ECONOMIC CRISES AND EMISSION OF POLLUTANTS: A HISTORICAL REVIEW OF SELECT ECONOMIES AMID TWO ECONOMIC RECESSIONS

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Abstract. *This paper investigates the historical trends in economic development through the impact of economic depressions and emissions of greenhouse gasses, namely carbon dioxide (CO_2). The analysis includes four countries: the United States, the United Kingdom, Germany and Japan. The focus, therefore, will be on the impact of two economic crises and their effect on global warming. Temperature changes in the longer period are very often regarded as a result of human activity, which can be measured by the increase of GDP (per capita). The findings indicate that GDP (per capita) parameters cannot be considered as correct measures of human pollution activity. The results show that the long-run temperature can be evaluated with the help of annual average temperatures of the previous four years. The proposed model does not only provide quite satisfactory forecasts, but is very stable with coefficients variables that can make a model more reliable for practice.*

Keywords: *economic influence, climate changes, global warming, Schumpeter, time series, forecasting*

When my mother died I was very young,
And my father sold me while yet my tongue
Could scarcely cry 'weep! 'weep! 'weep! 'weep!
So your chimneys I sweep, and in soot I sleep.
— William Blake

1. Introduction

The purpose of this paper is to investigate the relationship between macroeconomic parameters, gross domestic product (GDP per capita) and carbon dioxide (CO_2) emissions data in relation to global warming during major economic crisis in the 1870s and 1930s. The authors aim to examine whether the hypothesis that economic crisis,

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i.e., reduced amount of GDP (per capita) resulted in decreasing industrial activities, thus lowering the emission of CO_2 gases. Furthermore, it intends to check whether this had any effect on the climate change through the increase or decrease of annual mean temperatures. The authors suggest that CO_2 emissions are the most solid indicator to mirror the industrial development of a country. This is based on the fact that CO_2 is largely emitted by factories, which in turn reflects the industrial activities of the country, for both the internal demand, as well as for the export of final products.

The paper is a continuation of the paper of Giedraitis et. al. (2010) that supported the claim that economic crisis in 1930s actually did not have any significant effect on cooling temperatures. The authors of this paper intend to check the claim in the longer period, encompassing other major economic crises, during the period since 1850 to 1944. Temperature changes can, therefore, be observed for a longer period, helping to analyse the factors that influenced its development. Longer timescale will also allow seeing how structural GDP changes may have influenced the level of emission of pollutants. By analysing four different countries (USA, UK, Japan and Germany), the results will suggest whether different types of economies had different effects on the change of CO_2 emissions levels and temperature changes during the crisis. A separation is important as they all had their specific nature of economy, development rate, industrialisation level, etc. during the analysed period. One might notice that all the countries were developing rapidly since the beginning of the chosen research period, therefore, they can boast adequate data on the level of pollutants. However, there are some restrictions due to lack of accurate historical data, mainly for the temperature levels in some countries in the 19th century.

The paper consists of a review of literature and a theoretical framework, data and analysis section, methodology and eventually, conclusions.

2. Review of Literature and Theoretical Framework

In terms of economic development, the basic theoretical framework is based on the world-systems perspective (Amin, 1976 and 1994, Yotopolous and Sawada, 2005, Giedraitis, 2007). Already in the 1970s, Wallerstein (1974) and Frank (1978) suggested an expanding European economic "world-system", aiming to describe the way countries around the world had developed by stressing on an economic-historical approach. In their model, capitalist market relations are a method of redistribution of wealth, from periphery (poor countries) to the core (rich countries). Using Findlay's (1980) North-South Model, this would explain the wealth flow from the South to the North (Turchin, 2007; Arrighi, 1995). This, in turn, is related to forms and intensity of energy use: poorer peripheral (i.e., more agricultural) countries are far less energy intensive than richer core (i.e., more industrialised) countries. It is the latter that tend to be greater emitters of greenhouse gases due to economies that require more energy (Jorgenson et. al., 2014).

A central structural assumption of the world-systemic approach is the belief in centuries-old economic cycles – namely the 45 to 60 year Kondratiev cycles. The latter one has been regularly criticised by several scholars for insufficiently clarifying the origins of the cycle. Moreover, the Kondratiev waves are often seen as being merely economic correlations rather than providing an explanation of the cause of economic depressions or booms (Solomou, 2004). However, empirical evidence suggests a correlation between economic recessions and the troughs of the Kondratiev waves (e.g. 1870s and 1930s). Quasi-institutionalists such as Schumpeter (1943) advocated that innovators can influence the economy through the provision of innovations, such as the steam engine, which eventually resulted in the industrial revolution (Giedraitis and Rastenienė, 2009). Indeed, it can be argued that Kondratiev waves are associated with new forms of energy use.

Human-caused greenhouse gas emissions became an issue in Europe and the USA with the acceleration of the industrial revolution. Machine-based manufacturing, made possible through coal fired steam engines, resulted in a significant increase of productivity and capacity. The growth of industrial clusters based on heavy industry, ensured to maintain economic growth, were at the expense of rapidly increasing CO_2 emissions (Jenkins on et. al., 1991).

CO_2 emission, due to the increase of energy usage, causes changes in temperature (Solomon, Plattner, Knutti, Friedlingstein, 2009; Manabe and Stouffer, 1980). However, not every region is affected equally. As stated by the Intergovernmental Panel on Climate Change (IPCC, 2007), geographical areas closer to the North Pole have increased their mean temperatures more than the ones closer to Equator, suggesting that greater industry in northern hemisphere might have resulted in significantly higher increase of mean temperatures.

3. Data and Analysis

The following indicators were used in the analysis:

1) CO_2 emission level. The amount of carbon dioxide (gas), which is emitted in the atmosphere during the chosen time period, expressed in thousand metric tons of carbon.
2) GDP per capita. This number indicates the total value (in international dollars, fixed 2011 prices) of all goods and services made in each country per capita.
3) Mean temperature. This number indicates yearly average temperatures in all selected countries.

For the calculation of the emitted CO_2, data of the "Carbon Dioxide Information Analysis Center" was taken. Only data for Japan comes from 1895 rather than 1850. GDP (per capita) and the population figures for all four countries concerned were provided by the "Gap Minder Foundation". Mean temperatures were computed from different sources for each country: UK data was taken from an article by Gordon Manley, who computed not only yearly, but also monthly mean temperatures in Central England from 1659 to 1973 (Manley, 1974). Later years were compounded from the "Met Office Hadley Centre" dataset. The USA data were computed from the "National Centers for Environmental Information National Oceanic and Atmosphere Administration" (NOAA) databases, while Germany's data were taken from the official "Deutsche Wetterdienst" portal. Finally, the "Japanese Meteorological Agency" provided temperature levels for Japan. One of the flaws is that full mean temperature since 1850 are only available for the UK, while for Germany, this data is available since 1881, for USA – since 1895, and for Japan – since 1861.

TABLE 1. **General economic qualities of studied countries**

Country	Characteristics
United States of America	The USA economy during the discussed period experienced significant growth and change in its economy structure, especially after the Civil war with booming railway, machinery, iron and steel industries, growing cities, mass production and large corporations. The success of the economy is probably best marked by the surging influx of immigrants from Europe in the second part of the 19^{th} century. Unlike in the case of the European countries, it didn't experience significant downfall on its GDP (per capita) or either CO_2 emission levels during WW I. The only significant change was an increase of the volatility of these parameters. The most significant alteration point in the 20^{th} century for both parameters was the Great Depression, although the restoration was very rapid: GDP (per capita) reached the pre-crisis level in 1941, while carbon emission did the same in 1942.
United Kingdom	The United Kingdom led the industrialisation process in the World economy, and was the leading innovator in railways, steam engines, tool-making, etc. There is no surprise that its starting point in CO_2 emission and GDP (per capita) was the highest among all four countries in 1850s. Therefore, the growth of these two figures in the second part of the 19^{th} century and more so in the beginning of the 20^{th} century was modest. A further catalyst in the negative trend of the parameters was WW1 with declining consumption, increasing debt, closure of manufacturing business, shrinking European markets. The restoration of the economy after the war was further stopped by the Great Depression, although it was nowhere near as severe in the UK, as it was in the USA.
Germany	The economy of Germany had a similar development pattern as the USA. It was largely non-industrial until the second part of the 19^{th} century. Unification of Germany in 1871, the policy of the state and the driving force of the local bourgeoisie enabled rapid industrialisation of the country until WW I. Similar to other European countries, it experienced severe damages to its economy during the war, while post-war recovery was further harmed by hyperinflation and political instability that eventually led to the change of political system in the 1930s. The period until WW II was marked by the rapid increase of GDP and CO_2 per capita levels, with war industries being the main attributors.
Japan	Japan's economy also underwent an industrialisation process in the late 19^{th} century, due to a relatively aggressive state's policy. It enabled the establishment of many big enterprises, imported the technology and created suitable conditions for trade with other nations. Important for Japan's economic development was its aggressive foreign policy, especially at the turn of the $19\text{-}20^{th}$ centuries, which enlarged its labour market, land for business and agriculture development. Differently from the European countries, and more similar to the USA, Japan's economy actually gained more because of WW I. Despite that, it was relatively difficult for the industry to import high quality machines, the sudden increase of Japan's production (although still inferior in quality to Western counterparts) significantly altered its trade deficit. However, the 1920s were difficult with a series of recessions - most notable the Japanese Shōwa Financial Crisis of 1927. The 1930s were marked with difficult early situation, which was followed by the surging war industries that eventually fell down after WW2.

All four countries observed in this article were relatively developed throughout the chosen research period and had similar population and urbanisation trends. However, different in their nature of economies, their speed of industrialisation makes them solid cases for a focus on the way they reacted to the economic crisis, and how this development affected the emission of CO_2 and for that matter, the changes in temperature levels.

The dynamics of GDP (per capita) for investigated countries is presented in Fig.1. Fig.2 illustrates the dynamics of carbon emissions. It should be noted that the comparison between GDP per capita and CO_2 emissions cannot be oversimplified. If one country has a population twice as large as the other, and a twice larger gross domestic product, then both countries will have approximately the same level of GDP per capita - but the first country would, assumingly, have twice more greenhouse gas emissions. Therefore, it is very difficult to use such parameters for the analysis, but in this study, all investigated countries were approximately on the same level of development and had similar demographics rates. As a result, a relatively stable interdependence between GDP per capita and CO_2 emissions in the analysed countries was expected.

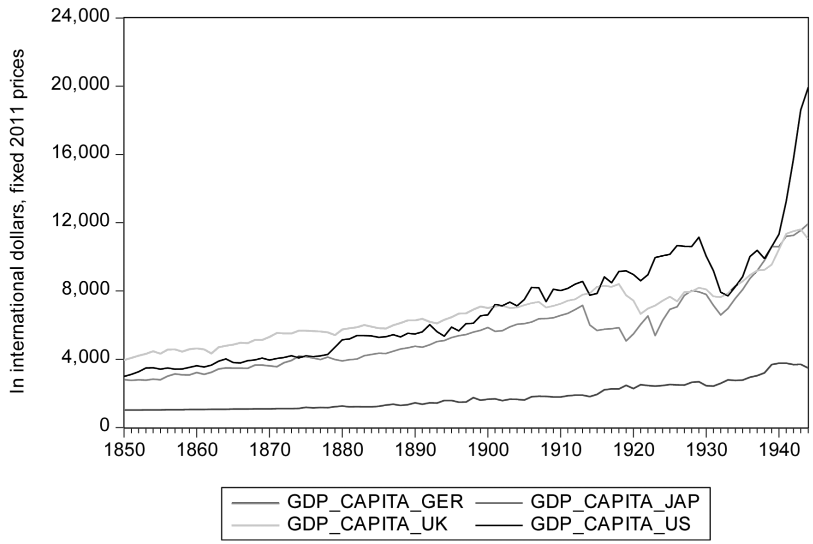

FIG.1. **The dynamics of GDP per capita**

The findings indicate a strong positive correlation between the CO_2 emissions and periods of economic recession, when industrial activity decreases. The economic activity is related to the general characteristics of each country. This trend was observed by using the scatterplot graph: The Y axis indicated the GDP (per capita) and the X axis the CO_2 emissions. The graphs suggest a mostly quadratic tendency only in the period till 1944. Fig. 3 contains data for four countries in one scatterplot.

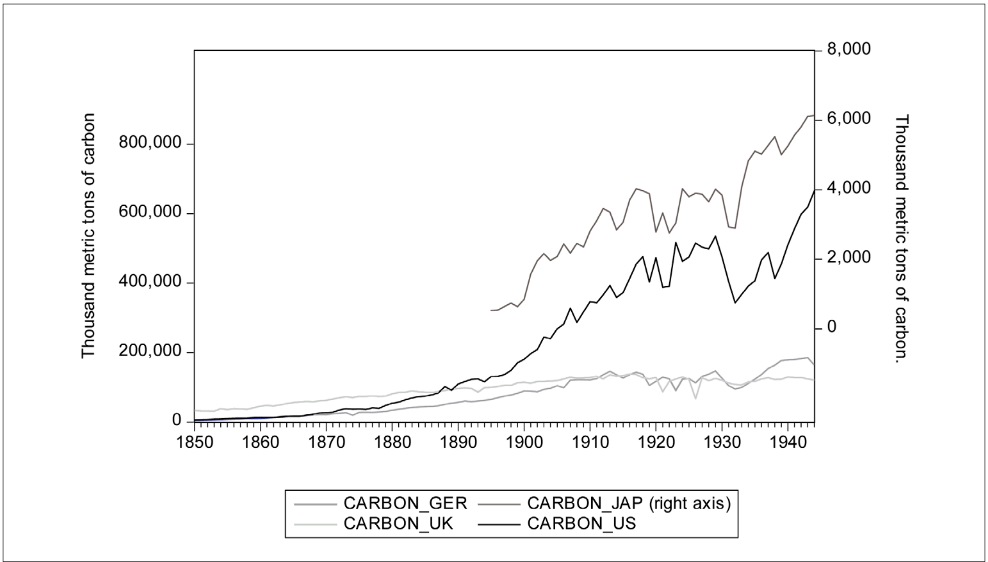

FIG. 2. **The dynamics of carbon emissions**

One may see that the dependence between variables has a quadratic relation. It means that for any increase of GDP (per capita), a country firstly needs to increase production, which results in a negative impact on the environment nature. After archiving a certain level of living standards, increased attention is paid to developing services in the structure of GDP that require less pollution for each additional dollar in GDP. Therefore, after reaching a specific level, the increase of pollution significantly slows.

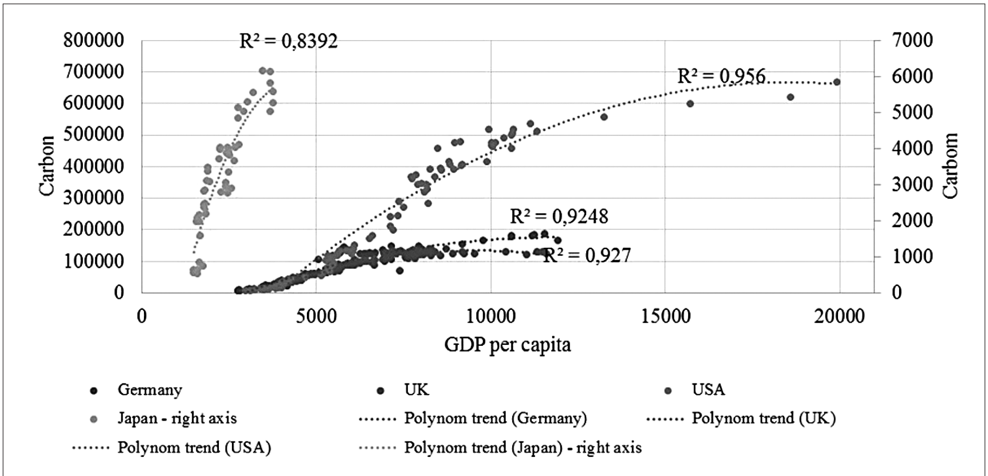

FIG. 3. **Carbon emissions (thousand metric tons of carbon) against GDP (per capita, international USD, fixed 2011 prices) in four countries between 1850–1944 (1895–1944 for Japan)**

4. Methodology

The overriding objective of this paper will be to test the relationship between the following three indicators: CO_2 emission, GDP per capita and temperature. In the first step, the correlations between the suggested variables have been checked and in the second step – the compatibility of the test results analysed. For that purpose, a correlation matrix was built for data till 1944, which contains the three main analysed variables for all countries. Under each correlation one may see the probability of non-significance of the correlation coefficient. It can be noted that in all matrices, the temperature level is not correlated with the other two parameters (except in the UK, where temperature has a low, but still significant correlation coefficient with GDP (per capita)). The correlation analysis supports the hypothesis that carbon emissions are highly correlated with GDP (per capita) (table 2).

TABLE 2. **Correlation matrices for countries**

Country	Sample size:	Indicator	Carbon	GDP per capita	Temperature
Germany	64	Carbon	1.000000		

		GDP per capita	0.869869	1.000000	
			0.0000	-----	
		Temperature	0.221544	0.168530	1.000000
			0.0785	0.1831	-----
UK	95	Carbon	1.000000		

		GDP per capita	0.849120	1.000000	
			0.0000	-----	
		Temperature	0.101554	0.212050	1.000000
			0.3275	0.0391	-----
USA	50	Carbon	1.000000		

		GDP per capita	0.849018	1.000000	
			0.0000	-----	
		Temperature	0.170447	0.151064	1.000000
			0.2366	0.2950	-----
Japan	50	Carbon	1.000000		

		GDP per capita	0.898413	1.000000	
			0.0000	-----	
		Temperature	0.057329	0.087597	1.000000
			0.6925	0.5452	-----

The lower rate of correlation between the variables of the UK might be explained by the nature of the economy as well. Here, the industrialisation had taken effect earlier than in other countries, with the CO_2 per capita rate, at the starting point of this research (year 1850), being more than 5 times higher than in the USA and almost 15 times higher than in Germany. It can be added in this respect that Germany's economic trend was by far more similar to the USA than to the UK.

The low correlation level with temperature raises the main question that needs to be solved: is it possible to predict country's temperature changes with high precision? Numerous investigations support the idea that temperature fluctuation is very hard to forecast because of their great volatility. Furthermore, a serious question must be raised on whether temperature changes at a certain location can be explained by solely one country's industrial activity, due to the nature of effect it gives. However, if we consider the Intergovernmental Panel on Climate Change (IPCC, 2007) report at least partially right, we could assume that in the long term there could be different regional temperature changes due to different regional emission levels. However, as stated above, with the low temperature correlation with two other parameters, yearly interdependence is weak; therefore, suggesting industrial activity in certain areas is not the main cause of temperature levels in a certain area.

At the same time, climate changes can be analysed much better. For that purpose, an econometric model was created, aiming to explain all fundamental shifts in temperature levels. In the first step, the average annual temperature for the four main industrial countries between 1850-1944 were taken. Based on these data, a trend was estimated by using a Hodrick-Prescott Filter for annual temperature levels (Hodrick and Prescott, 1981). Rather smoothed curves show that climate changes have great autocorrelation, therefore, it is suggested to use lagged variables to explain weather changes. In order to avoid any autocorrelation in the model, four years were selected to explain the temperature fluctuations. Surprisingly, the models for all chosen countries show high similarities. All of them have an equal structure and rather similar coefficients and characteristics.

More mathematically, the base model can be described in the following way:

$$hp\_temp_{t,j} = \beta_{0,j} + \sum_{i=1}^{4} \beta_{i,j} \cdot hp\_temp_{t-i,j} + \varepsilon_{t,j} \qquad (1)$$

where

$hp\_temp_{t-i,\,j}$ – smoothed by Hodrick-Prescott Filter average annual temperature in the period t for country j,

$\beta_{i,\,j}$ – model coefficients for country j,

$\varepsilon_{t,\,j}$ – residuals for period t for model for country j.

As countries have different temperature levels (for example, the average temperature for the USA is 11,0 degrees Celsius (°C), for the UK – 9,4, for Germany – 8,1 and for Japan – 14,9), it was decided not to use a panel regression model to avoid problems with distinctions in average temperature levels. Instead, we built 4 identical models (in line with equation (1)) for each country.

The model for the UK consists of 91 observations, 46 for the USA, 60 for Germany and 80 for Japan. The results are presented in the appendix (models 1–4), summaries are shown in table 3.

TABLE 3. **Estimation results of (1)**

Coefficient	Germany	UK	USA	Japan
β_1	0.053359	0.040964	0.047094	0.040530
β_1	3.184754	3.228390	3.208456	3.372935
β_2	-3.956369	-4.005908	-3.946930	-4.363636
β_3	2.291013	2.279167	2.240937	2.556736
β_4	-0.526034	-0.506064	-0.506764	-0.568739
R^2	0.999730	0.999750	0.999846	0.999867

As one may see (appendix, models 1-4), all models are significant and all coefficients are also significant. All built models reject the autocorrelation (LM test) and heteroscedasticity (White test) presence. It has to be noted that all coefficients are rather similar for all described models. The combination of these coefficients explain the fluctuation in temperature levels in all investigated countries.

The analysis strictly supports the idea about stability of the models. The Chow Breakpoint Test rejects the hypothesis about structural breaks in all points from 1900 till 1938. This sample was used for checking the structural breaks hypothesis, because a minimum of at least 20 observations was needed to correctly estimate models.

It is very important to mention that changes in coefficients are rather independent of the sample. Table 4 shows all the coefficient dynamics of the models for different samples and their descriptions.

TABLE 4. **Model (1) coefficients and their descriptive statistics**

Country	Coefficient	Mean	Median	Maximum	Minimum	Std. Dev.
Germany	β_1	3.174328	3.158533	3.326318	3.042807	0.081271
	β_2	-3.905957	-3.899473	-3.509905	-4.448797	0.252511
	β_3	2.224572	2.199536	2.918164	1.819855	0.276273
	β_4	-0.500043	-0.488828	-0.357172	-0.797239	0.107245
UK	β_1	3.157249	3.192786	3.232548	2.709373	0.101680
	β_2	-3.876238	-3.939188	-2.959497	-4.049883	0.194196
	β_3	2.232248	2.239784	2.349202	1.723447	0.102236
	β_4	-0.523971	-0.510502	-0.481532	-0.645657	0.040393
USA	β_1	3.157760	3.192817	3.263102	2.909753	0.091155
	β_2	-3.865380	-3.914884	-3.450515	-4.100608	0.169965
	β_3	2.171896	2.214193	2.399507	1.885185	0.142691
	β_4	-0.474111	-0.485325	-0.358955	-0.548755	0.050621
Japan	β_1	3.400391	3.390641	3.653731	3.157634	0.062968
	β_2	-4.446270	-4.404563	-3.697384	-5.221010	0.191333
	β_3	2.640565	2.592852	3.455402	1.729543	0.202266
	β_4	-0.597811	-0.581066	-0.188854	-0.892968	0.075269

The results show that coefficients have rather low volatilities. One can make a conclusion that at least until 1944, the temperature level was defined by temperature values of four previous years.

In order to support the hypothesis that the current temperature can be defined based on the four last values of the smoothed annual temperature. For this reason, the sample was expanded till 2014 for Germany. The model was estimated by using a restricted sample. The first observation was temperature for 1881 and the final year was changed from 1911 to 2013. For each such sample the real values of annual temperature were smoothed with the Hodrick-Prescott Filter, the model was estimated and a forecast was built for one next period. This procedure was repeated 113 times, giving 113 different forecasts. Forecast mistakes were calculated by using the given forecast value and the real observation number. The descriptive statistics are presented below (table 5).

TABLE 5. **Residuals descriptive statistics for model (1) for Germany**

Mean	-0.000808
Median	-0.001421
Maximum	2.115674
Minimum	-1.725505
Std. Dev.	0.764785
Skewness	0.133294
Kurtosis	2.874040
Jarque-Bera	0.409319
Probability	0.814925
Sum	-0.091289
Sum Sq. Dev.	65.50834
Observations	113

The mean value of all forecast mistakes is -0.000808, quite close to zero. The median for the residuals is also quite close to zero. Extreme values belong to the interval between -1.72 and +2.12. The standard deviation shows that at least 95% of all mistakes must be in the confidence interval [-1,49; 1,49]. All residuals are distributed normally, what is supported by Jarque-Bera statistics.

The expansion of the sample did not change the descriptive statistics for the coefficients (table 6), therefore a good stability of the model can be assumed.

TABLE 6. **Coefficients statistics for model (1) for Germany with dynamic estimation**

Characteristics	β_1	β_2	β_3	β_4
Mean	3.180730	-3.936911	2.265369	-0.516003
Median	3.184754	-3.956369	2.291013	-0.526034
Maximum	3.326318	-3.509905	2.918164	-0.357172
Minimum	3.042807	-4.448797	1.819855	-0.797239
Std. Dev.	0.050392	0.157706	0.173494	0.067366
Skewness	0.116330	-0.084689	0.256455	-0.669978
Kurtosis	4.748172	5.295423	5.801301	6.776332
Jarque-Bera	14.77363	25.16387	38.52422	76.26677
Probability	0.000619	0.000003	0.000000	0.000000
Sum	362.6032	-448.8079	258.2521	-58.82430
Sum Sq. Dev.	0.286952	2.810426	3.401312	0.512819
Observations	114	114	114	114

The research showed that no evidence of CO_2 emissions that correlate to the average temperature is found. The investigations support the hypothesis that the main law of temperature fluctuations did not change for 114 years of observations. Of course, it does not mean that emissions do not influence other aspects of climate and pollution, but the main trend in temperature levels seems to be stable for at least 120 years in different countries.

In further studies research, the model may be checked for more countries – as long as statistical data is available.

5. Conclusions

Since the paper is focused on data between 1850-1944, it would be relevant to focus on long-term continuous temperature changes. It was shown that temperature changes fluctuate greatly, although there is a general upward trend. In the long-run, no evidence was found that economic changes led to temperature fluctuation. Moreover, a very stable model was designed, which predicts temperature level with very high precision. In the short-term, sudden temperature fluctuations could be caused by several factors.

Firstly, it is likely that solar radiation explains periodical and non-periodical climate changes. Despite an ongoing debate among scientists on the degree/kind of effect variation in solar activity might have on global temperature, evidence suggests that changes in solar activity impact surface temperature. Eddy (1976) refers to the significantly lower temperatures during the seventy-year-long lasting prolonged sunspot of 1645.

Secondly, many scientists refer to natural disasters as being mainly responsible for sudden changes of temperature, e.g., volcanic eruptions release large quantities of ash and sulphuric gases into the atmosphere, significantly influencing solar radiation normally reaching the surface of the planet. A part of that effect can be contributed to clouds formed by sulfur aerosols with more water droplets that efficiently reflect the solar radiation. Volcanic eruptions, therefore, may have sudden and short-term lasting effects on temperature of the Earth – usually between 1-2 years long.

Thirdly, it is impossible to reject the influence of human activities as an important factor, which contributes (particularly since the early stages of the industrial revolution) to global warming. The majority of the greenhouse gases (mostly CO_2) are released as a result of the burning of non-renewable fossil fuels. Related to the abundance and characteristics of the individual sources of energy (coal, gas, oil), they affect the warming of the atmosphere to a different degree. For instance, CO_2 is said to produce eight times less greenhouse effects than methane – in other words: one molecule of methane reflects infrared radiation by the factor of eight, compared to a molecule of CO_2. With a focus on the concentration, among Carbone dioxide, methane and nitrous oxide, and water vapour after methane, the CO_2 is said to have the biggest impact on global warming. Moreover, whereby methane naturally breaks down relatively quickly in the atmosphere – the lifespan of CO_2 exceeds the first one.

A general review of all the factors discussed reveals that CO_2 is one of the main contributors to sudden and unexpected temperature changes, however not the only and by far, not necessarily the decisive one. These findings suggest (and might explain) that reduced amounts of CO_2 emissions during economic recessions – such as the Great Depression – had no significant cooling effects on the Earth.

At the same time, the research shows that the long-run temperature can be evaluated with the help of annual average temperatures for the 4 previous years. The proposed model does not only give quite satisfactory forecasts, but is very stable with coefficients variables that can make a model more reliable for practice.

The research showed that no evidence of CO_2 emissions was found, which correlates to the average temperature, but that does not necessarily imply that emissions do not influence other aspects of climate and pollution. Moreover, the main temperature fluctuations seem to be stable for at least 120 years in the observed countries.

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APPENDIX

Model 1
Dependent Variable: HPTREND_GER
Method: Least Squares
Date: 10/12/15 Time: 18:59
Sample (adjusted): 1885 1944
Included observations: 60 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.053359	0.021146	2.523350	0.0145
HPTREND_GER(-1)	3.184754	0.118455	26.88572	0.0000
HPTREND_GER(-2)	-3.956369	0.333810	-11.85214	0.0000
HPTREND_GER(-3)	2.291013	0.333164	6.876535	0.0000
HPTREND_GER(-4)	-0.526034	0.117591	-4.473408	0.0000
R-squared	0.999730	Mean dependent var		7.994129
Adjusted R-squared	0.999710	S.D. dependent var		0.214568
S.E. of regression	0.003654	Akaike info criterion		-8.306566
Sum squared resid	0.000734	Schwarz criterion		-8.132037
Log likelihood	254.1970	Hannan-Quinn criter.		-8.238298
F-statistic	50858.87	Durbin-Watson stat		2.096215
Prob(F-statistic)	0.000000			

Model 2
Dependent Variable: HPTREND_UK
Method: Least Squares
Date: 10/12/15 Time: 18:54
Sample (adjusted): 1854 1944
Included observations: 91 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.040964	0.019346	2.117367	0.0371
HPTREND_UK(-1)	3.228390	0.094681	34.09765	0.0000
HPTREND_UK(-2)	-4.005908	0.270246	-14.82319	0.0000
HPTREND_UK(-3)	2.279167	0.272328	8.369193	0.0000
HPTREND_UK(-4)	-0.506064	0.096931	-5.220848	0.0000
R-squared	0.999750	Mean dependent var		9.239824
Adjusted R-squared	0.999738	S.D. dependent var		0.221032
S.E. of regression	0.003578	Akaike info criterion		-8.374706
Sum squared resid	0.001101	Schwarz criterion		-8.236746
Log likelihood	386.0491	Hannan-Quinn criter.		-8.319048
F-statistic	85847.82	Durbin-Watson stat		1.995607
Prob(F-statistic)	0.000000			

Model 3

Dependent Variable: HPTREND_US
Method: Least Squares
Date: 10/12/15 Time: 19:11
Sample (adjusted): 1899 1944
Included observations: 46 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.047094	0.024394	1.930550	0.0605
HPTREND_US(-1)	3.208456	0.136688	23.47277	0.0000
HPTREND_US(-2)	-3.946930	0.391019	-10.09397	0.0000
HPTREND_US(-3)	2.240937	0.395869	5.660799	0.0000
HPTREND_US(-4)	-0.506764	0.141996	-3.568870	0.0009
R-squared	0.999846	Mean dependent var		11.02701
Adjusted R-squared	0.999831	S.D. dependent var		0.237411
S.E. of regression	0.003091	Akaike info criterion		-8.618634
Sum squared resid	0.000392	Schwarz criterion		-8.419869
Log likelihood	203.2286	Hannan-Quinn criter.		-8.544175
F-statistic	66378.31	Durbin-Watson stat		1.972352
Prob(F-statistic)	0.000000			

Model 4

Dependent Variable: HPTREND_JAP
Method: Least Squares
Date: 11/07/15 Time: 12:46
Sample (adjusted): 1865 1944
Included observations: 80 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.040530	0.019880	2.038753	0.0450
HPTREND_JAP(-1)	3.372935	0.096710	34.87667	0.0000
HPTREND_JAP(-2)	-4.363636	0.276562	-15.77816	0.0000
HPTREND_JAP(-3)	2.556736	0.275853	9.268465	0.0000
HPTREND_JAP(-4)	-0.568739	0.095711	-5.942242	0.0000
R-squared	0.999867	Mean dependent var		14.50482
Adjusted R-squared	0.999860	S.D. dependent var		0.617712
S.E. of regression	0.007310	Akaike info criterion		-6.938645
Sum squared resid	0.004008	Schwarz criterion		-6.789768
Log likelihood	282.5458	Hannan-Quinn criter.		-6.878956
F-statistic	141003.0	Durbin-Watson stat		1.669499
Prob(F-statistic)	0.000000			