European Journal of Business and Management www.iiste.org
ISSN 2222-1905 (Paper) ISSN 2222-2839 (Online)
Vol.7, No.1, 2015

Empirical Analysis of Mongolia's Carbon Emission Factors Based on Kaya Identity

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Abstract
This research is an empirical analysis of Mongolia's carbon emission factors, it identifies the relationship between carbon emission and factors of this emission, by analysing greenhouse effect and its function, also introducing the concept of ecological load capacity and using grey system theory. The result shows that the consumption of energy has the most important effect on carbon emission in Mongolia; there are other factors such as population, household final consumption expenditure, GDP and gross fixed capital formation. The challenge for government to balance the economic development and environment protection, carbon emission can be reduced but that needs an entire commitment and hard work of both government and people. The results from this study contribute to a more in-depth understanding of the carbon emissions status in magnolia and serves as reference when launching region-based emissions mitigation policies.
Keywords: Carbon Emissions; Kaya Identity; Grey System; Mongolia

1. Introduction

In recent years, relative studies assumed that, although everybody knows about the greenhouse effect and how disastrous the outcome can be for our shared home that we call earth, but unfortunately we still big and negative changes in the environment that consequently impacts our life on earth. In the prospective of the whole world, especially since the 1990s, the frequency of some extreme climate incidents, i.e. dry weather, frequent floods, extreme heat or cold in an unusual ways. As a result other problems had surfaced, such as drought, the rising sea level, dropping of grains and the continuous reduction of numbers of many species population. Extreme climate has already brought our humankind great economic and ecological loss which have large effects on human's societies and lives.

According to various studies conducted in Mongolia, the global warming will have a significant impact on natural resources such as water resources, natural rangeland, land use, snow cover, permafrost, major economic activity of arable farming, livestock, and society Mongolia is affected by serious problems of land, water and ecosystem degradation, desertification and biodiversity loss. The country is prone to natural disasters including dzud (harsh winter disaster), forest fires, floods and earthquakes. Mongolia's carbon emission per capita is above the global average, mainly due to the inefficient energy use, large amounts of live-stock and use of raw coal for heating. In order to create new market mechanism to trade carbon emission, the Ministry of Nature, Environment and Tourism has agreed to cooperate with the Institute for Global Environmental Strategies (IGES) to implement projects that decrease house plant gas emission. The cooperation was appreciated by the IGES, and it started to provide information on best practices and initiated new market mechanism, decreasing coal thermal plant gas emission. The increase in energy consumption is one of the key factors to the increased plant gas emission. For instance, total gas emission was 14,519 Hz in 2005, but in 2006 it became 15,628 Hz and increased by 7.6 per cent. All these in IPEC's eyes, are all caused by the increasing green house gases, especially carbon dioxide.

2. Empirical model, theory and Methodology:

2.1 Greenhouse Effect

Greenhouse effect, also called as "Flower House Effect", is the common name of thermal effect on the atmosphere. The short wave radiation of the sun comes to the earth through the atmosphere. As the atmosphere takes in the long wave radiation ray which is released by the short wave radiation of the sun from the earth, which causes the rise of the earth's temperature and the lower-layer of the atmosphere. It's called the greenhouse effect because the effect of this phenomenon, to some extent, is similar to the greenhouse where grains are planted. Carbon dioxide in the atmosphere is like a thick layer of glass, making our earth a big greenhouse.

Greenhouse effect is mainly caused by the excessive discharging of carbon dioxide from fossil fuel in modern industry society. And because of the effects of taking in heat and insulating against the heat, the increasing carbon dioxide in atmosphere in the outer layer of the earth, which represent a sheet of protection cover, protecting the heat that is radiated from the sun to the earth from distributing to outer space and makes the temperature on the surface of the earth grow higher and higher. Since Industrial Revolution, and because of the fast development of the high-energy consuming industries, the greenhouse gases like carbon dioxide that human beings put out into the air is growing years after years. And because of the strong ability of taking in heat of greenhouse gases, the greenhouse effects of atmosphere gradually become obvious, which also bring about a serious of climate incidents such as the hot weather of global climate. And considering the effects that greenhouse effects have on the circulation of atmosphere and ocean, the rising of average weather on the surface of the earth, has changed the distribution of energy field in atmosphere as well as the distribution of time and space of the rain. Thus, greenhouse effects will bring about more and more extreme hotter summer, colder winter, more frequent occurrence of dry climate and water logging. All those has taken all countries' attention all around the world.

Table 1. Greenhouse gas ratio

Category	Hydrofluoro-carbon (HFC)	Nitrous Oxide (N2O)	Biogas	Perfluoro-carbon (PFC)	Sulfur Hexafluoride (SF6)	Carbon Dioxide (CO2)
Content	1.5%	1.3%	2.1%	0.8%	08%	93.7%

"Kyoto Protocol", which was passed on the 3rd signatory conference on "Climate framework agreement" held in Kyoto, Japan in 1997, has set the models of the put out volumes of every countries, and in the attachment A in "Kyoto Protocol" defines greenhouse gases as CO2, CH4, N20, MFCS, PHCS and SF6, different kinds of those gases occupy different content in the air. (Table1), and have different effects on global warming. In which, putting out 1 ton of CH4 equals to putting out 21tons of CO2, putting 1 ton of N20 equals to putting out 310 tons of co2, and putting out 1 ton of HFCS equals to putting out 140-11700 tons of CO2. Among all those greenhouse gases, the scale and effect of CO2 is the largest, and it has the closest relations with human's production and living. In this senses, it has become the first goal of the world to take drastic measures to tackle this measures.

Table 2« Kyoto Protocol» Annex A greenhouse gases from the type and temperature rise influence index

Greenhouse gases	Effect of temperature rise index	Greenhouse gases	Effect of temperature rise index
CO2 (Carbon Dioxide)	1	HFCS (Hydrofluorocarbons)	140~11700
CH4 (Methane)	21	PFCS (Perfluorocarbon)	6500~9200
N2O (Nitrous Oxide)	310	SF6 (Sulfur Hexafluoride)	23900

2.2 Kaya Identity

The Kaya identity was developed by the Japanese scholar Kaya Yoyichi and published in the IPCC Special Report,it is widely recognized and accepted by the international community. Kaya identity reveals that the total emission level can be expressed as the product of four inputs.

$$C = \sum C_i = \sum \frac{E_i}{E} \times \frac{C_i}{E_i} \times \frac{E}{Y} \times \frac{Y}{P} \times P \tag{1}$$

C is global CO2 emissions; Ci is CO2 emissions from energy "i", generally including coal, petroleum, natural gas; E is primary energy consumption, which means energies which are from the nature without processing and converting, including raw coal and crude; Ei is energy "i" consumption; Y is gross domestic product; P is population of a country or region. That is, carbon emissions=population × GDP per capita × energy use per unit of GDP × carbon emissions per unit of energy consumed.

Kaya identity reveals that total emission level can be expressed as the product of four inputs:

(1) Population. It is predictable that population will continue to grow although net population growth in some European countries is negative, and that some Asian countries are going all out to control population. As man reports states, the total world population would exceed 7 billion in 2011 all over the world. The larger the population is, the more carbon emissions takes place. According to a report from laboratory of global carbon project of Japan's National Environmental Research Institute in 2009, CO2 emissions from human activities in 2008 increased by 2% compared to 2007 and the average per capita emissions reached 1.3 tons.

(2) GDP per capita. This is the macro economic indicator reflecting the living standards of residents. In modern society where economic development prevails, countries all over the world are striving to increase the GDP per capita. GDP per capita in developing countries is at a low starting point, but the growth has been rapid in recent years. Under the energy system based on fossil energies, the growth of GDP per capita inevitably leads to the corresponding growth of the carbon emissions.

(3) Energy used per unit of GDP or "energy intensity". Different industries have different energy intensities. In the same industry, the technological level also affects the energy intensity. As population and economy in modern society will continue to increase, CO2 emission reduction needs us to reduce energy intensity of per unit of GDP, optimize energy structure, fully apply low carbon technology with the core of energy efficiency technology and renewable energy technology, improve energy efficiency and save energy, which is one of the most effective solutions for emission reduction.

(4) Carbon emissions per unit of energy consumed, that is "carbon intensity". Energy structure factor Ei/E, which means the proportion of energy "i" in primary energy consumption.Carbon emissions per unit of energy

consumed is another major influencing factor of CO2 emissions. Carbon intensity differs greatly in different kinds of energies. For fossil energies, the carbon intensity of coal is the highest, followed by oil, and then natural gas. For renewable energies, carbon intensity of biomass energy is relatively low, while hydro-energy, wind energy, solar energy, nuclear energy, geothermal and tidal sand energy belong to zero carbon energies by reason of no effective carbon emissions in the process of usage. Therefore, effective means of the carbon footprint reduction include developing low-carbon energies and renewable energies and implementing diversified energy structures.

2.3 Grey Systems Theory

Grey Relational Analysis is an analytical method of Grey Systems Theory, aiming at the numerical relations between subsystems, quantitatively describing and comparing the development and change trends of the system, thus measuring correlation degree between factors based on the degree of similarity or dissimilarity of factors' development trends. The basic thought of Grey Relational Analysis is to determine how strongly these factors are related according to the similarity degree of geometry of sequence curves of systems. The more similar the geometry of the curve, the closer correlation between the corresponding sequences. Based on it, we can judge major and secondary factors inducing the development of the whole system. The basic idea is firstly deciding referenced sequence reflecting system's behaviour characteristic and several comparative sequences affecting system's behaviour as required and then analyzing correlation degree between each factor and the main factor by calculating the correlation degree between each comparative sequence and referenced sequence.

First: Create the referenced sequence X0'(k) and comparative series Xi'(k).

$$x_0'(k) = \left(x_0'(1), x_0'(2), \ldots, x_0'(k)\right) \tag{2}$$

$$x_i'(k) = (x_i'(1), x_i'(2), \ldots, x_i'(k)) \tag{3}$$

Where "i" is named for the number of comparative sequence, i= 1, 2, … m; "k" is named for the number of observed value, k=1, 2,…, N.

Second: Dimensionless operation on index data.

In the process of multi-index comprehensive evaluation, we can't directly calculate and compare by reason of different physical significances of factors in the system and the differences of units and magnitudes between different indicators. At the same time, in order to simplify the calculation, and avoiding different unit conversion of indicators, we should eliminate the influence of indicator dimension through mathematical manipulation, thus strengthening proximity between factors and enhancing the comparability.

Common dimensionless methods include initialization, equalization, extreme and others. This article adopts the initialization method, namely the data in each column divided by the first data in the column. After data processing, the corresponding new referenced sequence is X0(k) and comparative sequence is Xi(k).

$$x_0\ (k) = \frac{x_0'(k)}{x_0'(1)}; \quad x_i\ (k) = \frac{x_i'(k)}{x_i'(1)} \tag{4}$$

Third: Calculate the absolute difference values between referenced sequence Xi(k) and comparative series Δ0i(k) and find out the maximum and minimum values of corresponding sequence of difference value.

$$\Delta_{0i}(k) = \left|x_0\ (k) - x_i\ (k)\right| \tag{5}$$

$$\Delta\min = \min_i \quad \min_k \quad \left|x_0\ (k) - x_i\ (k)\right|; \ \Delta\max = \max_i \quad \max_k \quad \left|x_0\ (k) - x_i\ (k)\right| \tag{6}$$

Fourth: Calculate the correlation coefficient.

$$\zeta_i(k) = \frac{\Delta\min + \rho\cdot\Delta\max}{\Delta_{0i}(k) + \rho\cdot\Delta\max}, k = 1,2,\ldots N \tag{7}$$

Where "p" is resolution ratio, p϶(0,l). The significance is distortion caused by extremely weakening the maximum absolute difference value, improving the significant of difference between correlation coefficients. The smaller p, the larger definition, generally, p=0.5.

Fifth: Calculate the correlation degree.

Correlation coefficient is an indicator of describing the correlation degree between referenced sequence and comparative series at different times. As the comparison between different referenced sequence and comparative series can get many correlation coefficients so that global comparison and decision can't be conducted, we need to gather correlation coefficients at different times and determine the average value, through which we can measure the correlation degree between each influencing factor and the main factor.

$$r_{0i} = \frac{1}{N}\sum_{k=1}^{N} \zeta_i(k), (\ k = 1,2, \ldots, N) \tag{8}$$

Sixth: Arrange the correlation degree.

Arrange the correlation degrees calculated according to Formula (8) in numerical order. The larger the correlation degree, the closer correlation between comparative series and referenced sequence and the larger the influence between the corresponding influencing factor of the indicator and the corresponding main factor of referenced sequence.

3. Empirical Analysis

3.1 Data Selection and Processing

According to domestic and overseas researches and the actual national economic development, we can analyze the correlation degree between CO2 emissions and influencing factors in Mongolia through selecting five data indicators from countries all over the world from 2000 to 2010 provided by the world bank including gross domestic product (GDP), Gross fixed capital formation, Household final consumption expenditure, Energy use and population as influencing factors of CO2 emissions and selecting CO2 emissions in Mongolia from CO2 emissions of countries all over the world from 2000 to 2010 provided by America Energy Information Administration as evaluation indicator.

Table 3 : In 2000-2010 numerical CO2 emissions and other factors

	CO2 Emissions (Kt)	GDP (million US$)	Gross fixed capital formation (million US$)	Household final consumption expenditure (million US$)	Energy Use (ktoe)	Population
2000	7506.35	1136.896	28653	790.997	2396.59	2397473
2001	7884.05	1267.998	273.10	928.382	2414.75	2419669
2002	8287.42	1396.556	309.29	1065.57	2585.63	2443231
2003	8034.40	1595.297	464.56	1102.19	2525.39	2468595
2004	8551.44	1992.067	554.18	1276.97	2600.45	2496248
2005	8646.79	2523.360	704.98	1392.27	2624.67	2526502
2006	9497.53	3414.053	1136.96	1586.68	2924.95	2559496
2007	10091.58	4234.894	1486.82	1985.12	3114.45	2595068
2008	10029.25	5623.237	2036.46	3052.20	3155.93	2632834
2009	11052.34	4583.834	1324.22	2665.07	3252.27	2672223
2010	11510.71	6200.357	2017.76	3294.21	3454.21	2712738

3.1 Data Analysis

Analyze data by selecting CO2 emissions as the referenced sequence and selecting gross domestic product (GDP), gross fixed capital formation, Household final consumption expenditure, energy use and population as comparative series.

Based on the statistics in 2000, conduct dimensionless operation on sequences and form the following matrix:

$$x_j(k) = \begin{pmatrix} 1 & 1.05 & 1.10 & \cdots & 1.53 \\ 1 & 1.16 & 1.23 & \cdots & 5.45 \\ 1 & 0.95 & 1.10 & \cdots & 7.99 \\ 1 & 1.17 & 1.35 & \cdots & 4.16 \\ 1 & 1.00 & 1.09 & \cdots & 7.54 \\ 1 & 1.01 & 1.02 & \cdots & 1.13 \end{pmatrix} \tag{9}$$

Where j=0,1,2,…,5; k=l, 2,…,10

X0, X1, X2, X3, X4 and X5 are separately the corresponding sequences of development speed with fixed basis of CO2, GDP, gross fixed capital formation, household final consumption expenditure, energy use and population.

The series matrix of the corresponding difference values of five influencing factors are as follows:

$$\Delta_{0i}(k) = \begin{pmatrix} 0 & 0.065 & 0.124 & \cdots & 3.920 \\ 0 & 0.099 & 0.005 & \cdots & 6.462 \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ 0 & 0.041 & 0.085 & \cdots & 0.402 \end{pmatrix} \tag{10}$$

Then Δmin=0, Δmax=6.462.

Set p=0.5, we can get sequence matrix of correlation coefficient:

$$\zeta_{0i}(k) = \begin{pmatrix} 0.98 & 0.96 & 0.91 & 0.84 & 0.75 & 0.65 & 0.58 & 0.47 & 0.56 & 0.45 \\ 0.97 & 0.99 & 0.85 & 0.80 & 0.71 & 0.54 & 0.46 & 0.36 & 0.51 & 0.37 \\ 0.98 & 0.95 & 0.99 & 0.90 & 0.87 & 0.84 & 0.75 & 0.58 & 0.66 & 0.58 \\ 0.99 & 0.99 & 0.99 & 0.98 & 0.98 & 0.99 & 0.99 & 0.97 & 0.97 & 0.97 \\ 0.99 & 0.97 & 0.99 & 0.97 & 0.97 & 0.94 & 0.93 & 0.93 & 0.90 & 0.89 \end{pmatrix} \tag{11}$$

According to Formula (8) of correlation coefficient, we can calculate the correlation coefficient:

r_1	r_2	r_3	r_4	r_5
0.715003	0.656791	0.810522	0.98229	0.947885

Through the above analysis, we can see:

(1) Through the correlation coefficient we can reach the conclusion that r04>r05>r03>r01>r02. On the whole, the main factors affecting CO2 emissions in Mongolia are energy use and population, followed by household final consumption expenditure, GDP and fixed investment. Among them, by using Eviews software we can draw the conclusion that correlation coefficient between energy use and CO2 emissions is maximum, 0.98229,

confirming the causality between energy use and CO2 emissions in the analysis, while relatively closer correlation between population and CO2 emissions is the complementary instruction of no remarkable causality in the analysis.

The current energy structure where high-carbon fossil fuels such as coal, oil, natural gas and others are main energies determines that the energy use will inevitably gives out more CO2 emissions, but the current economic growth pattern is basically at the expense of large energy use. Therefore, energy use and economic growth directly affect CO2 emissions, which accords with laws of economic development of countries all over the world. From Figure 1, we can see that standard curves of energy use and CO2 emissions are the most similar, indicating their correlation degree is strongest.

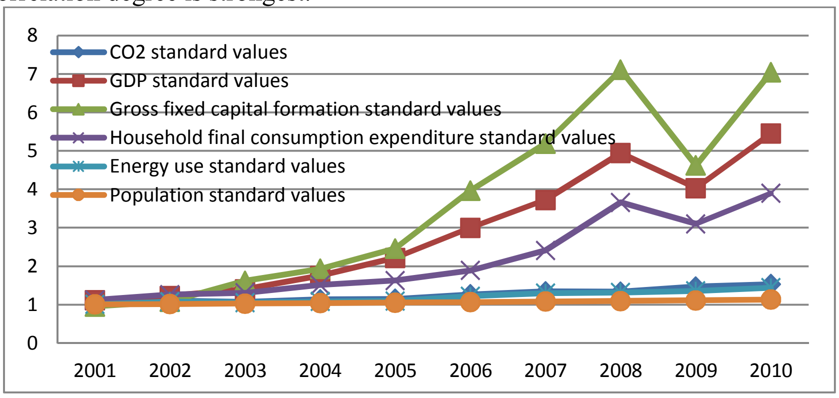

Figure 1 2001-2010 years of each factor standard sequence trend graph

(2) As we can see from Figure 1 that standard curves of five influencing factors show increasing trend, indicating five influencing factors and CO2 emissions are positive correlation. Population growth will not only lead to the increase of personal carbon CO2 emissions but also increase material and energy use, indirectly increasing CO2 emissions. The increasing gross fixed capital formation will promote economic growth and increase energy use, may contributing to CO2 emission if the investment flows to high energy use of industrial production. The increasing household final consumption expenditure will lead to an increase in investment, thus increasing CO2 emissions according to transitivity of correlation degree.

4. Conclusion

Theoretically, greenhouse effect is mainly caused by the amounts of CO2 in the atmosphere caused by the excessive burning of fossil fuels in modern industrial society, this has led to a series of serious problems such as global warming and others. For agriculture, greenhouse effect has a remarkable impact on crop yield with a declining quality; it may also result in the decline of soil fertility, which consequently impact primary the productivity of the soil. Therefore the harm is more and more severe.

Based on the study of Japanese scholar Kaya Yoyichi, four inputs of carbon emissions are population, GDP, energy use per unit of GDP, carbon emissions per unit of energy consumed. In the analysis of influencing factors of CO2 emissions in Mongolia through the Grey Relational Analysis, from the correlation degree we can reach a conclusion that energy use affects CO2 emissions to the maximum degree, followed by population, and then household final consumption expenditure, GDP and gross fixed capital formation. Taking into account a win-win situation of economic development and environmental protection, carbon emissions can be reduced through improving energy use, controlling population, adjusting gross fixed capital formation and guiding the household final consumption expenditure and others, which helps Mongolia to adopt policies of low-carbon development and select the path.

Due to the global warming and the greenhouse effect, the earth's glaciers and ice shelves are currently continuing to melt, and the speed is further accelerated. Today industrialization constantly deepens on energy where CO2 emission is the main factor of global warming. In order To solve this problem of CO2 emission or at least reduce its impact on the environment we need first to find out the influencing factors of CO2 emissions, and take practical and effective policy measures that can reduce the CO2 emissions, and finally take this global warming crisis under control.

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