The Impact of CO_2 Emissions and Climate on Economic Growth and Productivity: International Evidence

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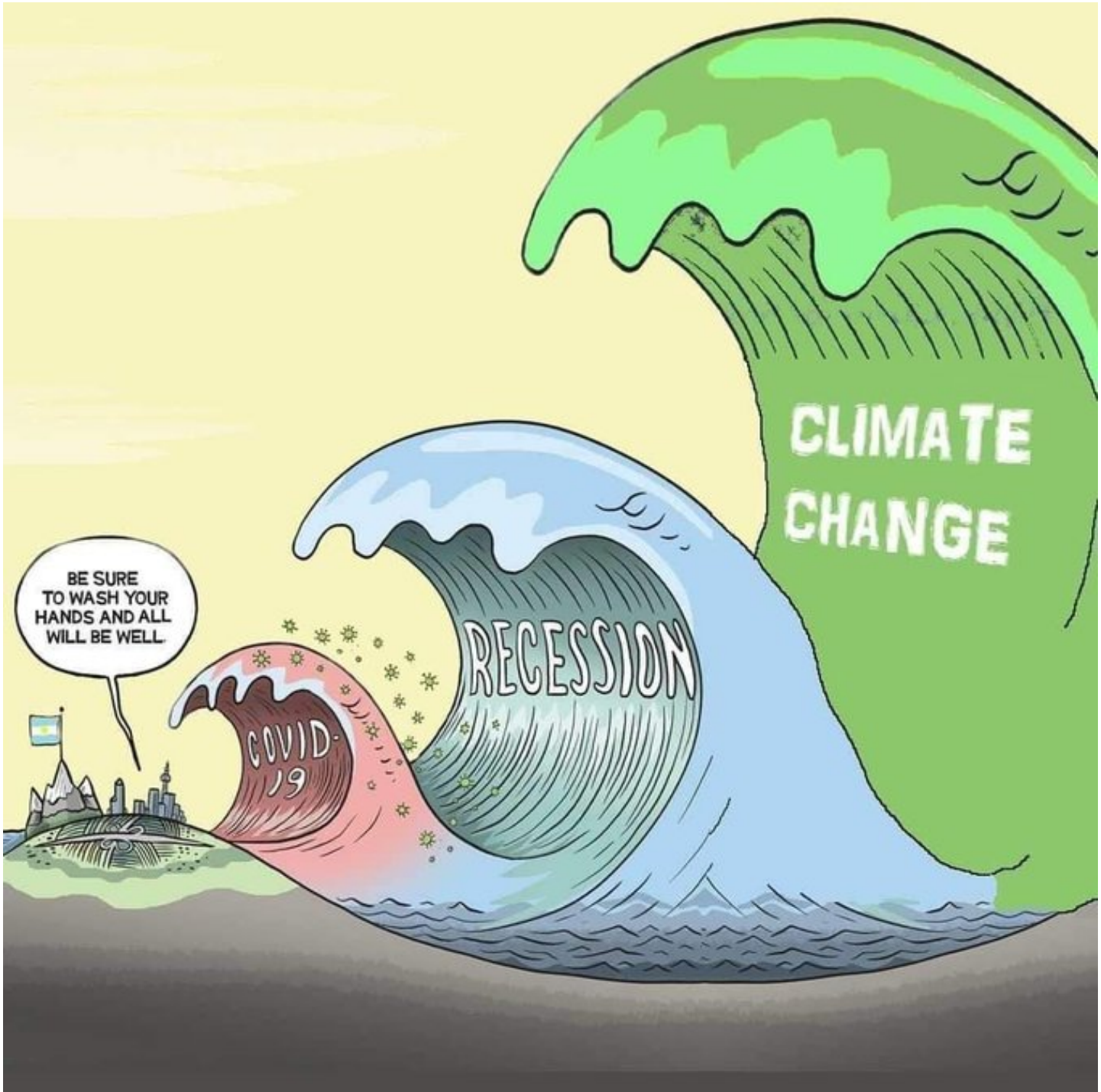
Outline

Preview

Sneak Preview:

- The role of climate change on economic growth. Climate change as a compilation of CO_2 emissions, temperatures and rainfall.
- Poor get poorer, while richer seem to remain intact.
- Renewable energy sources need to get bigger share of energy production.


CLIMATE CHANGE
RECESSION
COVID-19
BE SURE TO WASH YOUR HANDS AND ALL WILL BE WELL

Introduction

- One of the most critical and biggest problems of contemporaneous generations is the climate crisis that has emerged over the last decades.
- Climate change is the term used to describe the human made change of meteorological or natural phenomena that holds for long time periods causing global warming, deforestation, melting of permafrost and other risky effects that result in dangerous paths.
- Uncontrollable environmental pollution, mainly from pollutant releases of the industry sector, has caused the greenhouse effect which is responsible of the temperature increase and the climate change that is conducted.

Climate Change and Economy

- The impacts of pollution and rising temperatures drive to climate change risks that cause economic shocks, meaning unpredictable events that can produce significant harm within an economy, especially on agricultural sector which is the most vulnerable sector of the economy due to its nature.
- Climate change not only creates unfriendly environmental conditions for citizens and regions but also has an impact on the economy at regional and country level.
- Labour productivity also deteriorates when human body is exposed in prolonged heat conditions. Air humidity can make higher temperatures even more dangerous.
- Pollutant releases and contamination can cause greater hazard by increasing the temperature and by worsening the environment.

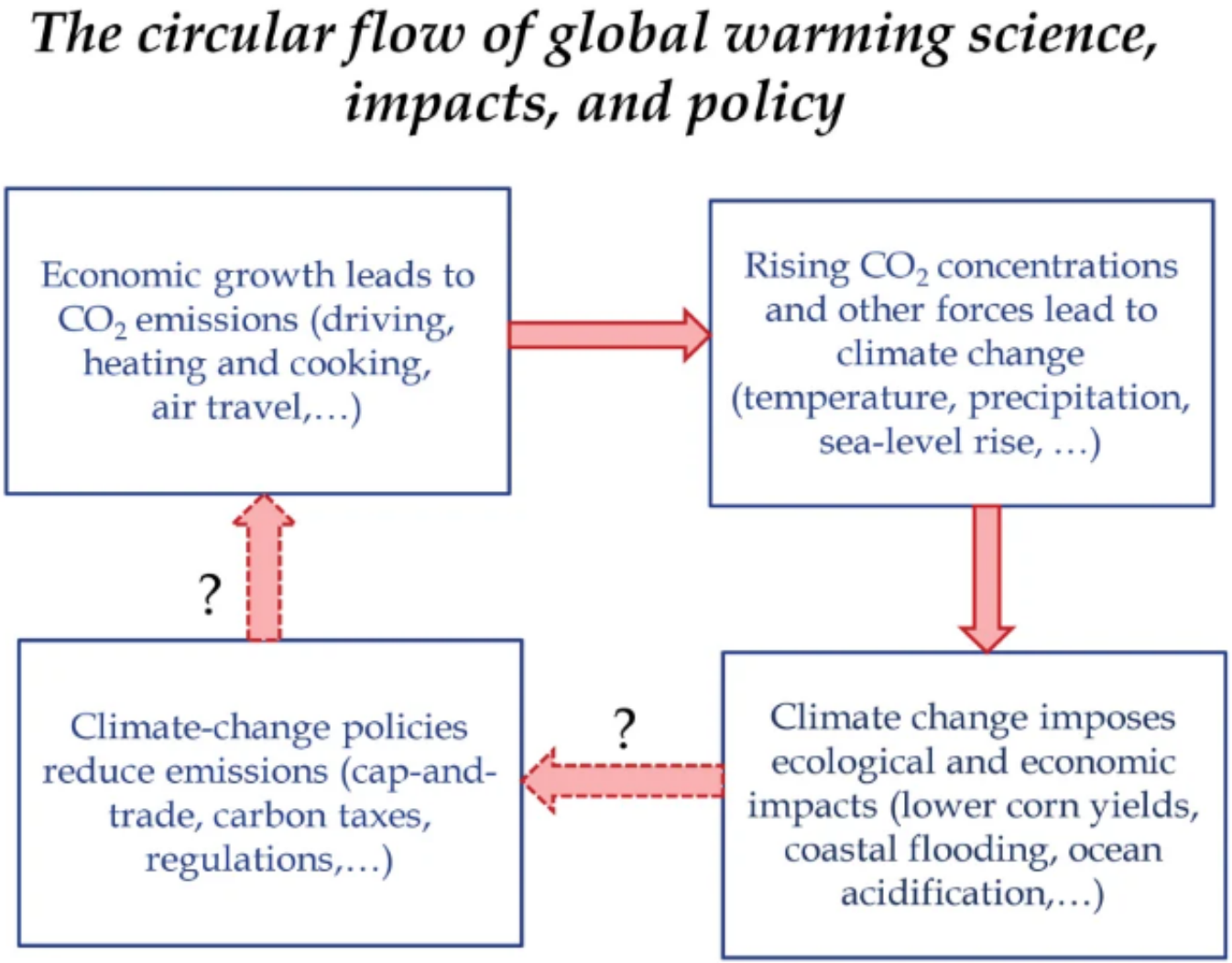


Figure: William Nordhaus, The Climate Casino, 2013

Literature Review

- Many studies examine the effects of temperature in the agricultural sector (Neidel (2012), Mendelsohn (2008), Deschenes (2007)). However this can not fully explain GDP losses, especially in national economies with a weak agricultural sector.
- Temperature increase by 1^oC for a given year reduces that year's GDP by 1.3% (Dell, 2012). Poor countries tend to be more vulnerable.
- Similar results are presented when the temperature-countries TFP growth relationship is investigated (Letta, 2019). Also, temperature lags have an effect on countries' economic growth implying a persistence of weather in the medium run.
- Precipitation is whether a weak significant and positive estimator of economic productivity (Dell, 2012) or not significant at all (Letta, 2019).

Pollution and Productivity

- Increasing amount of emissions and air pollution brings along impacts on the economy. Multiple researches have investigated the relationship between different types of greenhouse gases (GHG's) and economic growth or productivity (Tol(2018), Pindyck(2020)).
- Most studies explore the short-run relationship between pollution and labor supply, mainly through work hours. Common finding in those studies is that emissions have a negative impact on worker productivity (Hanna(2015), Graff-Zivin(2012)).
- Chang et al.(2019) find the effect of emissions on labor productivity can also be found on jobs that do not require human presence on open space. Similar evidence is provided by a handful of other studies (He(2019), Koundouri(2010)) suggesting that air pollution has significant negative impacts on worker productivity.

Renewable Energy Sources

- The amount of energy produced from renewable sources is considered as clean or green energy because no emissions are created during the energy production process.
- Le et al.(2020) find that the use of renewable energy sources help limit emissions but only in developed countries. They also indicate that GHG emissions have a significantly positive effect on economic growth.
- Apergis (2010) testing for OECD countries, find positive and statistically significant nexus between renewable energy consumption and economic growth detecting bidirectional causality for the two variables of interest.

Emissions and Temperature Nexus

- It is well known that the anthropogenic emissions (and more specifically carbon dioxide) are responsible for the increase of temperature that has been conducted since the industrial revolution and the passage from manual work to machines.
- Kaufmann (2006) supports the above mentioned causal relationship and also states that reverse causality is existing. More specifically, high temperatures have changed the way that carbon dioxide emissions flow in the atmosphere, thus increasing atmospheric concentration.

Methodology and Empirical Framework

- The purpose is to estimate the relationship among countries' economic growth, capital, labor, energy, carbon dioxide emissions, temperature and share of renewable energy sources.
- We make use of a standard production function and use two methods for estimation:
  - Fixed effects OLS
  - Instrumental Variable Regression
- Fixed effects estimators although better than the standard regression estimators, may still be biased. More specifically, unobserved time varying differences across countries, imply selection bias. A second problem that arises potential bias is the reverse causality that results from the link between emissions and growth.

Fixed-effects Estimation

Fixed-effects Estimation

$$Y_{it} = \beta_0 + \beta_1 K_{it} + \beta_2 L_{it} + \beta_3 En_{it} + \beta_4 CO2_{it} + \beta_5 W_{it} + \alpha_i + \pi_t + \varepsilon_{it}$$

- Y_{it} describes economic growth of a country (i) for a given year (t)
- K_{it} is countries' gross capital stock
- L_{it} is total number of employees
- En_{it} depicts countries' energy consumption
- W_{it} is a vector of weather variables including annual mean temperature and annual mean cumulative precipitation
- $CO2_{it}$ describes each country's annual tons of carbon dioxide
- α_i depicts country fixed effects that are caused by time invariant country characteristics and affect GDP growth
- π_t is year fixed effects and capture annual transnational shocks to countries' economic growth, such as macroeconomic effects
- ε_{it} is the error term and captures time variant country characteristics that are unobservable and not included in the parameters of the estimation, but affect countries' economic growth

Instrumental Variable Regression

First Stage of Instrumental Variable Regression

$$CO2_{it} = \rho_4 W_{it} + \rho_5 RE_{it} + \alpha_i + \pi_t + \mu_{it}$$

or

$$temp_{it} = \rho_4 CO2_{it} + \rho_5 prec_{it} + \alpha_i + \pi_t + \mu_{it}$$

- RE_{it} is each country's share of renewable energy
- μ_{it} is the error term

Second Stage of Instrumental Variable Regression

$$Y_{it} = \beta_0 + \beta_1 K_{it} + \beta_2 L_{it} + \beta_3 En_{it} + \beta_4 CO2_{it} + \alpha_i + \pi_t + \varepsilon_{it}$$

or

$$Y_{it} = \beta_0 + \beta_1 K_{it} + \beta_2 L_{it} + \beta_3 En_{it} + \beta_4 tempit + \alpha_i + \pi_t + \varepsilon_{it}$$

Data

- We make use of a panel shaped dataset consisting of 115 countries, covering 1961 to 2015 period.
- *GDP data:* Output side real GDP (at chained PPP's and also in million 2011 US $) and TFP level at current PPP's are being used as dependent variables. Both are derived from Penn World Table version 9.1 dataset.
- *Capital & Labor:* Capital stock (expressed at 2011 national prices) and the number of persons engaged (in millions) for every country, are being used in order to create a classic Cobb-Douglas production function.
- *Energy data:* We collect data from World Bank for energy use (kg of oil equivalent per capita).
- *RES:* By using World Bank datasets we collect combustible renewables and waste dataset (expressed as a percentage of energy) which is comprised from solid biomass, liquid biomass, biogas, industrial waste, and municipal waste, measured as a percentage of total energy use. For robustness checks we use RES produced from wind and solar photovoltaic (PV) technologies.

Data

- *Emissions:* The CO_2 emissions dataset (metric tons per capita) from World Bank, includes country-year quantities of carbon dioxide emissions during consumption of solid, liquid and gas fuels and gas flaring.
- *Climate:* Temperature and precipitation records (derived from Matsuura and Willmott) are used as proxies for climate. Data is on monthly level and represent recorded temperature and precipitation for a particular geographical area bounded by 0.5^o latitude and by 0.5^o longitude contours. We convert monthly climatic records to annual average temperature and annual cumulative precipitation. Then, we match them to country boundaries and construct average annual average temperature and annual average cumulative precipitation for 115 countries and 55 years.

Data - Temperature

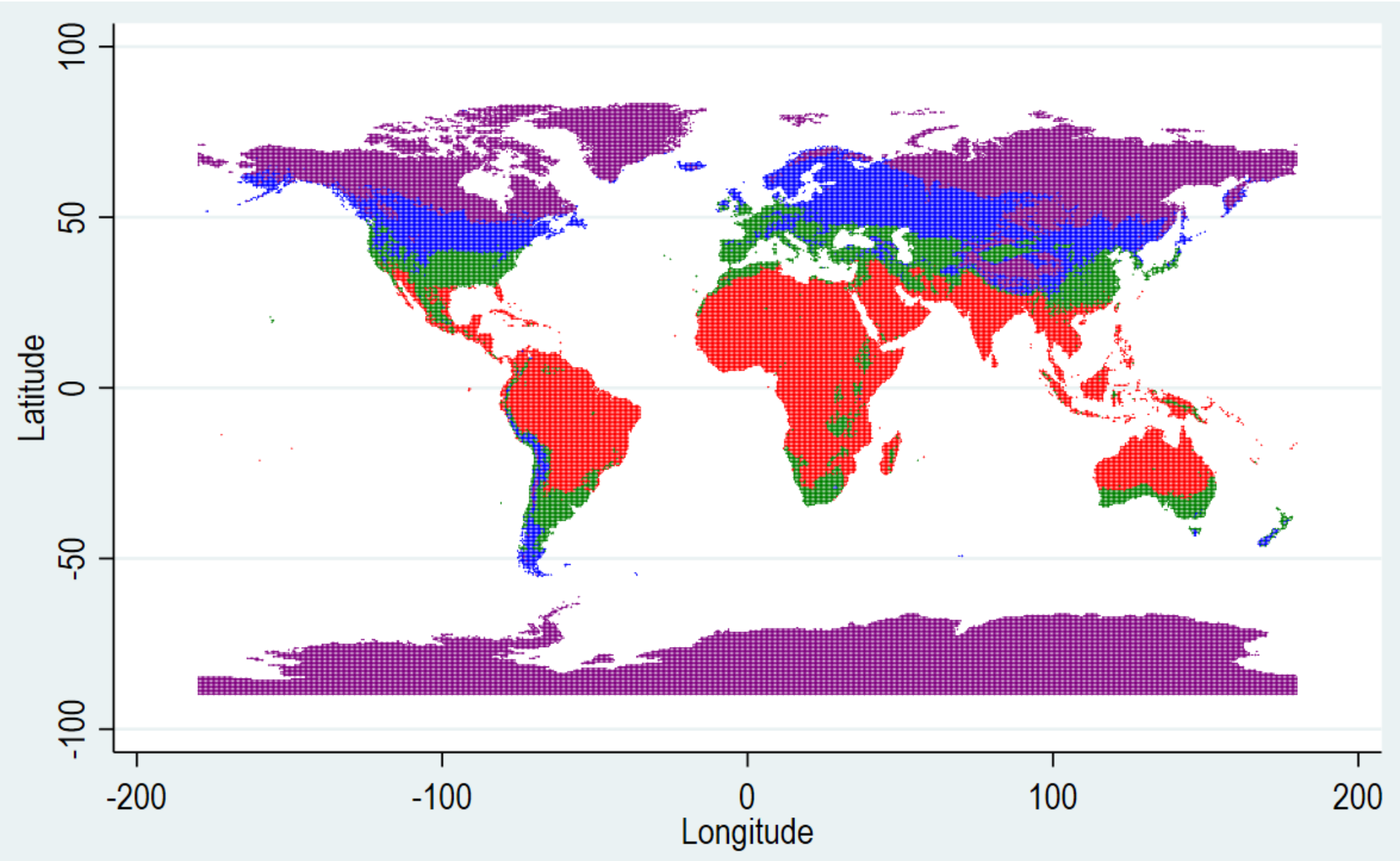


Figure: Mean temperature for year 2014

Data - CO_2

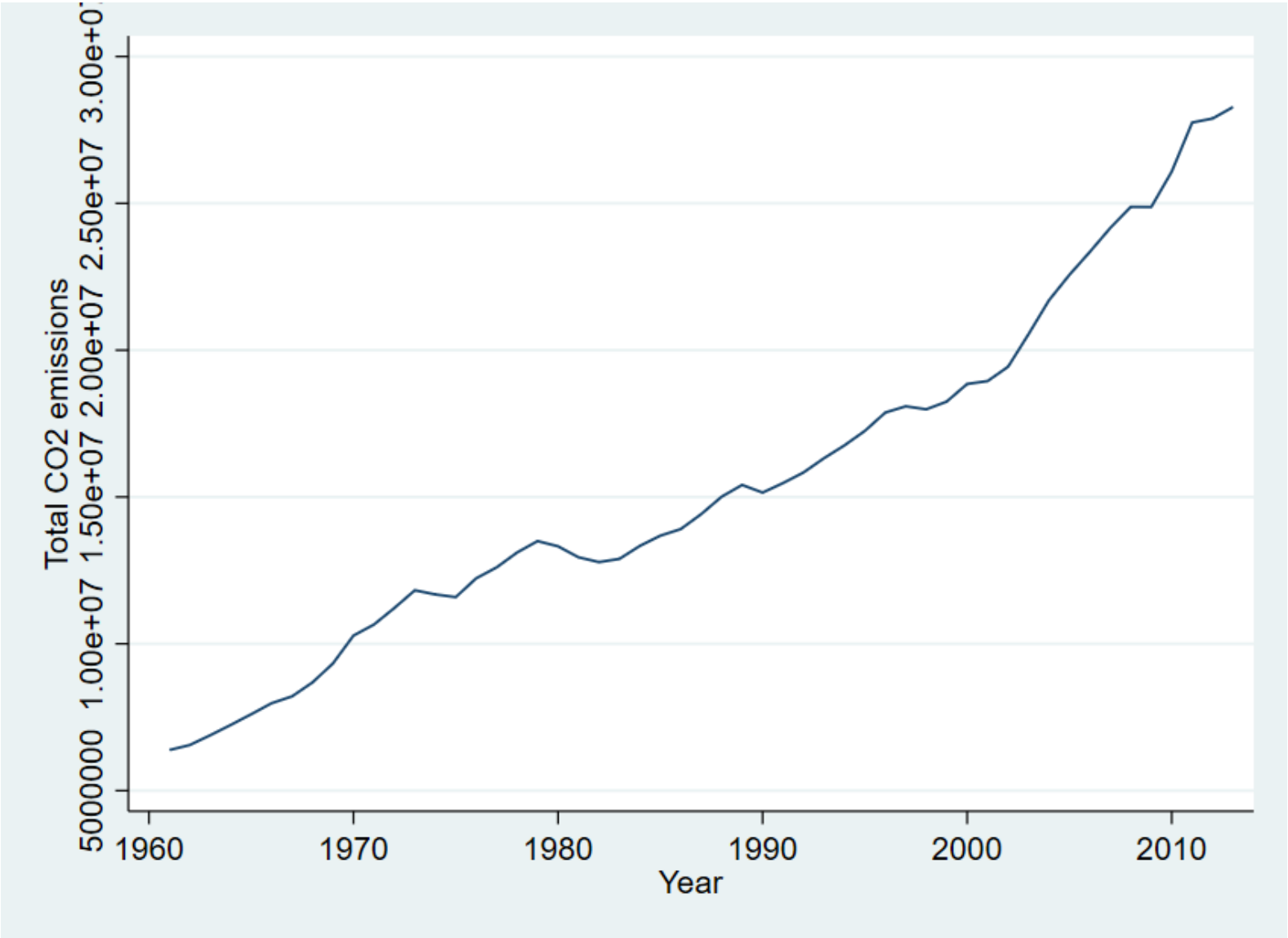


Figure: Total CO_2 releases over 1961-2015 period

Data - CO_2 Intensity

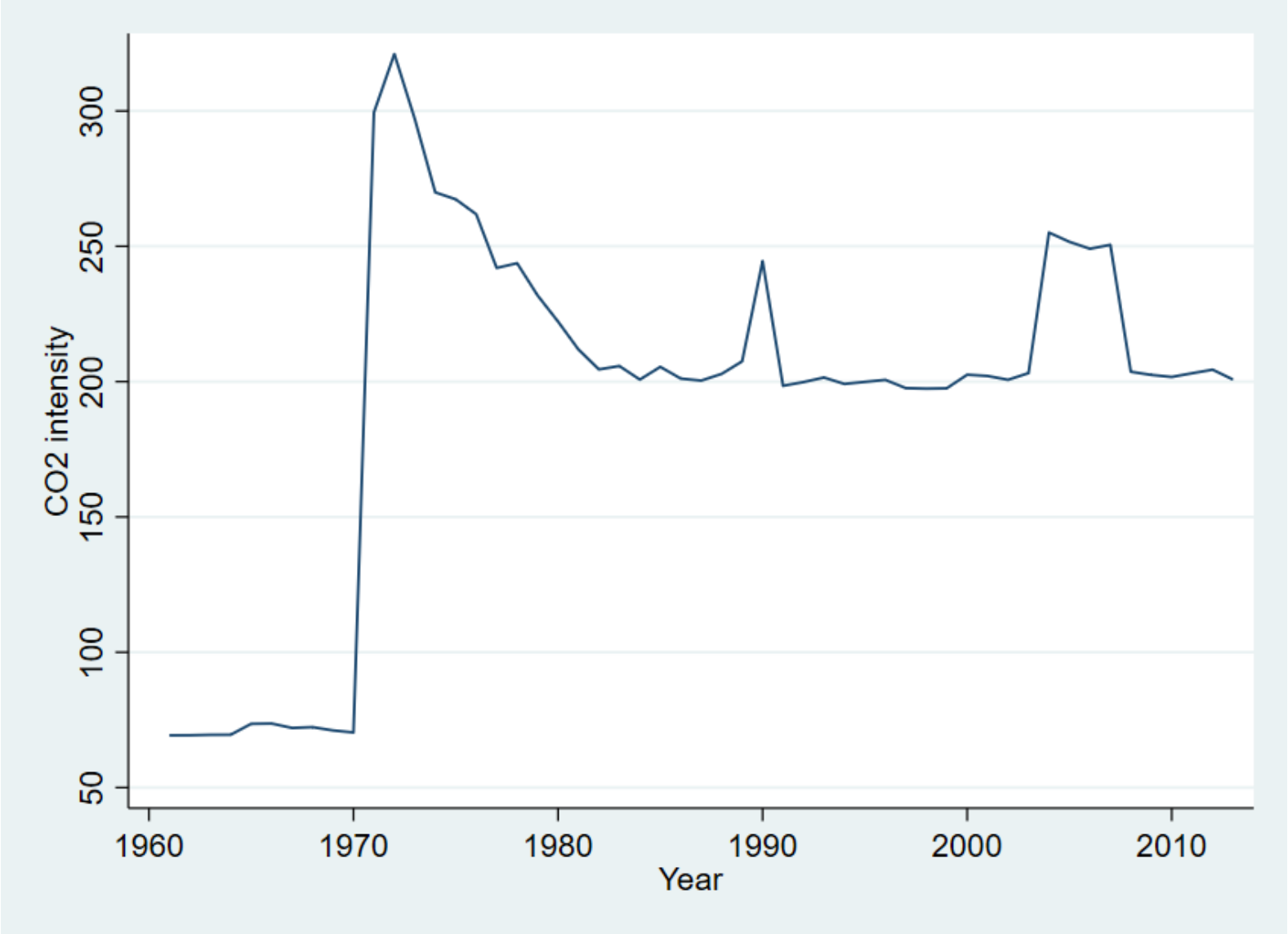


Figure: CO_2 Intensity over 1961-2015 period

Data - Summary Statistics

Table: Summary Statistics

Variables	Mean	Standard deviation	Maximum	Minimum
GDP (in million 2011 US$)	11.323	1.77	7.54	16.54
TFP level at current PPP's	-0.037	0.23	-0.87	1.62
Capital stock	12.790	1.82	7.44	17.77
Labor force	1.500	1.60	-2.68	6.64
Energy	7.215	1.03	4.71	9.88
CO_2 emisions	10.042	2.09	3.09	15.89
Country Temperature	17.985	0.27	1.05	29.07
Country Precipitation	10.574	6.80	0.10	53.57

*All variables except for Country Temperature and Country Precipitation are presented here in their logarithmic values.

Empirical Results

Table: Regression Estimations

	O.L.S.		2 S.L.S.	
			1^{st} stage	
Dependent Variable		CO_2	Temp	CO_2
Temperature		0.211^{***}		0.172^{***}
Precipitation		-0.070^{***}	-0.022^{***}	-0.083^{***}
Renewable		-2.249^{***}		-1.729^{***}
CO_2			-0.001	
			2^{nd} stage	
Dependent Variable			Y_{it}	tfp_{it}
C	0.351^{***}	0.476^{***}	0.414^{***}	0.015
L	0.101^{***}	0.358^{***}	0.290^{***}	0.048^{***}
En	0.045^{**}	0.209^{***}	0.101^{***}	0.081^{***}
CO_2	0.165^{***}	0.145^{***}		-0.067^{***}
Temp	0.079^{**}		-0.709	
Sample Size	3813	3813	3813	3289
Year F.E.	Y	Y	Y	Y
Countries F.E.	Y	Y	Y	Y

$***p < 0.001, **p < 0.05, *p < 0.1$

Empirical Results

1. Because of the selection bias, OLS estimates are upward toward or above zero. We focus on 2SLS results.
2. The coefficient of temperature on the 1^{st} stage is a powerful predictor of CO_2 concentrations. The Kleibergen-Paap Wald rk F-statistic (679.75) for weak identification is much larger than the Stock-Yogo critical value of 13.91
3. A 1% increase of RES, decreases CO_2 concentrations by 2.25% for a given year and a given country.
4. CO_2 concentrations increase GDP by 0.14% for a given year and a given country, while CO_2 reduce countries' TFP by 0.067%.
5. When focusing on temperature as instrumented variable, we find a negative statistically insignificant effect on GDP growth.

Robustness Checks

1. We investigate for temperature non-linear effects in order to detect inverted U-shaped relationship between temperature and GDP growth.

1^{st} stage equation will be:

$$CO2_{it} = \rho_0 + \rho_1 C_{it} + \rho_2 L_{it} + \rho_3 En_{it} + \rho_4 temp_{it} + \rho_5 temp_{it}^2 + \rho_6 RE_{it} + \alpha_i + \pi_t + \mu_{it}$$

2. We create a dummy variable based on whether a country's median GDP over the period 1961-2013 is above or below median GDP of all countries.

Robustness Checks Results

Table: Regression Estimations

	(1)	(2)
	1^{st} stage	
Dependent Variable	CO_2	
Temp	0.373^{***}	0.187^{***}
$Temp^2$	-0.042	
Renewable	-2.528^{***}	-1.722^{***}
Poor Country Dummy		-0.120^{***}
	2^{nd} stage	
Dependent Variable	Y_{it}	
C	0.478^{***}	0.002
L	0.279^{***}	0.036
En	0.013^{***}	0.052
CO_2	0.219^{***}	-0.047
Sample Size	3813	3813
Year F.E.	Y	Y
Countries F.E.	Y	Y

$***p < 0.001, **p < 0.05, *p < 0.1$

The End

Thank you!!!