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Human Activity and the Global Temperature of the Planet

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Abstract. This paper reports on the dependence of the average global temperature on those factors that influence. The current assessment of global temperature is also influenced by previous assessments as of this process as well as by various dynamic factors of human activity. Human activity can be evaluated using a set of factors: waste generated by electricity, gas, steam and air conditioning; waste generated by households; global GDP; road freight traffic; fresh surface water extraction; area of forested land. This paper details the important processes in any given natural environment: a) climatological disasters; b) changes in CO2 levels; (c) proportion of greenhouse gases caused by changes to industry; d) proportion of greenhouse gases caused by changes in agriculture; e) changes in global temperatures; f) changes in fresh water reserves g) changes in area of forested land. To theoretically model the effect of human activity on global temperatures, the autoregressive distributed lags (ADL) model was chosen. Current values generated using the ADL model depend both on previous values, and on the current and previous values of other variables. Empirical testing of the model is described and carried out to validate the results.

1. Introduction

The environment comprises both mankind's habitat and the sphere of its activity. Moreover, the environment includes everything that surrounds the human world including both natural and man-made environments. The number of people on the planet, as well as their quality of life and level of environmental conscientiousness, is directly proportionate to changes in the environment. There are more than 7 billion people on earth and the population continues to grow.

Exponential population growth will lead to a greater human impact on the environment. Many existing problems are caused by the fact that energy consumption plays an important role in human life: people cannot exist without consuming energy. Here, energy is understood as any area of human activity that is connected with the production and consumption of energy.

A significant portion of energy consumption can be attributed to energy released during the combustion of organic fossil fuels (oil, coal and gas), leading to a huge amount of greenhouse gases and pollutants being released into the atmosphere [1]. The air temperature of the environment increases and the greenhouse effect develops. The so-called greenhouse effect is caused by the growth in the concentration of greenhouse gases in the atmosphere. The concentration of these gases is increasing as a consequence of the burning of huge amounts of organic fuel (oil, natural gas, coal, firewood, peat, etc.) due to processes in industry, transport, agriculture and residential settlement. Humans are thus responsible for significant increases in the output of greenhouse gases and are constantly destroying natural ecosystems that regulate their concentration. Deforestation is ongoing, and, according to some estimates, 35-40% of forested land worldwide has undergone deforestation in the last millennium alone.

Moreover, almost all of the steppes have been ploughed and natural meadows destroyed. The human influence on global warming is no longer simply a hypothesis, but an established fact.

2. Indicators estimating the state of the environment

The environment is characterised by the set of processes taking place within it. These include the environmental processes analysed in this paper: a) climatological disasters; b) change of CO2 content associated with emissions; c) change in greenhouse gases associated with industrial emissions; d) change in greenhouse gases associated with agricultural emissions; e) global temperature change; f) change in fresh water reserves; g) change in area of forested land.

Climatological Disasters. These are destructive events caused by extreme climates that damage property and pose a threat to human life. The costs of climatological damage may be estimated in terms of millions of US dollars.

CO2 Emissions. Earth's environment is characterised by the existence of CO2 in the atmosphere. The presence of CO2 depends on CO2 emissions. In order to manufacture a product, it is necessary to consume a certain amount of resources (raw materials, electricity, etc.). As a result of such production, carbon dioxide and other harmful substances are released into the atmosphere. The change in CO2 content is estimated using grams of CO2 per unit of production (gr./USD).

Industrial greenhouse gas emissions. The main greenhouse gases are water vapour, carbon dioxide, methane and ozone. Human industrial activity has led to reduction in wooded areas, the main natural absorbers of carbon dioxide. Industrial greenhouse gas emissions are estimated in tons of CO2 equivalent.

Agricultural greenhouse gas emissions. Agriculture directly and indirectly promotes the emission of three main greenhouse gases: carbon dioxide, methane and nitrous oxide. The change in greenhouse gas content is estimated in CO2 nitrogen equivalent tons.

Global Temperature Change. The environment may be characterised in terms of global temperature. The average temperature is calculated annually for each country and the global temperature derived from the arithmetical mean. Rates of temperature increase are determined by the average global temperature values.

fresh surface water extraction. Water is essential for agriculture and food security. One of the main problems preventing sustainable development is currently a lack of water. Fresh water resources are steadily declining. Fresh surface water extraction is quantified in millions of cubic metres.

Deforestation has a detrimental effect on the planet and happens both as a result of human activity and natural processes. The change in forested area may be quantified in terms of km^2.

3. Literature review

The negative impacts of human activity on the environment have been thoroughly studied. Leading scientists have proposed a number of methods that could be used to negate these negative effects. These focus on the need for every person to make the prevention or slowing of ecological decline a priority [2]. In [3], conflict between human beings and the biosphere is investigated.

Other studies focus on problems pertaining to the atmosphere and to the planet including the preservation of water reserves, subsoil, flora and fauna [4-6]. In [7], a correlation between the declining ecological status of the planet and the use and production of electricity is investigated. In [8] the problem of the influence of multinational corporations on the environment is discussed. In [9], the main questions of global climate change, their influences on ecological systems as well as many aspects of the activities of the global community working towards the decrease of anthropogenic impact on the planet's climate are described.

In [10] communication strategies for reducing poverty are studied. One of the most significant sources of greenhouse gases is the livestock sector [11]. Scientists detail empirical estimates of the influence of climate change on the price of electricity [12].

Investment policy decisions are analysed under the influence of climate change. Scientists have developed an innovative approach which combines three physical climatic models (the model of geophysical dynamics, Goddard's model of space research and the model of the climate) with the general equilibrium model of global trade for studying the influence of climate change [13]. The models of human activity influencing the greenhouse effect are also presented [14-17].

4. Analytic methodology for studying factors influencing global temperature change

In this section, the methods used in this study are described and discussed. When analysing the factors influencing the change in global temperature, it is important to take into account the peculiarities of the global temperature change process. The current assessment of global temperature is influenced by: a) the history of the process; b) the various dynamic factors of human activity; c) other environmental processes.

As a theoretical model of the analysis of factors influencing the change in global temperature we chose the autoregressive distributed lags (ADL) model in which the current values of the series depend both on previous values of the series, as well as on the current and previous values of other temporary variables. It should be noted that this model has been chosen for analysis because it considers the influence of "previous" periods on "current" ones. Moreover, the model allows the prediction of an endogenous indicator for "future" periods.

The multiplicative type of ADL model is as follows:

$$Y_t^i = \prod_{k=1}^{m}\left(Y_{t-k}^i\right)^{a_{1k}} \times \prod_{k=0}^{m}\left(X_{1,t-k}^i\right)^{a_{2k}} \times \prod_{k=0}^{m}\left(X_{2,t-k}^i\right)^{a_{3k}} \times \prod_{k=0}^{m}\left(X_{3,t-k}^i\right)^{a_{4k}} \quad (1)$$

Having expressed the left and right part of the equation through logarithms on e basis, we get a linear equation of the form:

$$\ln Y_t^i = a_1 \ln Y_{t-k}^i + a_2 \ln X_{1t}^i + a_3 \ln X_{2t}^i + a_4 \ln X_{3t}^i \quad (2)$$

The multiplicative function is transformed to the additive one.

$$\ln Y_t^i = \sum_{j=1}^{k^1} a_0 \ln Y_{t-j}^i + \sum_{j=1}^{k^2} a_1 \ln X_{1,t-j}^i + \sum_{j=1}^{k^3} a_2 \ln X_{2,t-j}^i + \sum_{j=1}^{k^4} a_3 \ln X_{3,t-j}^i \quad (3)$$

A method for empirically testing the model is developed. The method includes the following main stages. When testing the stationarity of time series variables, the Dickey-Fuller test is used to find the coefficient in the autoregression equation of this form:

$$y_t = a\, y_{t-1} + \varepsilon_t \quad (4)$$

, where y_t — is the time series, ε_t — is the error.

If $|a| < 1$, the series is stationary. If a=1 then the process has a unit root. In this case, the series is non-stationary, it is an integrated time series of the first order.

The testing of exogenous variables' multicollinearity: Testing the exogenous variables' multicollinearity is performed by finding the coefficients of pair correlation between the exogenous variables. When the value of the correlation coefficient is greater than $|0.7|$, one variable of the pair is excluded from further analysis. If $t_{tempirical} > t_{theoretical}$ the received coefficients are significant i.e. selection corresponds to the population.

The choice of endogenous variable lags, which have a strong correlative connection with the variable's value in the last period, as well as testing of the significance of autocorrelation coefficients, is carried out by means of Ljung-Box Q-test. The choice of endogenous variable lag having a strong correlative connection with the same variable value in the last period was carried out by means of autocorrelation coefficients. The significance of autocorrelation coefficients was confirmed using the Lyyunga-Boksa criterion. Based on the results, we chose those lags having a strong correlation with the value of the indicator in the previous period. The choice of exogenetic variables has a strong correlative connection with the value of an endogenous variable in the former period; the significance of correlation coefficients was tested. The composition of the structural form of ADL uses a model of the multiplicative type. The values of the natural logarithms of the endogenous and exogenous variables are derived for the period from 1995 to 2016. New variables were introduced and the structural form of the additive type of ADL model presented.

The determination of model coefficients was carried out using regression analysis. The significance of the regression equation and coefficients of the regression equation were verified. Equations were written out using the multiplicative form. Analysis of the economic signification of exogenetic variable coefficient values was performed.

5. Data and analysis of primary data

The work with the initial data consisted of two stages: a) data collection for selected variables; b) primary processing of endogenous and exogenous variables in accordance with the requirements of the model. The data were collected over a period of time from 1995 to 2016.

The data contain the values of the variables for the corresponding year: endogenous variable; exogenous variable – a background process; exogenous variables are factors of human life whereas exogenous variables are characteristics of other processes. Data were taken from the following sources: Euromonitor Passport Database, http://www.euromonitor.com/; World Bank Open Data, http://data.worldbank.org/; CIA of the USA website ttps://www.cia.gov/.

6. Empirical testing of the model

The check of the time series variables for stationarity using the Dickey-Fuller test showed that all the series are stationary.

All the series in the autoregressive equation, the coefficient $|a|<1$, the values of the coefficient lie in the range $[0.030-0.9791]$.

The checking of exogenetic variables' multicollinearity revealed the existence of a strong connection between some exogenetic variables. Inspection of the correlation coefficients' significance showed that for all factors the condition of calculation $t_{tempirical} > t_{theoretical}$.

$X_5, X_6, X_7, X_8, Y_6, Y_7$ are excluded from the further analysis: waste generated by electricity, gas, steam and air conditioning supply (tonnes); waste generated by households (tonnes); global GDP (US$ per capita); road freight traffic (million net tonne-kilometres); fresh surface water extraction (million m^3); forest land (km^2).

The choice of the endogenous variable lag showed that two prior periods in the last period have a high autocorrelation coefficient of a variable. The check of the significance of autocorrelation coefficients on Q-statistics has confirmed their significance (values of Q-statistics are equal to 16.65940 and 27.51671, it is more than the tabular value $\chi^2_{0.05,2}=5.991$).

The choice of exogenous variables which have a strong correlative connection with the value of an endogenous variable in the previous period allowed preservation of the exogenous variables for the analysis. Factors of human activity: methane emissions $(k_t \text{ of } CO2 \text{ equivalent})$ (X_1) in t and $t-1$ periods; greenhouse gas emissions (tones of CO2 equivalent) (X_3) in t, $t-1$, $t-2$ periods; CO2 emissions from the consumption and flaring of fossil fuels (tonnes) (X_4) in t period*;* agricultural land (sq. km) (X_9) in t, $t-1$, $t-2$, $t-3$ period and exogenous variables - characteristics of other processes: CO2 Emissions per Unit of Output (grams per USD inconstant prices) (Y_2) in t period; greenhouse gas emissions from Agriculture (tones of CO2 equivalent) (Y_4) in t period. All values of correlation coefficients are significant, $t_{tempirical}$ is in the range $[6.87768 \; to \; 8.43441]$ at $t_{theoretical}=1.753$.

The structural ADL model of a multiplicative type has the form:

$$Y_{5_t} = a_0 \cdot Y_{5_{t-1}}^{a_1} \cdot Y_{5_{t-2}}^{a_2} \cdot x_{1_t}^{b_1} \cdot x_{1_{t-1}}^{b_2} \cdot x_{3_t}^{c_1} \cdot x_{3_{t-1}}^{c_2} \cdot x_{3_{t-2}}^{c_3} \cdot x_{4_t}^{d_1} \cdot x_{9_t}^{e_1} \cdot x_{9_{t-1}}^{e_2} \cdot x_{9_{t-2}}^{e_3} \cdot x_{9_{t-3}}^{e_4} \cdot Y_{2_t}^{f_1} \cdot Y_{4_t}^{g_1} \quad (5)$$

The introduction of new variables allowed the presentation of the structural form ADL models in an additive form:

$$A_{5_t} = a_0 + a_1 A_{5_{t-1}} + a_2 A_{5_{t-2}} + b_1 B_{1_t} + b_2 B_{1_{t-1}} + c_1 B_{3_t} + c_2 B_{3_{t-1}} + c_3 B_{3_{t-2}} + d_1 B_{4_t} + e_1 B_{9_t} + e_2 B_{9_{t-1}} + e_3 B_{9_{t-2}} + e_4 B_{9_{t-3}} + f_1 A_{2_t} + g_1 A_{4_t} \quad (6)$$

The model coefficients are found using the regression analysis:

$$A_{5_t} = -23.6543 - 0.3595 \cdot A_{5_{t-1}} - 0.5790 \cdot A_{5_{t-1}} + 0.5554 \cdot B_{1_t} + 0.5442 B_{1_{t-1}} + 0.5695 B_{3_t} + 0.4643 B_{3_{t-1}} - 0.4387 B_{3_{t-2}} + 0.3057 B_{4_t} + 1.6649 B_{9_t} + 1.6157 B_{9_{t-1}} + 0.9317 B_{9_{t-2}} + 0.9867 B_{9_{t-3}} - 0.3206 A_{2_t} + 0.9846 A_{4_t} \quad (7)$$

The equation in a multiplicative form is written as:

$$Y_{5_t} = -23.6543 \cdot Y_{5_{t-1}}^{-0.3595} \cdot Y_{5_{e-2}}^{-0.5790} \cdot x_{1_t}^{0.5554} \cdot x_{1_{t-1}}^{0.5442} \cdot x_{3_t}^{0.5695} \cdot x_{3_{t-1}}^{0.4643} \cdot x_{3_{t-2}}^{-0.4387} \cdot x_{4_t}^{0.3057} \cdot x_{9_t}^{1.6649} \cdot x_{9_{t-1}}^{1.6157} \cdot x_{9_{t-2}}^{0.9317} \cdot x_{9_{t-3}}^{0.9867} \cdot Y_{2_t}^{-0.3206} \cdot Y_{4_t}^{0.9846} \quad (8)$$

7. Results and Discussion

Following analysis of the model, it is possible to draw some conclusions. The indicator "change in average value of global temperature" in the previous period is weakly influential in the current period. This can be explained by the fact that the population increases every year, involving an increase in the production and consumption of resources. The result of an increase in these indicators is the emission of carbon dioxide into the atmosphere, leading to an increased global warming effect. There is "an effect of accumulation" of CO2 and other greenhouse gases in the atmosphere.

The influence of the "change in average value of global temperature" indicator is increased by the growth of the "methane emissions" indicator. In terms of promoting global warming, methane is the second most prevalent greenhouse gas after CO2. The logic is the same as described above. The annual increase in population leads to growth in the consumption of resources and consequent emissions. The result of the growth of these indicators is the emission of various gases into the atmosphere, leading to a heating effect.

With the growth of the "emissions of greenhouse gases" indicator, the influence of this indicator on "change in average value of global temperature" is increased in the current period. The greater the prevalence of greenhouse gases in the atmosphere, the more severe the resultant global warming effect.

With the growth of the indicator "CO2 emissions caused by consumption and combustion of fossil fuels" the influence on "change in average values of global temperature" is increased. This may indicate that as more resources are consumed, more waste gas is formed and the global warming effect becomes stronger.

The variable "area of land used for agriculture " has a strong influence on the indicator "change in the average value of global temperature". If the indicator "area of land used for agriculture" increases, then first of all considerable areas of woodland (which is the main "processor" of carbon dioxide) are cut down or burned. Furthermore, development of agriculture involves emissions of gases from cattle, etc. This indicator affects the increase in change in global temperature more strongly than the rest.

The variable "CO2 emissions per unit of production" has the opposite effect on "change in average values of global temperature" in the current period. Possibly this is so because of restrictions for emissions introduced by the enterprises which, in turn, promote a change to newer technologies and more rational use of resources.

The influence on "change in average value of global temperature" is increased in the current period due to the growth of the "emissions of greenhouse gases from agriculture" indicator. Agriculture is one of the main causes of climate change. Emissions of greenhouse gases from this kind of activity are significant. These gases concentrate in the atmosphere and thereby promote the global warming effect.

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