THE IMPACT OF CLIMATE CHANGE ON INFLATION: EVIDENCE FROM EUROPEAN COUNTRIES

Vesna Stojcevska
Dijana Janevska-Stefanova
Marko Josimovski

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Introduction

- Climate change – not only an environmental issue, but an economic one as well
- Severe weather events have a negative impact on both the level and growth rate of GDP (NGFS, 2024)
- No clear consensus regarding the effect of climate change, or more specifically the severe weather shocks, on inflation

Literature review

- **Certain studies argue that climate change (extreme weather events) exerts an upward pressure on inflation** (Kotz et al., 2023; Ciccarelli et al., 2024; Mukherjee and Ouattara, 2021; Li, Zhang, and He, 2023; Odongo et al., 2022; Qi et al, 2025; Škrinjarić, 2023)
- **On the other hand, some studies find an inverse (or no) relationship between climate change and inflation** (Kabundi, Mlachila, and Yao, 2022; Cevik and Jalles, 2023)

Research questions

1. How does climate change, measured by more adverse weather conditions, affect inflation?
2. Which specific extreme weather conditions affect inflation?
3. How does climate change, measured by more adverse weather conditions, affect energy inflation?
4. Which specific extreme weather conditions affect energy inflation?
5. How does climate change, measured by more adverse weather conditions, affect food inflation?
6. Which specific extreme weather conditions affect food inflation?

Hypotheses

- H1: Climate change, measured by more adverse weather conditions, contributes to higher total inflation.
- H2: Climate change, measured by more adverse weather conditions, contributes to higher energy inflation.
- H3: Climate change, measured by more adverse weather conditions, contributes to higher food inflation.

Variables

Variable	Description	Source
Inflation	Yearly inflation rate for all the items comprising the HICP	Eurostat
Energy inflation	Yearly inflation rate for the energy sub-index in the HICP	Eurostat
Food inflation	Yearly inflation rate for the food sub-index in the HICP	Eurostat
E3CI	The European Extreme Events Climate Index (E3CI) provides a general overview of weather-induced hazards by combining seven components: extreme maximum and minimum temperature, drought, extreme precipitation, hail, fire, extreme wind; all values over 1 represent extreme climate events; the index is given by the mean of the different components	European Extreme Events Climate Index
Drought	A component of the E3CI index, all values over 1 represent extreme climate events in terms of drought	European Extreme Events Climate Index
Extreme maximum temperature	A component of the E3CI index, all values over 1 represent extreme climate events in terms of extreme maximum temperatures	European Extreme Events Climate Index
Extreme minimum temperature	A component of the E3CI index, all values over 1 represent extreme climate events in terms of extreme minimum temperatures	European Extreme Events Climate Index
Extreme precipitation	A component of the E3CI index, all values over 1 represent extreme climate events in terms of extreme precipitation	European Extreme Events Climate Index
Extreme wind	A component of the E3CI index, all values over 1 represent extreme climate events in terms of extreme winds	European Extreme Events Climate Index
Forest fire	A component of the E3CI index, all values over 1 represent extreme climate events in terms of forest fires	European Extreme Events Climate Index
Hail	A component of the E3CI index, all values over 1 represent extreme climate events in terms of hailstorms	European Extreme Events Climate Index
GDP per capita	GDP at market prices; chain linked volumes (2020), euro per capita; neither seasonally adjusted nor calendar adjusted data	Eurostat
Unemployment	Total unemployment including both males and females, from 15-74 years, as a percentage of total population, seasonally adjusted data, not calendar adjusted data	Eurostat

Data and descriptive statistics

- The dataset covers 32 European countries in the period 2009 Q1 – 2024 Q4

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
Inflation	2.560	1.768	25.878	-3.870	3.361	2025
Energy inflation	3.885	1.886	90.494	-36.377	12.553	2025
Food inflation	3.202	1.962	48.001	-7.886	5.310	2025
E3CI	0.192	0.088	14.372	-0.321	0.730	2025
Drought	0.017	0.024	1.692	-1.711	0.508	2025
Extreme maximum temperature	0.961	0.835	5.021	-0.530	0.853	2025
Extreme minimum temperature	-0.122	-0.167	1.329	-0.597	0.262	2025
Extreme precipitation	0.168	0.090	13.419	-0.426	0.664	2025
Extreme wind	0.074	0.030	2.068	-0.483	0.307	2025
Forest fire	0.394	-0.298	98.235	-1.769	4.787	2025
Hail	-0.146	-0.130	1.095	-1.911	0.368	2025
GDP per capita	8097.195	6090.000	27860.000	1000.000	5614.790	2025
Unemployment	5.525	4.600	19.400	1.300	3.182	2025

Note: The descriptive statistics covers the period 2009Q1-2024Q4.

Correlation matrix

Variables	Inflation	Energy inflation	Food inflation	E3CI	Drought	Extreme maximum temperature	Extreme minimum temperature	Extreme precipitation	Extreme wind	Forest fire	Hail	GDP per capita	Unemployment
Inflation	1.000												

Energy inflation	0.673	1.000											
	0.000	---											
Food inflation	0.866	0.395	1.000										
	0.000	*0.000*	---										
E3CI	-0.013	-0.039	0.008	1.000									
	0.552	*0.076*	*0.714*	---									
Drought	0.215	0.200	0.208	0.205	1.000								
	0.000	*0.000*	*0.000*	*0.000*	---								
Extreme maximum temperature	0.053	-0.099	0.106	0.249	0.206	1.000							
	0.017	*0.000*	*0.000*	*0.000*	*0.000*	---							
Extreme minimum temperature	-0.027	0.049	-0.011	0.048	0.101	-0.282	1.000						
	0.230	*0.026*	*0.633*	*0.032*	*0.000*	*0.000*	---						
Extreme precipitation	-0.037	-0.003	-0.022	0.094	-0.282	0.028	-0.130	1.000					
	0.098	*0.909*	*0.322*	*0.000*	*0.000*	*0.202*	*0.000*	---					
Extreme wind	-0.018	-0.021	0.005	0.235	0.010	0.186	-0.106	0.068	1.000				
	0.418	*0.355*	*0.824*	*0.000*	*0.638*	*0.000*	*0.000*	*0.002*	---				
Forest fire	-0.002	-0.023	0.008	0.970	0.129	0.076	0.048	-0.014	0.145	1.000			
	0.931	*0.299*	*0.703*	*0.000*	*0.000*	*0.001*	*0.029*	*0.541*	*0.000*	---			
Hail	-0.477	-0.307	-0.488	0.008	-0.267	-0.133	0.155	0.040	0.051	-0.033	1.000		
	0.000	*0.000*	*0.000*	*0.708*	*0.000*	*0.000*	*0.000*	*0.071*	*0.021*	*0.135*	---		
GDP per capita	-0.087	0.014	-0.088	0.044	0.021	-0.061	-0.029	-0.036	0.052	0.060	-0.024	1.000	
	0.000	*0.516*	*0.000*	*0.049*	*0.341*	*0.006*	*0.190*	*0.103*	*0.018*	*0.007*	*0.286*	---	
Unemployment	-0.184	-0.062	-0.175	-0.044	-0.141	-0.135	0.149	0.054	-0.022	-0.034	0.150	-0.377	1.000
	0.000	*0.006*	*0.000*	*0.047*	*0.000*	*0.000*	*0.000*	*0.014*	*0.326*	*0.127*	*0.000*	*0.000*	---

Notes: The p-values are reported below the correlation coefficients. The calculations are performed over the period 2009Q1-2024Q4.

Econometric approach

- **Dynamic panel dataset**
  - We include the lag of the dependent variable as a control variable
- **Panel regression models**
  - Since we have large T (63 periods) and small N (32 countries), the Nickell bias is minimal (Alam et al. (2019))
- **Fixed or random effects approach**
  - The choice depends on the results of the Hausman test

Econometric approach

1. $Inflation\ rate_{i,t} = \beta_0 + \beta_1 * E3CI_{i,t-1} + \beta_2 * Inflation\ rate_{i,t-1} + \beta_3 * Ln(GDP\ per\ capita)_{i,t-1} + \beta_4 * Unemployment_{i,t-1} + Country_i + Period_t + \varepsilon_{i,t}$

2. $Inflation\ rate_{i,t} = \beta_0 + \beta_1 * Drought_{i,t-1} + \beta_2 * Ext\ max\ temp_{i,t-1} + \beta_3 * Ext\ min\ temp_{i,t-1} + \beta_4 * Ext\ precipitation_{i,t-1} + \beta_5 * Ext\ wind_{i,t-1} + \beta_6 * Forest\ fire_{i,t-1} + \beta_7 * Hail_{i,t-1} + \beta_8 * Inflation\ rate_{i,t-1} + \beta_9 * Ln(GDP\ per\ capita)_{i,t-1} + \beta_{10} * Unemployment_{i,t-1} + Country_i + Period_t + \varepsilon_{i,t}$

3. $Energy\ inflation\ rate_{i,t} = \beta_0 + \beta_1 * E3CI_{i,t-1} + \beta_2 * Energy\ inflation\ rate_{i,t-1} + \beta_3 * Ln(GDP\ per\ capita)_{i,t-1} + \beta_4 * Unemployment_{i,t-1} + Country_i + \varepsilon_{i,t}$

4. $Energy\ inflation\ rate_{i,t} = \beta_0 + \beta_1 * Drought_{i,t-1} + \beta_2 * Ext\ max\ temp_{i,t-1} + \beta_3 * Ext\ min\ temp_{i,t-1} + \beta_4 * Ext\ precipitation_{i,t-1} + \beta_5 * Ext\ wind_{i,t-1} + \beta_6 * Forest\ fire_{i,t-1} + \beta_7 * Hail_{i,t-1} + \beta_8 * Energy\ inflation\ rate_{i,t-1} + \beta_9 * Ln(GDP\ per\ capita)_{i,t-1} + \beta_{10} * Unemployment_{i,t-1} + Country_i + Period_t + \varepsilon_{i,t}$

5. $Food\ inflation\ rate_{i,t} = \beta_0 + \beta_1 * E3CI_{i,t-1} + \beta_2 * Food\ inflation\ rate_{i,t-1} + \beta_3 * Ln(GDP\ per\ capita)_{i,t-1} + \beta_4 * Unemployment_{i,t-1} + Country_i + Period_t + \varepsilon_{i,t}$

6. $Food\ inflation\ rate_{i,t} = \beta_0 + \beta_1 * Drought_{i,t-1} + \beta_2 * Ext\ max\ temp_{i,t-1} + \beta_3 * Ext\ min\ temp_{i,t-1} + \beta_4 * Ext\ precipitation_{i,t-1} + \beta_5 * Ext\ wind_{i,t-1} + \beta_6 * Forest\ fire_{i,t-1} + \beta_7 * Hail_{i,t-1} + \beta_8 * Food\ inflation\ rate_{i,t-1} + \beta_9 * Ln(GDP\ per\ capita)_{i,t-1} + \beta_{10} * Unemployment_{i,t-1} + Country_i + Period_t + \varepsilon_{i,t}$

Results

Variables	Inflation rate FE (1)	Inflation rate FE (2)	Energy inflation rate RE (3)	Energy inflation rate FE (4)	Food inflation rate FE (5)	Food inflation rate FE (6)
Constant	-6.285 **	-6.055 **	0.451	-11.862	-7.097	-7.099
	3.101	*3.021*	*2.196*	*16.222*	*6.926*	*6.756*
E3CI (-1)	0.010		0.010		0.090 ***	
	0.017		*0.330*		*0.030*	
Drought (-1)		0.013		0.119		-0.094
		0.086		*0.508*		*0.149*
Extreme maximum temperature (-1)		-0.013		-0.303		0.201 **
		0.051		*0.271*		*0.096*
Extreme minimum temperature (-1)		-0.156		-1.043		-0.381
		0.120		*0.685*		*0.258*
Extreme precipitation (-1)		-0.008		-0.101		0.017
		0.024		*0.176*		*0.097*
Extreme wind (-1)		0.169 **		1.173 ***		-0.093
		0.068		*0.440*		*0.124*
Forest fire (-1)		0.000		-0.018		0.011 ***
		0.002		*0.014*		*0.004*
Hail (-1)		0.155 *		-1.756 ***		0.418 ***
		0.082		*0.621*		*0.160*
Inflation (-1)	0.837 ***	0.835 ***				
	0.036	*0.036*				
Energy inflation (-1)			0.846 ***	0.730 ***		
			0.072	*0.058*		
Food inflation (-1)					0.793 ***	0.791 ***
					0.052	*0.051*
ln (GDP per capita (-1))	0.776 **	0.754 **	0.027	1.504	0.880	0.860
	0.347	*0.341*	*0.243*	*1.855*	*0.784*	*0.769*
Unemployment (-1)	-0.019	-0.023	-0.014	-0.070	0.002	0.007
	0.024	*0.024*	*0.072*	*0.104*	*0.049*	*0.049*
Country fixed effects	Yes	Yes		Yes	Yes	Yes
Period fixed effects	Yes	Yes		Yes	Yes	Yes
Country random effects			Yes			
Period random effects			No			
Number of countries	32	32	32	32	32	32
Number of periods	63	63	63	63	63	63
Observations	1994	1994	1994	1994	1994	1994
Adjusted R-squared	0.933	0.934	0.719	0.859	0.911	0.911
Hausman (cross-section) test (p-value)	0.000	0.000	0.640	0.007	0.000	0.000
Breusch Pagan LM cross-section dependence test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000

Notes: ***, **, * indicate significance at 1%, 5% and 10% levels, respectively. Models 1, 2, 4, 5 and 6 are panel regressions with country and period fixed effects, whereas model 3 is a panel regression with country random effects. White cross-section robust standard errors are reported below the coefficient estimates. For the Hausman test and the Breusch Pagan LM test for cross-section dependence, the p-values are reported. The regressions are performed over the period 2009Q1-2024Q4.

Results

- **Higher values of the E3CI index,** or more extreme weather conditions as a whole, are only related to **higher food inflation,** but not to total inflation nor energy inflation
- **Extreme winds and hailstorms** have an impact on **total inflation,** leading to higher inflation
- Higher values of **extreme winds** also have an impact on energy inflation rates, leading to **higher energy inflation**
- **Extreme maximum temperatures, forest fires and hailstorms are related to higher food inflation**

Conclusion

- **Limitations** and avenues for **future research**
  - The same research methodology for only one country or a group of countries in the **same geographical region** (an increased maximum temperature level might cause problems in a southern country such as Spain, but it might not have an adverse impact in a generally colder country, such as Finland)
- In the case of European countries, **climate change** results in an **increased food inflation**
- **Extreme winds, hailstorms, extreme maximum temperatures, and forest fires** are related to **higher inflation**
- **Central banks could anticipate food inflation** in the upcoming quarter based on **extreme weather conditions** in the current quarter

Thank you!