residual term. In order to ensure robust and dynamic result, the study applied the Pesaran et al. (2001) ARDL bounds testing approach to cointegration. The reason behind the selection of this estimation method is due to the distinguishing advantages that are commonly traceable on the application of the ARDL model when compared with the Johansen cointegration techniques (Johansen and Juselius, 1990).[1] In addition to that, the

[1] Some key specific advantage of the ARDL model are that, in estimating the model the number of sample size is quite immaterial in as far as it is not below what the software could accept. This is typically in contrast with the Johansen cointegration technique (Ghatak and Siddiki, 2001). Additionally, the ARDL bounds testing approach is the only model that could robustly accept and estimate variables that are irrespective of being in a unified cointegrating order. Meaning that the ARDL approach can be successfully implemented even if the variables are purely I(0) or I(1), or mutually integrated. Finally and in summary, this methodological technique has a unique method of providing the dynamic interrelationship of the selected variable by assessing the impacts of the short and long-run effects of

ARDL bounds testing approach has the remarkable ability to distinguish between the dependent and explanatory variables in a parsimonious way. Following this development and for the implementation of ARDL model to take place, Eq. (1) is remodeled in the unconditional error correction model (UECM) below:

$$\Delta \ln C_t = c_o + \sum_{i=1}^{p} c_i \Delta \ln Y_{i=1} + \sum_{i=1}^{p} d_i \Delta \ln C_{i=1} + \sum_{i=1}^{p} d_i \Delta \ln Y_{i=1}^2 + \sum_{i=1}^{p} d_i \Delta \ln E_{i-1} + \sum_{i=1}^{p} d_i \Delta \ln EX_{i-1} + \sum_{i=1}^{p} d_i \Delta \ln IM_{i-1} + \pi_1 \ln C_{t-1} + \pi_2 \ln Y_{t-1} + \pi_3 \ln Y_{t-1}^2 + \pi_4 \ln E_{t-1} + \pi_5 \ln EX_{t-1} + \pi_6 \ln IM_{t-1} + \pi_D \ln DUM_t + \mu_{2t} \quad (3)$$

In the above model, the notation Δ refers to the first different operator, while the C_0 and d_0 refers to the drift elements of the model. Apart from that, DUM refers to dummy variable instituted to capture the changes that are likely to occur with the series as a result of structural break date,[2] p on the other hand, is the maximum selected lag length[3] and u_t is the usual white noise residuals. To estimate the ARDL bounds test approach, it is mandatory that two key significant steps has to be followed. The first step is the estimations of the variables to determine the F-statistical values. This is very essential in order to determine the joint significance of the lagged level variables. Following to this, the value from the F-statistics are set in such a way as to determine their position with respect to the null hypothesis for the nonexistence of a long-run relationship that is denoted by H_0: $\pi_1 = \pi_2 = \pi_3 = \pi_4 = \pi_5 = \pi_6 = 0$ and compared against the H_a: $\pi_1 \neq \pi_2 \neq \pi_3 \neq \pi_4 \neq \pi_5 \neq \pi_6 \neq 0$ (Pesaran et al., 2001). The next step is to proceed with the generation and determination of the lower and upper critical bounds for the *F*-test. It is vital at this juncture to remember that, the lower bound's critical values suggest that all of the variables are I (0), in contrast to that, the upper bound's critical values assume that all of the variables are I(1). To determine the cointegrating relationship, the ARDL model suggest that, if the F-statistic is higher than the upper critical bound, the null hypothesis of no cointegration among the variables can be rejected. However, if the F-statistic lies on the lower segment of the respective bound, then the null hypothesis of no long-run relation is accepted.[4] With the attainment of this level, the subsequent step is the estimation of the long-and-short-run parameters, and this is commonly achieved by using the error correction model (ECM). To ensure the convergence of the parameters to the long-run equilibrium, the sign of the coefficient for the lagged error correction term (ECM_{t-1}) must be negative and statistically significant. The ARDL model estimation as adopted in this study is following Rafindadi (2015a, 2015b), Al-Mulali et al. (2016), Shahbaz et al., (2013), Rafindadi and Ozturk (2015), and Rafindadi and Yusof (2015) see also Rafindadi and Yusoff (2013a,b). In addition to that, the diagnostic tests comprise the testing for the serial correlation, functional form, normality, and the heteroscedasticity (Pesaran and Pesaran, 2009). The stability of the ARDL bounds testing estimates is tested by applying the CUSUM and CUSUMsq tests.

(*footnote continued*)
the variables, apart from that function, the model also has the unique features of distinguishing the short- and long-run effects simultaneously (Bentzen and Engsted, 2001).

[2] This study included the dummy variable in the ARDL *F*-test equation as widely suggested in the estimation procedure based on CMR unit root test with single unknown structural break arising in the series.

[3] Pesaran et al. (2001) pointed out that it is necessary to balance selection of the lag length.

[4] In a situation where the estimated F statistics results is detected to have fallen between the lower and upper bounds, the interpretations of the result suggest that it is inconclusive. The alternative efficient way of establishing cointegration is testing significant negative lagged error-correction term (Kremers et al., 1992).

4. Results and discussion

To obtain robust result from the analysis in this study, the Ng-Perron (2001) unit root test is applied in the process of examining the unit root positions of the data. It is vital to note that this test is parsimonious with respect to time series study that has limited sample data. Apart from the preceding, Ng-Perron unit root test is found to be an essential mechanism that provides a consistent and parsimonious outcome. The estimation results of this test are provided in Table 1. The findings in that table indicated the existence of unit root problem at level with intercept and trend. However after undergoing the first-difference, the study found all the series to be stationary. One notable weakness of this test is that it does not have the means of accommodating key information with respect to the existence of structural break arising from the series. For this study to solve this problem, the Zivot and Andrew structural break test was applied. This test has the power of providing vital information about one single unknown structural break information in the series.

In the application and estimation of the ZA test, the selection of the break date revolves around the findings obtained from T-statistic. Following this development, the break date is chosen in such a harmonious way where the evidence are found to be favorable with respect to the null hypothesis. It is significant to mention that while conducting the Zivot and Andrews (1992) test the pattern of determining the critical values of the ADF unit root test process is strictly adhered to. The econometric model of the Zivot and Andrew test as used in this study is outlined below:

$$ax_{t-1} + bt + cDU_t + \sum_{j=1}^{k} d_j \Delta x_{t-j} + \mu_t \quad (4)$$

$$\Delta x_t = b + bx_{t-1} + ct + bDT_t + \sum_{j=1}^{k} d_j \Delta x_{t-j} + \mu_t \quad (5)$$

$$\Delta x_t = c + cx_{t-1} + ct + dDU_t + dDT_t + \sum_{j=1}^{k} d_j \Delta x_{t-j} + \mu_t \quad (6)$$

In the equation above, the letters DU_t simply refers to the dummy variable included in that test, in addition to that, it

Table 1
Ng-Perron unit root test.

Variables	MZa	MZt	MSB	MPT
$\ln C_t$	−0.3625 (1)	−0.2176	0.6003	76.1807
$\ln Y_t$	−1.8697 (2)	−0.7274	0.3890	33.7591
$\ln E_t$	−2.5413 (2)	−0.8878	0.3493	27.6418
$\ln EX_t$	−3.7729 (3)	−1.1970	0.3172	21.7644
$\ln IM_t$	−4.1685 (2)	−1.3245	0.3177	20.6512
$\Delta \ln C_t$	−22.8310 (2)**	−3.3786	0.1479	3.9913
$\Delta \ln Y_t$	−24.2497 (1)*	−3.4540	0.1424	3.9255
$\Delta \ln E_t$	−23.3290 (1)**	−3.4152	0.1464	3.9063
$\Delta \ln EX_t$	−35.4354 (2)*	−4.2092	0.1187	2.5717
$\Delta \ln IM_t$	−24.1564 (3)*	−3.4742	0.1438	3.7788

Note: Lag order is shown in parenthesis.
* Represent significance at 1%, level.
** Represent significance at 5% level.

establishes the shifting positions with respect to the mean in each point. Moreover, the letters DT_t points out the position of the shifts in the trending variable.

$$DU_t = \begin{cases} 1\dots\ if - t \geq TB \\ 0\dots\ if - t \leq TB \end{cases} and DU_t = \begin{cases} t - TB\dots\ if.\ t \geq TB \\ 0\dots\ if.\ t \leq TB \end{cases} \tag{7}$$

The equation above, inform us that the null hypothesis of unit root break date is $c=0$ suggesting the likely possibilities of the presence of structural breaks in the series with drift but essentially not having the information with respect to the structural break stemming in the series. Moreover, $c<0$ hypothesis indicates that the variable is assessed to be having a trend-stationarity with one unknown time break. Following to this common property of a time series data, Zivot-Andrews unit root test is vested with the power of taking care of all those points that are the potential for possible time break. In this respect, a regression estimation for all possible structural breaks is carried out to fix the successive break points in a parsimonious way. Afterward, this unit root test selects that time break that decreases one-sided t-statistic to test $\acute{c}(=c\text{-}1)=1$. Zivot-Andrews test emphasized that in the presence of end points, the asymptotic distribution of the statistics tend to diverge to infinity point. It is necessary to select that position by which the end points of sample period are excluded. In addition to that, Zivot-Andrews (1992) suggested the trimming regions to be (0.15 T, 0.85 T), and this is what is followed in the estimation process. In this study, the findings from the Zivot and Andrew are reported in Table 2. From the foregoing development, the study discovered how all the variables are non-stationary at level in the presence of structural breaks. The structural breaks at level were identified in the following series of years 1967, 1985, 1997 and 1998 while the structural breaks at first difference changed to the following series: 1971, 1982, 1984, 1988 and 1976. At first difference, the variables were discovered to be stationary. This confirms the robustness of the selected unit root analysis and at the same time validating the findings of the Ng-Perron estimated results.

The finding in Table 2 established that CO_2 emissions, economic growth, energy consumption, exports, and imports have unit root problem in the case of Japan at level with intercept and time trend. The structural breakpoints are also indicated in the series. At first difference, all the variables were found to be integrated (see Table 2). This implies that all the series are integrated at I(1). This lead us to employ the ARDL bounds testing approach to cointegration, in the presence of structural breaks. The AIC criteria is also used in the lag selection exercise. In that analysis, the best maximum lag length is found to be 1. With respect to this development, the study proceeds to estimate the F-statistic, which will in turn confirm the existence of cointegration among the variables or otherwise. The established procedure is that, if calculated F-statistic is greater than critical bounds, then the study is bound

Table 2
Zivot-Andrews structural break trended unit root test.

Variable	At level		At 1st difference	
	T-statistic	Time break	T-statistic	Time break
ln C_t	−3.111(3)	1967	−8.150 (2)**	1971
ln Y_t	−1.543 (1)	1985	−6.156 (2)*	1982
ln E_t	−3.792 (2)	1967	−5.557 (4)**	1984
ln EX_t	−4.332 (1)	1997	−6.841 (2)*	1988
ln IM_t	−4.195 (2)	1998	−7.182 (1)*	1976

Note: Lag order is shown in parenthesis.
* Represent significance at 1% level.
** Represent significance at 5% level.

to reject the hypothesis of no cointegration. The result of this empirical exercise is reported in Table 3. The findings in that Table shows that in the exports model, the estimated F-statistics exceed upper critical bounds at 5 percent and 10 percent levels respectively. This indicates the existence of three cointegrating vectors as CO_2 emissions; economic growth and energy consumption were used as the dependent variables. This development concludes that there is cointegration between the variables in the presence of structural breaks in the series.

The long-run results are presented in Table 4. The findings in that Table show that linear and square terms of real GDP per capita are linked positively and negatively with CO_2 emissions. This development validates the presences of environmental Kuznets curve (EKC) i.e. inverted U-shaped relationship between economic growth and CO_2 emissions in the case of Japan. With the discovery of the existence of the EKC in this study despite the dwindling economic productivity and revenue in Japan, it then challenge the EKC theory and all existing studies on EKC. This development suggests that natural disasters are in themselves strong causative agents for the EKC to unfold and it is immaterial whether the economic fortunes of a country is increasing or decreasing. In addition to that, the findings of the study further established that a 1% increase in real GDP will raise CO_2 emissions by 5.76% while the negative sign of squared term seems to corroborate the delinking of CO_2 emissions and real GDP at the higher level of income. This shows that CO_2 emissions seem to increase initially but decline after a threshold point of income per capita in Japan. Energy consumption was, on the other hand, found to have a positive and significant impact on CO_2 emissions. In another related development, the study discovered that; a 1% increase in energy consumption in Japan will lead to an increase of 0.7427% of CO_2 emissions. While exports were found to impact on CO_2 emissions positively, and it is statistically significant at 1% level. All else is same. Moreover, the study further identified that a 1% increase in exports will lead to an increase of 0.7427% in CO_2 emissions in the case of Japan. Additionally, Imports affect CO_2 emissions at 1% level of significance. This is on the basis that a 1% increase in imports will lead to increase in CO_2 emissions by 0.2327% keeping other things constant.

The results of the short-run analysis are reported in Table 4 (lower segment). The study discovered that the relationship between economic growth and CO_2 emissions is U-shaped, and it is statistically significant at 10% level. It was further discovered that in the short-run, energy consumption adds in CO_2 emissions significantly. Exports increase CO_2 emissions, and it is statistically significant at 5% level. The relationship between imports and CO_2 emissions is positive and significant. The value of the ECM is found to be negative and statistically significant. The estimated CO_2 emissions function is −0.1613. This indicates that short-run deviations toward long-run equilibrium will be corrected by 16.13%. The results of the diagnostic tests indicate that error terms of the short-run model is normally distributed in all models. There is no heteroskedasticity, serial correlation, and ARCH problem. The value of Ramsey reset test also shows that the functional form for the short-run models are well specified. The stability of the ARDL estimates is tested by applying the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMsq) proposed by Brown et al. (1975). The plot of the CUSUM and CUSUMsq are presented in Figs. 1 and 2 respectively. The figures show that the line is within the bounds and significant at 5%.

To validate the findings of the ARDL model, and assess the direction of causality between the variables, the study applied the innovative accounting approach. The innovative accounting approach is a combination of variance decomposition approach and impulse response function. The variance decomposition approach provides direction of causality ahead of the sample period. Table 5

Table 3
The results of ARDL cointegration test.

Bounds testing to cointegration				Diagnostic tests			
Estimated models	Optimal lag length	Structural Break	F-statistics	χ^2_{NORMAL}	χ^2_{ARCH}	χ^2_{RESET}	χ^2_{SERIAL}
$F_C(C/Y, E, EX, IM)$	1, 1, 0, 0, 1	1967	7.662***	0.8615	[1]: 0.0289	[1]: 0.7839	[1]: 0.2249
$F_Y(Y/C, E, EX, IM)$	1, 1, 1, 1, 1	1985	9.198**	1.6529	[1]: 0.2197	[2]: 0.4206	[1]: 1.0878
$F_E(E/C, Y, EX, IM)$	1, 0, 0, 1, 0	1967	8.850**	1.1230	[1]: 0.0009	[2]: 0.6093	[1]: 1.0262
$F_{EX}(EX/C, Y, E, IM)$	1, 1, 1, 0, 1	1997	3.353	0.2551	[1]: 0.0294	[2]: 7.2611	[2]: 0.1453
$F_{IM}(IM/C, Y, E, EX)$	1, 1, 2, 1, 1	1998	1.033	0.7272	[1]: 0.5139	[1]: 0.0655	[1]: 0.5983
Significant level	Critical values (T=51)#						
	Lower bounds $I(0)$	Upper bounds $I(1)$					
1 per cent level	9.800	10.675					
5 per cent level	6.930	7.785					
10 per cent level	5.800	6.515					

Note: The optimal lag length is determined by AIC. [ ] is the order of diagnostic tests. # Critical values are collected from Narayan (2005).
** Denote the significant at 5 per cent level.
*** Denote the significant at 10 per cent level.

Table 4
Long-and-short run results.

Dependent variable = $\ln C_t$				
Long run analysis				
Variables	Coefficient	T-statistic	Coefficient	P-value
Constant	−48.4865*	10.8316	−4.4763	0.0000
$\ln Y_t$	5.7594*	1.5526	3.7095	0.0006
$\ln Y_t^2$	−0.2094*	0.0510	−4.0991	0.0002
$\ln E_t$	0.7427*	0.1061	6.9980	0.0000
$\ln EX_t$	−0.0944**	0.0398	−2.3672	0.0222
$\ln IM_t$	0.2327*	0.0550	4.2274	0.0001
Short run analysis				
Variables	Coefficient	T-statistic	Coefficient	P-value
Constant	−0.0128*	0.0034	−3.7102	0.0006
$\Delta \ln Y_t$	−0.2628***	0.1412	−1.8602	0.0700
$\Delta \ln Y_t^2$	2.9283***	1.5931	1.8381	0.0733
$\Delta \ln EX_t$	0.7050*	0.1009	6.9856	0.0000
$\Delta \ln EX_t$	0.0794**	0.0356	2.2303	0.0313
$\Delta \ln IM_t$	0.1672*	0.0430	3.8845	0.0004
ECM_{t-1}	−0.1613***	0.0954	−1.6898	0.0986
R^2	0.9156			
F-statistic	74.1348*			
D. W	1.8455			
Short run diagnostic tests				
Test	F-statistic	Prob. value		
$\chi^2 NORMAL$	1.9764	0.3742		
$\chi^2 SERIAL$	0.2516	0.7787		
$\chi^2 ARCH$	0.0733	0.9320		
$\chi^2 WHITE$	0.2193	0.9684		
$\chi^2 REMSAY$	1.8268	0.2281		

* Show significant at 1% level of significance.
** Show significant at 5% level of significance.
*** Show significant at 10% level of significance.

reports the results of variance decomposition analysis. In that Table, the study discovered that a 35.69% of CO_2 emissions is contributed by its innovative shocks and one standard deviation shock in economic growth. Additionally, energy consumption, exports, and imports explain CO_2 emissions by 20.76% 6.335% 5.149% and 31.81% respectively in the case of Japan. The contribution of CO_2 emissions, energy consumption, exports and imports to economic growth is 16.24% 33.55%, 1.027%, and 7.126% respectively while 42.04% of economic growth is contributed by its innovative shocks. CO_2 emissions, economic growth, and energy consumption contribute to exports by 23.89%, 22.96%, and 17.12% respectively. Imports are found to contribute to exports by 32.96%. in addition to that, a 44.18%, 26.95%, 7.92% and 1.32% is found to be contributed in imports by CO_2 emissions, economic growth, energy consumption, and exports respectively. This result is in line with the findings of Rafindadi et al. (2014) where the authors established that fossil fuel energy consumption has a significant and positive relationship with carbon dioxide emission in China, Japan, Malaysia, Singapore, Philippines, and Brunei. The authors continue to point out that there is a one-to-one corresponding relationship between the fossil fuel energy consumption and carbon dioxide emission in Japan, South Korea, Indonesia, Malaysia, Singapore, and The Philippines. Similarly, the GDP per unit use of energy in Japan was persistently found to have a significant and positive relationship with carbon emissions. Overall, the present study discovered that CO_2 emissions are the cause of economic growth in the case of Japan. Following to that finding, the study discovered the existence of the feedback effect between imports and CO_2 emissions. Economic growth was, on the other hand, found to cause energy consumption and in return, energy consumption causes economic growth. Energy consumption is caused by CO_2 emissions and imports. CO_2 emissions and economic growth cause imports.

The impulse response function is another alternative to variance decomposition method. It shows how long and to what extent does the dependent variable reacts to shock stemming in the independent variables. The finding in this segment of analysis reveals that the response in CO_2 emissions in the case of Japan increases initially until when it goes to the peak it then declines due to standard shock in economic growth. This indicates the validation of environmental Kuznets curve and confirms the regression results and estimations in this study to be perfect. Following to that, the finding of the impulse response analysis continue to establish that CO_2 emissions respond negatively after 7th and 6th time horizon due to standard shock occurring in energy consumption, exports and imports. Economic growth responds negatively due to shock in CO_2 emissions, energy consumption, exports and imports particularly after the 4th, 7th, 8th and 3rd time horizon respectively. The relationship between energy consumption and economic growth is, on the other hand, found to be an inverted U-shaped i.e. energy consumption rises initially until when it goes to the peak and then declines due to standard shocks

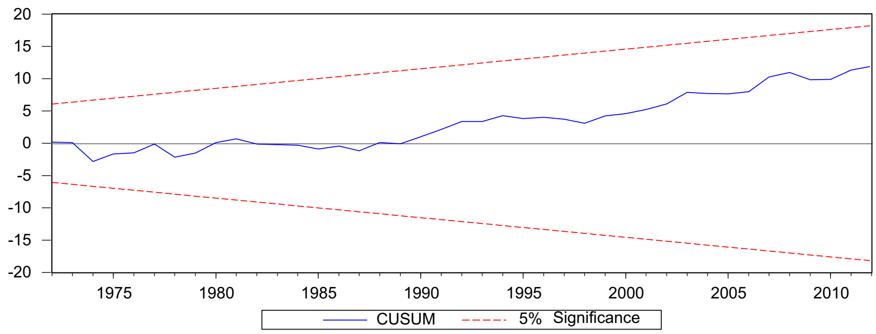

Fig. 1. Plot of cumulative sum of recursive residuals. The straight lines represent critical bounds at 5% significance level.

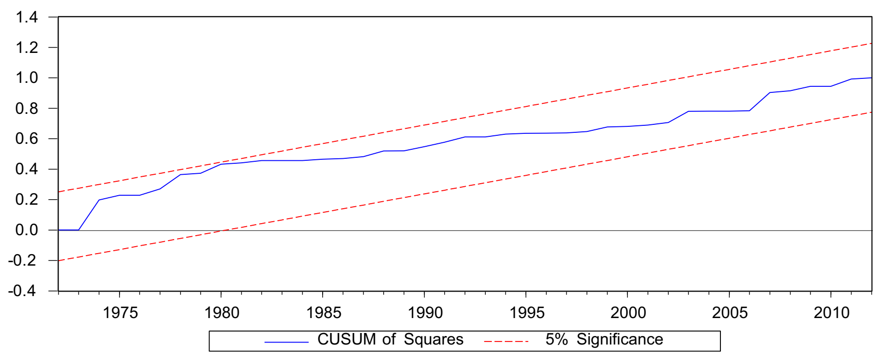

Fig. 2. Plot of cumulative sum of squares of recursive residuals.

that occur in the Japanese economic growth prospects. As a result of this development, the study found how Exports are affected by standard shocks in CO_2 emissions, economic growth, energy consumption and imports, but their impact is minimal. The response in imports is fluctuating due to shocks arising from CO_2 emissions, economic growth, energy consumption and exports. Fig. 3 provides the outcome of the impulse response test. In that test, the result clearly supported the existence of an EKC in the case of Japan as found in the rest of analysis of this study.

5. Conclusions

This paper investigates the presence of an environmental Kuznets curve in the case of Japan by incorporating exports and imports in a CO_2 emissions function. The EKC hypothesis tries to draw the attention of environmental economist as to how the structure of environmental quality could vary in proportion to the changes of national fortunes up to a given level. Following this development, a question is raised on the fact that what if a country's fortune is dwindling amidst a natural environmental disaster, could the EKC still apply? If yes, then how progressive may the Japanese economic growth prospects be amidst this natural disaster? To ensure this, time series data from 1961 to 2012 was used while the unit root properties of the data were analyzed using the Ng-Perron unit root test. In addition to that, the Zivot and Andrews structural break unit root test was also applied in assessing the structural breaks stemming from the series. The outcome of this test was then analyzed using the ARDL bounds testing approach to cointegration, while the innovation accounting test is used to detect the direction of causality between the variable. The innovative accounting test also shows how long and to what extent does the dependent variable reacts to shock stemming from the independent variables. The findings of the study indicated the presence of cointegration between the variables. Moreover, it was discovered that the relationship between economic growth and CO_2 emissions has an inverted U-shape i.e. the EKC was found to exist irrespective of the country's economic predicaments and dwindling fortunes. In a more specific development, the study discovered how energy consumption in Japan to be the major contributor to environmental degradation. This finding suggests that as a result of the Fukushima energy disaster, large environmental pollutants from the nuclear reactors had a significant bearing on the Japanese economy. To support this claim, the study discovered that a 1% increase in real GDP raises CO_2 emissions by 5.76% while energy consumption was found to increase CO_2 emissions by 0.7427%. Similar to this, it was also discovered that a 1% increase in exports led to 0.7427% increase in CO_2 emissions. Additionally, a 1% increase in imports was also found to lead to a 0.2327% increase in CO_2 emissions. The innovative accounting test, on the other hand, supported the direction of these findings by revealing that economic growth, energy consumption, exports, and imports aggravated the rise in CO_2 emissions by 20.76%, 6.335%, 5.149% and 31.81% respectively in Japan.

On the second question on whether hope exists for Japan's economic growth prospects after the Fukushima energy crisis, the study discovered that energy consumption, exports, and imports contribute 33.55%, 1.027% and 7.126% to economic growth respectively. These findings suggest the need for more concerted economic and energy developmental efforts that should be added on top of the current level of the Japanese economic and energy momentums. It further suggest the need for significant increase in the level of the Japanese exports which is in a state of decline as suggested by the figures above. Going by these discoveries, the study is of the view that, the Japanese economy could rekindle but only and only if the energy system of the country could have a secure, sufficient, efficient, and sustainable outlook. This is because energy has no close substitute when it comes to production optimality attainment. Meaning to say that economic growth is akin to energy and energy is in its self a propeller to economic growth. In addition to the foregoing, the study discovered the existence of

Table 5
Variance decomposition analysis.

Period	ln C_t	ln Y_t	ln E_t	ln EX_t	ln IM_t
Variance decomposition of lnC_t					
1	100.0000	0.0000	0.0000	0.0000	0.0000
2	96.21588	1.9774	0.3290	0.9040	0.5735
3	89.0798	5.7700	0.8354	2.2664	2.0482
4	80.4401	10.3552	1.2701	3.5909	4.3435
5	71.7058	14.8983	1.5081	4.6577	7.2298
6	63.7308	18.8708	1.5434	5.4169	10.4378
7	56.9206	22.0148	1.4444	5.8989	13.7210
8	51.3848	24.2656	1.3066	6.1611	16.8817
9	47.0597	25.6800	1.2189	6.2622	19.7790
10	43.7927	26.3817	1.2452	6.2529	22.3273
11	41.3967	26.5228	1.4174	6.1730	24.4899
12	39.6835	26.2558	1.7385	6.0526	26.2694
13	38.4838	25.7176	2.1896	5.9129	27.6958
14	37.6556	25.0204	2.7393	5.7688	28.8156
15	37.0875	24.2493	3.3514	5.6300	29.6816
16	36.6957	23.4643	3.9912	5.5026	30.3460
17	36.4200	22.7048	4.6292	5.3898	30.8559
18	36.2190	21.9938	5.2424	5.2933	31.2513
19	36.0648	21.3428	5.8145	5.2135	31.5643
20	35.9394	20.7557	6.3354	5.1497	31.8196
Variance decomposition of ln Y_t					
1	19.7890	80.2109	0.0000	0.0000	0.0000
2	14.70132	84.5939	0.2815	0.0467	0.3764
3	11.0316	86.6737	1.0903	0.1544	1.0497
4	8.7073	86.6335	2.5053	0.3099	1.8439
5	7.5327	84.8476	4.4932	0.4918	2.6345
6	7.2453	81.7968	6.9328	0.6774	3.3473
7	7.5727	77.9701	9.6591	0.8482	3.9498
8	8.2754	73.7893	12.5048	0.9916	4.4387
9	9.16837	69.5724	15.3294	1.1022	4.8276
10	10.1230	65.5304	18.0297	1.1794	5.1372
11	11.0597	61.7843	20.5403	1.2262	5.3893
12	11.9342	58.3891	22.8264	1.2473	5.6027
13	12.7272	55.3557	24.8759	1.2480	5.7930
14	13.4339	52.6691	26.6916	1.2333	5.9719
15	14.0582	50.3004	28.2854	1.2079	6.1480
16	14.6080	48.2152	29.6741	1.1754	6.3270
17	15.0928	46.3784	30.8768	1.1391	6.5127
18	15.5217	44.7566	31.9129	1.1013	6.7072
19	15.9035	43.3198	32.8011	1.0638	6.9117
20	16.2455	42.0414	33.5589	1.0278	7.1261
Variance decomposition of ln E_t					
1	78.2706	1.3426	20.3867	0.0000	0.0000
2	73.6767	7.2799	16.8802	0.9596	1.2033
3	64.5782	15.1676	13.9293	2.3342	3.9905
4	54.0780	22.8676	11.6761	3.5278	7.8502
5	44.3607	29.0986	10.0804	4.3276	12.1324
6	36.4380	33.4376	9.05364	4.7473	16.3232
7	30.5191	35.9796	8.51288	4.8818	20.1063
8	26.4099	37.0435	8.38676	4.8310	23.3287
9	23.7667	37.0025	8.60711	4.6741	25.9494
10	22.2282	36.2035	9.10417	4.4661	27.9979
11	21.4743	34.9336	9.80715	4.2425	29.5422
12	21.2466	33.4135	10.6480	4.0242	30.6675
13	21.3491	31.8013	11.5656	3.8229	31.4608
14	21.6414	30.2030	12.5086	3.6441	32.0025
15	22.0278	28.6841	13.4368	3.4897	32.3614
16	22.4459	27.2805	14.3206	3.3594	32.5934
17	22.8579	26.0076	15.1403	3.2520	32.7419
18	23.2427	24.8679	15.8840	3.1657	32.8394
19	23.5900	23.8557	16.5463	3.0985	32.9092
20	23.8964	22.9613	17.1265	3.0483	32.9673
Variance decomposition of ln EX_t					
1	19.3054	6.9079	3.9328	69.8537	0.0000
2	20.9768	6.4046	2.5532	69.0199	1.0453
3	22.1477	6.2322	2.1386	66.7002	2.7810
4	22.8893	6.3517	2.2571	63.8852	4.6165
5	23.2760	6.7505	2.6274	61.1329	6.2131
6	23.3678	7.4145	3.1048	58.6726	7.4401
7	23.2160	8.3118	3.6302	56.5515	8.2903
8	22.8711	9.3901	4.1875	54.7363	8.8147
9	22.3853	10.5835	4.7800	53.1678	9.0832
10	21.8106	11.8224	5.4169	51.7856	9.1643
11	21.1955	13.0427	6.1077	50.5377	9.1161
12	20.5811	14.1919	6.8588	49.3837	8.9843
13	19.9991	15.2320	7.6721	48.2939	8.8027
14	19.4712	16.1402	8.5448	47.2481	8.5954
15	19.0101	16.9071	9.4696	46.2343	8.3787
16	18.6204	17.5340	10.4355	45.2462	8.1637
17	18.3015	18.0296	11.4294	44.2816	7.9577
18	18.0485	18.4074	12.4371	43.3415	7.7652
19	17.8546	18.6834	13.4447	42.4279	7.5891
20	17.7119	18.8738	14.4392	41.5439	7.4310
Variance decomposition of ln IM_t					
1	56.4197	0.4218	0.6544	0.0121	42.4917
2	59.7893	0.9048	0.4407	0.0454	38.8197
3	60.9861	2.9447	0.7497	0.0646	35.2547
4	60.6795	5.9045	1.1964	0.0661	32.1533
5	59.4836	9.26031	1.5603	0.0594	29.6362
6	57.8585	12.6409	1.7601	0.0580	27.6822
7	56.1072	15.8076	1.8067	0.0744	26.2039
8	54.4082	18.6198	1.7611	0.1165	25.0942
9	52.8526	21.0073	1.7019	0.1870	24.2509
10	51.4743	22.9498	1.7031	0.2840	23.5885
11	50.2734	24.4626	1.8204	0.4019	23.0415
12	49.2320	25.5854	2.0855	0.5330	22.5639
13	48.3259	26.3720	2.5064	0.6688	22.1267
14	47.5303	26.8821	3.0715	0.8019	21.7139
15	46.8241	27.1746	3.7563	0.9262	21.3184
16	46.1906	27.3029	4.5300	1.0376	20.9386
17	45.6172	27.3124	5.3607	1.1338	20.5757
18	45.0950	27.2398	6.2192	1.2140	20.2318
19	44.6176	27.1135	7.0808	1.2787	19.9092
20	44.1803	26.9545	7.9264	1.3290	19.6095

the feedback effect. This development suggests that, economic growth in Japan is the Granger cause of energy consumption and in return, energy consumption Granger causes economic growth. Following this discovery, the study argues for the need that Japanese policy makers should strive and create economic policies that will help in the increase of the country's exports and ensure the best energy mix that will sustain the persistent rise in energy demand of the country. In another development, the study discovered that CO_2 emissions increase by a minimum of 16.24%, 23.89% and 44.18% as a result of any rise in economic growth, export and import respectively. Going by this high rise in CO_2 emissions, Gowdy (2004) argued that the social welfare of individuals in the society should be prima facie rather than the continuous accrual of income per capita at the expense of societal welfare. The author continue to assert that the prime focus of government policies should be on improving societal welfare in general. Supporting this view, Di Tella and MacCulloch (2008) emphasized that environmental degradation reduces life satisfaction, instead it ensures deterioration of welfare and reduces life expectancy. This view was further supported by Ang (2008) who, in his empirical wisdom, argued that there is growing evidence that environmental degradation does not only have a negative impact on the quality of life within the society basically through reduced health, but it also affects the economy significantly by impeding human capital which in the long-run retards national productivity.

To reduce the impact of CO_2 emissions on the Japanese environment, the study underscores the fact that although energy is a crucial part of production and a cardinal means of achieving sustainable economic growth, meaning that, an ailing energy system is synonymous with a flawed national planning process which in turn is tantamount to precarious economic growth. As a result of this, the study argues that the higher the degree of

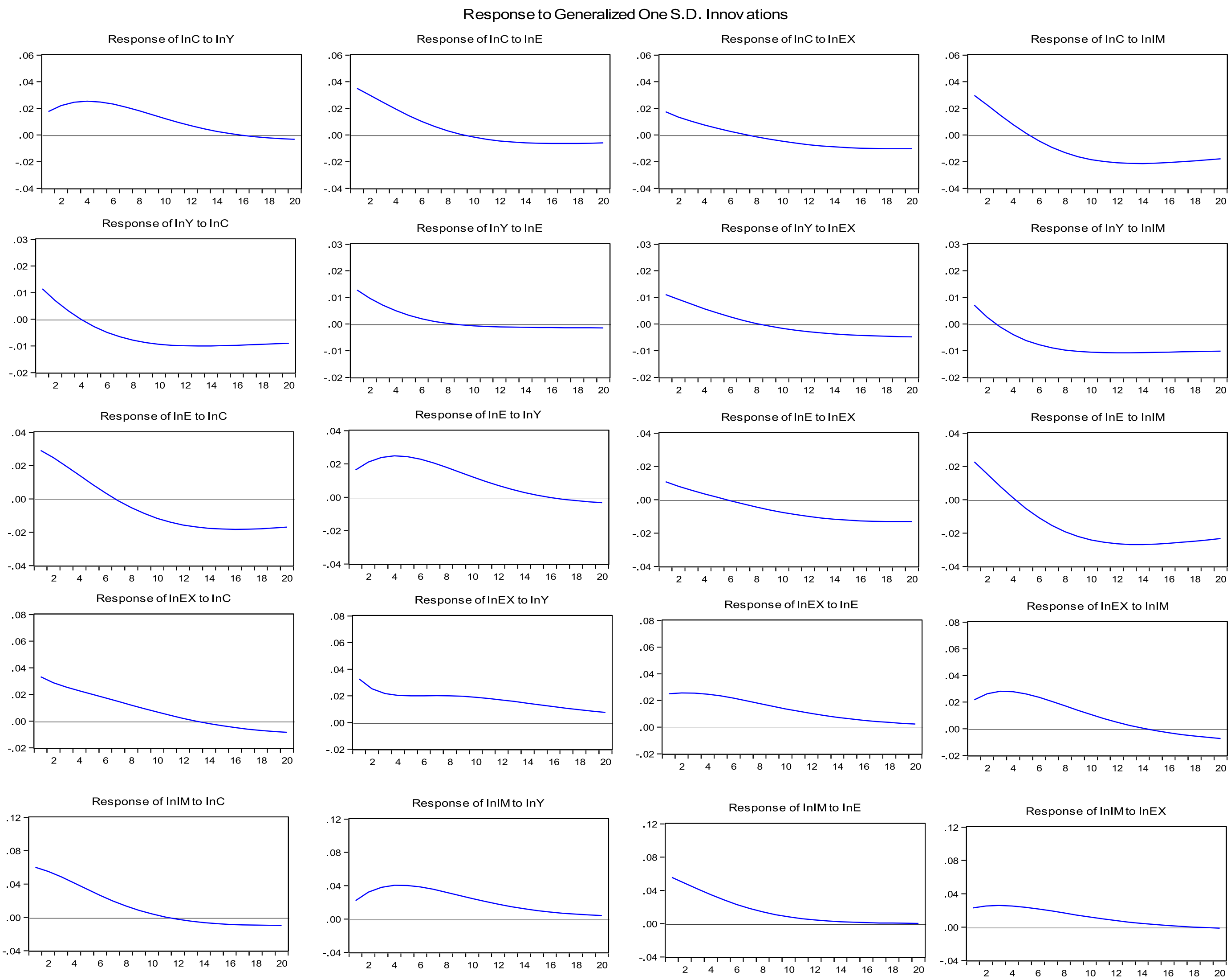

Fig. 3. Impulse response function.

economic growth in Japan the greater the energy consumption and subsequently the greater the CO_2 emissions. Following to this, and in order to strike a balance where desirable energy consumption for sustainable economic growth will not harm the environment, the study proposes for the Japanese energy policy makers to invest heavily in new renewable energy sources and technologies. In addition to that, the study further advocates the use of new 'green' technologies that are less dependent on fossil fuels within the industrial sector. While at the household level, investment should be encouraged in the appropriate energy infrastructure that could assist with the simultaneous satisfaction of efficient energy usage, in doing so, both the economic performance and the quality of the environment can be sustained and balanced. To achieve this, the study proposes a number of policy instruments that not only manage environmental quality but also ensures sound energy consumption towards sustainable economic growth after the Fukushima energy crisis in Japan.

The continuum of key policy instruments as proposed in this study that will help the Japanese environmental management includes: the enforcement of a taxation system or financial levy for those energy consumption outlets that exceed a standardized level of environmental pollutants. Apart from these, subsidies may be provided for those industrial outlets that have no record of emitting environmental pollutants in Japan. In addition to the aforementioned, the study is of the view that the ministry of environment in conjunction with the law enforcement agencies in Japan should formulate some means to regulate those production entities known to have significant record of environmental pollution by limiting their pollutants below a prescribed policy target and specifying the maximum expected industrial emission through the adoption of key accepted standards to be observed nationwide. Similar to that earlier assertion, fossil fuel consumption in Japan should also be standardized within a minimum quality range that is acceptable for industrial usage in the country. However, by virtue of the Japanese advanced industrial economic outlet the study noted and emphasized on the need for flexible selection and adoption of the appropriate policy mix that needs to be consistent with changes in the economic growth level attained, energy sufficiency or reduction in environmental pollutants attained within a given period. To ensure the optimum policy instruments that will help in realizing a balanced environment amidst efficient energy consumption and successful environmental management in Japan, the study advocates the following instruments for environmental management as supported by Panayotou (1994), Bhattacharyya (2011) and Akpan and Abang (2014). The following questions should be answered as key environmental policy guide and instrumental development:

- Environmental effectiveness: Policy makers need to determine the quality, and the efficacy of the instrument. The question should be asked, could the newly developed instrument be able to achieve the Japanese environmental objective on time and with some certainty, could the instruments be able to produce some quality changes?
- Cost effectiveness: Will the costs that relates to the design and execution of the policy instruments be cost effective to the society? And could the execution of the instrumental content be achieved within the best possible time factor particularly as the instrument strives to achieve the environmental objective?
- Flexibility: Does the instrument have the flexibility to adapt to market conditions, resource scarcity, economic challenges such as fall and rise in revenue and changing nature of modern technology? How effective are the instruments in periods of crisis and how effective could they be managed in such periods?
- Dynamic efficiency: Does the instrument promote an environmentally sound infrastructure and an incentive to technological innovation? How effective and efficient could the instruments be in periods of worst case energy and environmental challenges and vice-versa? Could there be an entrenched signaling mechanism (to policy makers) within the confines of the instruments?
- Equity: Will the costs and benefits of the instruments be beneficial to the Japanese public finance system? What could be the changing roles of the instruments costs in periods of inflation, budgetary deficit, and the financial crisis? Are these efficient and sufficient factors to retard the operationalization of the environmental policy instruments efficacy?
- Ease of introduction: Is the instrument in line with the country's legal framework or does it require new legislation? How feasible is this and does the regulatory body have the administrative capacity to govern the new instrument?
- Ease of monitoring and enforcement: How difficult will monitoring and enforcement of the instrument be and at what cost?
- Predictability: Does the instrument combine predictability and flexibility? Will predictable costs be imposed on polluters in the long-term?
- Acceptability: This is highly important – is the selected instrument understood by the Japanese public, or the industry at large? How saleable is the instrument in the context of the country's political landscape?

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