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Greenhouse emissions and economic recessions: Did industrial economies “Stay Cool” during the 1930s economic crisis?

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In this historical economic interdisciplinary research we investigate the impact of the 1930s economic crisis and their relationship to global warming. We investigate two consecutive hegemonic powers: the United Kingdom and the United States. Our assumption was that a reduction in demand would lead to a decrease in mean global temperatures during depressions. We find that in fact reduced carbon dioxide in the atmosphere resulting from lowered production does not result in cooling temperatures.

JEL Classifications: B23, B52, N50, Q54

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Purpose and overview

Our purpose is to use empirical data to show the relationship between country gross domestic product (GDP) and carbon dioxide (CO₂) emissions. We believe that CO₂ emissions are the most suitable indicator for judging a country's industrial development, because this kind of gas is produced by factories, which indicate the industrial activity of the country.

In this paper we examine the CO₂ emission level and country economic performance during the period of 1927-1944. This particular interval was chosen for a few reasons. Firstly, it covers the Great Depression. Secondly, there are easy accessible data of this interval: the “GapMinder” foundation and the “Carbon Dioxide Information Analysis Center” both provide valid data which we used. We had wanted to study the GDP/CO₂ connection during the crisis of the 1870s, but were not able to find valid data for that period. Our general assumption is that during financial crises, consumer spending drops, causing industries to operate less, and thereby emit less greenhouse gases, specifically, CO₂.

Review of literature and theoretical framework

We theoretically base our work on the world-systemic perspective, which developed as a reaction to dependency theorists (Amin, 1976 and 1994; Kohler and Tausch, 2002; Yotopolous and Sawada, 2005; Giedraitis, 2007). During the 1970s, historical economic sociologists such as Wallerstein (1974) and Frank (1978) began to theorize an expanding European economic world-system, which could be used to explain the historical economic development (or lack thereof) of countries around the world. This model sees capitalist market relations as a means of wealth redistribution, from the poor peripheral countries to rich core countries, or from the global South to the global North (Arrighi, 1995; Turchin, 2007).

One of the structural constants of the world-systemic perspective is the assumption of centuries old business cycles. This emphasis on 45 to 60 year Kondratiev business cycles have been criticized by some for not explaining the origins of the cycle, or Kondratiev waves as being simply economic correlations rather than a cause of economic growth or depression (Solomou, 2004). Empirical evidence, however, indicates a correlation between the trough of a Kondratiev wave (ex. 1870s and 1930s), and economic depressions. Schumpeter (1943) noted that innovators can breathe life into an economy through the introduction of new technologies and innovations such as the steam engine which helped bring about the industrial revolution (Giedraitis and Rasteniene, 2009).

World-systems analysis sees different powers as being dominant at different historical periods (Chase-Dunn 1991). The Dutch economy was based on trade rather than industrial might, as its two consecutive successors: the United Kingdom (UK) and the United States (USA).

With the arrival of the industrial revolution came an increase in emissions of greenhouse gases. Coal fuelled steam power enabled the transition of a manual labour based economy to machine-based manufacturing. This resulted in a significant increase in production capacity. Further development of technologies, mainly heavy industry, ensured continuing economic growth, but at the expense of rapidly increasing CO₂ emissions.

Data and analysis

In this part we analyse the relation between CO₂ concentrations in the atmosphere and economic activity (in our case - GDP per capita) during financial crisis. Economic activity is based on general characteristics of each country. Table 1 shows a summary of the type of economy present in each of our two observed countries.

TABLE 1. GENERAL ECONOMIC QUALITIES OF STUDIED COUNTRIES

| Country | Characteristics |
|----------------|---|
| United States | The period from 1927 to 1944 is marked by the Great Depression, recession and application of Keynesian economics. However, preparation for World War II led to an increase in production. That is an explanation of why CO ₂ emission dropped in 1929 and began to recover in 1938. |
| United Kingdom | The Great Depression affected the UK economy in several ways: firstly, the UK was forced to sell its gold and dollars reserves to pay for munitions and raw materials from the United States (which led to a further increase in production in the United States), secondly, UK exports in 1940 declined one third compared to 1935. What is more, World War II caused a huge loss in amount of general wealth. |

Looking from the historical perspective it must be noted that the United Kingdom and United States were industrial countries. CO₂ emissions are highest in the United States, whose economy, despite the Great Depression, was increasingly driven by burgeoning war industry.

Methodology

The main objective of this paper is to test the relationship between two indicators: CO₂ emission per capita and GDP per capita. Our hypothesis was that as GDP per capita increased, CO₂ would increase. Below is an elaboration of our indicators:

1. CO₂ emissions level. This number indicates the amount of carbon dioxide gas emitted in the atmosphere during our chosen period of time (1927 - 1944);
2. GDP per capita. This number indicates the total value (in dollars) of all goods and services made in each country;
3. World population data. This number shows the amount of inhabitants in each country.

We used two sources to gather our data: the “Carbon Dioxide Information Analysis Center”, which provides the amount of emitted CO₂. Other data is from the “GapMinder Foundation”, which stores various kinds of world developing data. In this paper we used the data from the latest release, which was published in at the end of 2009.

The first problem which we faced was that there is no clear CO₂ emission per capita statistics. Therefore, we compute this variable by manually. We did so in this way: first we took the CO₂ emission level, then divided it by the number of inhabitants, and multiplied by 100.

Before running correlations between variables, we checked the linear trend with scatterplot graph: GDP per capita on the Y axis and CO₂ emission on X axis. Graphs showed a mostly linear tendency. Then two kinds of calculations were done. Firstly, we checked the correlation between variables, then our model compatibility to the data. It must be noted, that our sample was quite small (n=18). Because of this, calculations should be understood not as a conclusive argument for the relation between GDP and CO₂ emissions, but rather as supporting data.

Statistical analysis and interpretation

Statistical data was analyzed for both countries as listed below.

TABLE 2. CORRELATION BETWEEN GDP AND CO2 EMISSION LEVELS IN THE USA

| Correlations | | GDP_USA | CO2_USA |
|--------------|---------------------|---------|---------|
| GDP_USA | Pearson Correlation | 1.000 | -0.161 |
| | Sig. (2-tailed) | | 0.522 |
| | N | 18.000 | 18 |
| CO2_USA | Pearson Correlation | -0.161 | 1.000 |
| | Sig. (2-tailed) | 0.522 | |
| | N | 18 | 18.000 |

From this table could be judged that, according to the statistical calculations there is no direct relation between these two variables.

TABLE 3. CORRELATION BETWEEN GDP AND CO2 EMISSION LEVELS IN THE UK

| Correlations | | GDP_UK | CO2_UK |
|--------------|---------------------|--------|--------|
| GDP_UK | Pearson Correlation | 1.000 | -0.220 |
| | Sig. (2-tailed) | | 0.380 |
| | N | 18.000 | 18 |
| CO2_UK | Pearson Correlation | -0.220 | 1.000 |
| | Sig. (2-tailed) | 0.380 | |
| | N | 18 | 18.000 |

As in the USA, in the UK there is no direct relation between GDP and CO2, and the correlation is very similar.

Finally, the prediction model compatibility to the data must be checked. For that we used a classical ANOVA table.

TABLE 4. MODEL COMPATIBILITY TO THE DATA: GDP PER CAPITA IN USA AND CO2 EMISSION LEVEL PER CAPITA IN USA

| ANOVA ^b | | | | | |
|--------------------|----------------|----|-------------|-------|--------|
| Model | Sum of Squares | df | Mean Square | F | Sig. |
| Regression | 3.61E+28 | 1 | 3.61E+28 | 0.428 | 0.522a |
| Residual | 1.35E+30 | 16 | 8.44E+28 | | |
| Total | 1.39E+30 | 17 | | | |

Notes: a. Predictors: (Constant), CO2_USA; b. Dependent Variable: GDP_USA

It must be pointed out, that regression coefficient is higher than 0.05 (meaning is 0.522). Therefore we can assume that there is no significant correlation between variables, and, what is more, this model is not very suitable for such calculations. At last, the second ANOVA table was computed to check this model compatibility to the United Kingdom case.

TABLE 5. MODEL COMPATIBILITY TO THE DATA: GDP PER CAPITA IN UK AND CO2 EMISSION LEVEL PER CAPITA IN UK

| ANOVA ^b | | | | | |
|--------------------|----------------|----|-------------|-------|--------|
| Model | Sum of Squares | df | Mean square | F | Sig. |
| Regression | 7.72E+28 | 1 | 7.72E+28 | 0.814 | 0.380a |
| Residual | 1.52E+30 | 16 | 9.48E+28 | | |
| Total | 1.59E+30 | 17 | | | |

Notes: a. Predictors: (Constant), CO2_UK; b. Dependent Variable: GDP_UK

In this case situation is slightly better: the regression coefficient is a bit smaller than in the previous table. Therefore this model is more suitable for analysis. On the other hand, statistically, 0.38 is a higher number than 0.05 and because of this reason we argue that our model fits nor the USA, nor the UK.

In short, several tendencies should be pointed out. Firstly, due to the small number of variables ($n=18$) correlation analysis should be understood only as a supporting argument for our thesis. Secondly, our hypothesis was partially supported. Finally, it must be taken into account, that one indicator (in our case - CO₂ emissions) is not enough to make unequivocal statements about a country's economy development. These calculations are only a first step in the identification of the delicate and complicated relation between environmental pollution and economic performance.

Conclusion

Since our paper is based on the period of 1927 -1944 it would be irrelevant to focus on long-term continuous temperature changes. Therefore, short-term and sudden temperature fluctuations were analyzed, which could be caused by several factors.

Firstly, solar radiation accounts for periodical and non-periodical climate changes. Even though scientists still argue what kind of effect solar variation has on global temperature, there is evidence proving, that changes in solar activity influences surface temperature. For instance, during a prolonged sunspot minimum which lasted for seventy years since 1645, temperatures were significantly lower than average (Eddy, 1976).

Another natural factor causing sudden temperature changes is volcanic eruption. During explosive volcanic eruptions large quantities of ash and sulfur gases are released into the atmosphere, which limit the amount of solar radiation reaching the earth's surface. Moreover, sulfur aerosols form clouds with more water droplets, which also efficiently reflect solar radiation. As a result, eruptions have sudden and short-term (1-2 years) cooling effect on earth. It is important to point out, that during the period of the Great Depression no unusual changes in volcanic activity were recorded.

Third, human activities since the beginning of industrial era were important factors contributing to surface temperature changes. Greenhouse gases (primarily CO₂) are emitted in the atmosphere during combustion of fossil fuels such as coal, oil and gas in power plants, automobiles, industrial facilities (cement manufacture, steel production etc.). According to their abundance and characteristics these gases contribute differently to global warming. For instance, in equal amounts, CO₂ is eight times weaker greenhouse gas than methane. This means that one molecule of methane can reflect eight times more infrared radiation (i.e. heat) back to the earth's atmosphere, compared to one molecule of carbon dioxide. However, among carbon dioxide, methane (CH₄), nitrous oxide (N₂O), and water vapor, CO₂ is the second most important gas causing the greenhouse effect, when considering concentrations.

This brief review of factors causing sudden temperature changes reveals carbon dioxide as an important contributor, yet by far not the decisive one. This explains why even largely reduced amounts of emitted and cumulative CO₂ in the atmosphere during the Great Depression had no cooling effect on earth.

Further arguments supporting this statement include analysis of the 1930s economic recession. In various countries the downturn began and lasted for different time periods. For instance, the USA suffered from a severe and sudden recession, but recovered faster than the Netherlands (which preceded the UK as the global hegemonic power), where crippling effects on the economy lasted longer than in most other countries. However, according to "Climate Analysis Indicators Tool (CAIT)" (Washington, DC: World Resources Institute, 2010) "the Netherlands account only for 1.33% of total world CO₂ emissions in the year 1932 (year when the lowest point in global carbon dioxide concentrations was reached), while the United States of America emitted 39.93% of world total CO₂.

Thus, combining various countries' influence on global carbon dioxide emission capacity during the period of Great Depression, the year 1932 is seen as the year when CO₂ emissions stop decreasing and start to increase again. This time span is too short for all cumulative carbon dioxide to leave the atmosphere by natural processes (incorporation into plants via photosynthesis, mixing into oceans, etc.). As a result, reduced quantities of CO₂ emission from anthropogenic activities during the Great Depression had no effect on earth's temperature.

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