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## Article

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## THE ASSESSMENT OF CLIMATE RISK IMPACT ON THE ECONOMY: A PANEL DATA APPROACH

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### Abstract

In this paper, we investigate how climate risk impacts the sovereign risk, the stock market evolution, and the degree of competitiveness, starting from the macroeconomic and financial effects globally produced by climate change. Using both quantile and logistic regression and a sample of 22 countries, of which 16 EU members and 6 OECD members, during the 2008-2019 period, the results highlight a negative relationship between climate risks and the evolution of stock market capitalization as a percentage of GDP. Moreover, the climate risk leads to an increase in sovereign risk only across inferior quantiles, i.e., when the CDS level is small. In addition, based on a logit regression model, we show that the level of competitiveness of a country is influenced to a small extent by the level of climate risk. This could be a consequence of concerns among authorities and companies in each country willing to implement development strategies to achieve the goals proposed by the European Green Pact and standardization of the global price of CO<sub>2</sub>.

**Keywords:** climate risk index, stock market capitalisation, sovereign risk, global competitiveness, quantile regression, logistic regression.

**JEL Classification:** C1, C58, D53, E60, G20, Q54

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## Introduction

The speech at the European level on the risks generated by climate change has become greater since 2019, when several initiatives were adopted: i) launching an international platform for sustainable financing to enable a stronger involvement of financial institutions in the development of sustainable projects; ii) the adoption of the European Green Pact, which aims to create a more resilient and internationally competitive European economy, as well as to improve the health and quality of life.

The awareness of the impact of these initiatives and the risks of a disorganized transition to a low-carbon economy was studied in a large strand of literature provided by academia, researchers, and financial institutions presenting different ways of assessing the impact of climate risk on macroeconomic variables, namely indicators of the banking financial system, sovereign risk, and the competitiveness of European countries.

Several articles published in most relevant journals have highlighted the fact that the relationship between climate risk and the degree of financial development will become increasingly close in the coming years. Thus, Acemoglu et al. (2012) pointed out that banks will play a crucial role in the transition of highly polluting countries to low carbon. An empirical study conducted on the US capital market showed that there are concerns about the impact that climate risks have on economic growth and well-being (Bansal, Kiku and Ochoa, 2016). They argue that climate change affects the risk premium and shares traded on the stock exchange, while Gibson, Krueger and Schmidt (2020) believe that changing the risk premium for equities will increase the cost of financing. Another analysis highlighted the effect of climate risk on the capital structure at the company level, the authors concluding that, after 2015, the leverage effect decreases if climate risk increases (Gingler and Moreau, 2021). Based on an APT model, Gregory (2021) argues that the impact of climate shocks on the cost of equity could be up to 2.80% yearly, equivalent to a global GDP loss of 2.2 trillion USD.

The Paris Agreement (European Commission, 2016) has brought to light the necessity to limit global warming. Increased pressure from all stakeholders (investors, implementing agencies, shareholders, civil society, etc.) to implement measures to reduce the negative impact of climate change has led to increased measures taken by each state to achieve the objectives set out by this agreement.

The European Union has made commitments to reduce greenhouse gas emissions by at least 55% by 2030 compared to 1990. The European Green Pact was devoted to achieving climate neutrality and zero greenhouse gas emissions conditioned by sustainable economic growth with a reduced impact on the use of natural resources (European Commission, 2019).

The fulfilment of the objectives set by European Green Pact requires legislative changes, of which we can mention the FIT FOR 55 package, which includes a series of proposals on the regulatory framework based on an impact analysis in the context of mixed policy (European Commission, 2021), which involves profound economic changes and significant implications on government policies, public finances, financial system, civil society, and companies. To achieve the goals of the Paris Agreement and the European Union's Green Pact, economies need to invest in sustainable projects. According to a study conducted on the UK market, the cost of climate risks (for transition and physical) by 2100 has been estimated to be between 16 and 32 billion GBP (OBR, 2019). Zenois (2021) argues that the negative effects of climate changes on public debt will be visible in the future, starting with 2030 being necessary to include them in the calculation of sovereign risk.

This article seeks to answer a question that has caused great global controversy: What is the impact of the climate risk on the economic-financial system evolution? In order to answer in a coherent way to this question, it is necessary to design a panel-type approach, in contrast with a single-country analysis, as is used in the same studies from the literature. Also, the econometric techniques used to study the interactions between climate risk and economic-financial development are among the most efficient and intensively used both in the financial field and in the field of environmental economics.

In this paper, we contribute to the literature by providing additional evidence on the impact of climate change on financial markets and the macroeconomic environment. Our results are in line with the current state-of-the-art in the impact of climate risk. The novelty of our paper relies on the econometric approach, but also on the selected sample, which includes EU countries, but also OECD members highly exposed to climate risk and by variables tested. The reminder of the paper is structured as follows: Section 1 reviews the literature, Section 2 presents the data, Section 3 reviews the econometric approach, Section 5 highlights the results, while Section 6 concludes the paper.

The paper is structured in the following parts: i) the review of the literature that includes the latest and most relevant studies in the field of climate risk; ii) the methodology used, in which we present details regarding the data used, the sources, and elements connected with the econometric approach; iii) the results obtained; iv) the conclusion of the study.

## **1. Literature review**

Awareness of the climate risks (mental, transitional, and liability / legal risks) raises challenges that need to be addressed so that climate change policies and risks link the environment with the economy. Stern, Stiglitz and Taylor (2022), based on a mathematical model find that it is necessary to reconsider the analytical fundamentals regarding climate risks and their impact on the global economy. The expansion of climate change has irreversible effects on the economy and society; 77% of respondents to an international survey saying that although the lack of actions is detrimental, efforts to reduce the effects of climate risk are low (World Economic Forum, 2022).

The effects of climate change on the economy take into account both macroeconomic and microeconomic aspects, which are affecting the companies in terms of their profitability, liquidity, yield, share price, company value, and also the public finances. Empirically, based on a sample of 33 countries, for the period 2004-2018, and on an approach based on fixed and variable effects, was highlighted an insignificant relationship between climate risk and the cost of corporate debt (Liu, 2021), which also used panel data specific approach, while other authors consider that the change in debt costs contracted by a company will trigger changes in capital structure, with implications for stock prices and market capitalization (Kleimeier and Viehs, 2018; Meng and Yin, 2019; Capasso, Gianfrate and Spinelli, 2020). Moreover, Rajhi and Albuquerque (2017), based on a VAR Structural Panel model, show that natural disasters are leading to an increase in the non-performing debts of the companies and to an increase in the risk of default with negative effects on the banking system.

Other studies, also using linear methodologies specific to panel data, suggest that climate risks affect the market evolution, the profits (Pankratz, Bauer and Dewall, 2019), the value and creditworthiness of the company (Berkman, Jona and Sonderstrom, 2019), the return on

shares (Barnett, 2019), affecting in the same time the value of the capital market transactions and the stock market capitalization. Blasberg, Kiesel and Taschini (2021) used Credit Default Swap (CDS) to highlight the asymmetric exposure of economic sectors to climate transition risk. They concluded that the result showed that the exposure is directly related to the cost incurred by companies if they do not meet their environmental obligations.

Delis, de Greiff and Ongena (2019) tested this hypothesis based on a fixed-effect panel model, comparing the interest rate charged by banks to companies which use fossil fuels with the one charged on other companies. In conclusion, the study finds that, before 2015, banks did not assess and include in their interest rates the climate exposures premiums.

Furthermore, Görgen et al. (2020), taking into account the market value of the companies and based on a sample of more than 1600 listed companies for the period 2010-2017, and a fixed effects model, stated that firms more exposed to the transition climate risk are less successful compared to others. In addition, Furukawa, Ichiue and Shiraki (2020) argue that asset prices are used to extract information about climate risks. In their view, financial markets need to differentiate companies based on their carbon footprint, leading to increased efforts to reduce emissions.

Campiglio, Monnin and von Jagow (2019) highlight the extent to which climate risk is embedded in the price of financial market assets, arguing that if, in the efficient markets, investors have already incorporated the cost of climate change into their assessments, then current costs cannot predict future returns.

According to Lamperti et al. (2019), the consequences of climate change on the stability of the banking system will be more serious, a situation in which banks with problems in the asset portfolio will generate a fiscal pressure of about 5-15% of annual GDP. Schüwer, Lambert and Noth (2019) highlight the change in banks' net exposure according to their status as independent banks or holding banks, finding that independent banks based in disaster areas will increase their equity levels after a natural disaster, while the banks that are members of a banking holding company do not take such measures.

Buranatrakul and Swierczek (2018) address the strategic actions taken by a sample of 15 international banks grouped in four regions. The result shows that banks need to develop more effective environmental measures showing that international differences are important. More to the point, European banks have ranked first in terms of reducing CO2 emissions (to achieve the provisions of the European Green Pact) over time through lending compared to Asian banks which have received the lowest score in all categories of strategic actions on climate change.

The impact of climate risk on the capital market evolution was studied by various researchers, some of them considering that the stock market under reacts to their effects on firm profitability (Hong, Li and Xu, 2019), while others consider that capital markets are not efficient in terms of pricing according to climate risks, which are underestimated (Karydas and Xepapadeas, 2019; Roncoroni et al., 2021).

Another paper which performed an analysis on US listed companies during 2013 to 2016 concluded that more regulation is needed in the market (Bryant, Griffin, and Perry, 2020) while other authors believe that if such climate risk related changes will be included into legislation, they could affect the company's profitability (Ramadorai and Zeni, 2021; Cochrane, 2021).

Climate risks have implications for all macroeconomic and microeconomic variables, affecting economic, political, social stability, and the effects are visible in all countries, regardless of the level of development (Kahn et al., 2019) and can impact the sovereign risk (Volz et al., 2020; Agarwala et al., 2021). The impact of climate risks on the capital market is significant in the case of developing countries; 1% increase in them will lead to an increase in the rate of long-term government bonds by about 3% (Cevik and Jalles, 2020) with negative influence on competitiveness.

Climate change affects labour productivity differently, depending on the industry, through declining market shares and profits and adapting competitiveness to climate-change mitigation efforts is a concern across countries worldwide (Desmet and Rossi-Hansberg, 2021). The efforts of all actors to increase competitiveness are supported by the need to standardize the global carbon price and increase exports. Although in the short term the losses generated by a global warming increase, in the long term, the negative effects are diminishing (Ward, Steckel and Jakob, 2019).

Various studies have shown that climate change has led to an increase in the cost of public debt, by more than 1.17% between 1996 and 2016 (Kling et al., 2018). For the case of Southeast Asian countries for the period 2002-2018, climate change has had a positive effect on the yield on sovereign bonds (Beirne, Renzhi and Volz, 2021). Other research suggests that climate change could lead to significant economic losses, with costs accounting for between 2% and 21% of global economic output by the end of the century (Kahn et al. 2019; Burke, Hsiang and Miguel, 2015).

Based on the studies above mentioned, we can argue that the link between climate risk and economic and financial environment, is of real interest to both public policy makers and investors on capital market. For this reason, in the following, we will present an approach that details much more clearly the conditions under which climate risk affects the developments on the stock market, sovereign risk, and the degree of competitiveness. The methodologies proposed for achieving this goal are quantiles regression and LOGIT regression.

The first one, which has not been used in any of the studies mentioned above, is the tough point of the contribution of this article to the literature. Basically, this method allows us to identify at what levels of the stock market capitalization or sovereign risk, the impact of climate risk is statistically significant.

## **2. Research methodology**

In the data selection process, we choose only those countries in which there were statistical data on the climate risk index, which led to the elimination of some countries whose inclusion would have given more robustness to the results. Despite these limitations, we worked on a sample of 263 observations, consistent and able to generate reliable estimates. Regarding the selection of explanatory factors, in addition to climate risk, we have selected some economic and financial variables that have been used in previous studies to explain the dynamics of market capitalization, sovereign risk, and competitiveness. Finally, the working methods were chosen to provide a more persuasive picture of the interactions between climate risk and dependent variables.

## 2.1. Data description

This section provides a detailed description regarding the data series used in the econometric approach, as well as their sources. We used a sample of 22 EU and OECD member countries (Australia, Austria, Belgium, Canada, Czech Republic, Denmark, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States) over 12 years, from 2008 to 2019.

We choose both EU and OECD members to cover a wider geographical area and to include the effects of climate risks as frequent and diverse as possible. A summary of the variables is presented in table no. 1.

**Table no. 1. The definition of the variables**

Variables	Type	Source	Description
<b>Sovereign Risk (CDS)</b>	Dependent variable	Bloomberg	CDS quotations are computed as the annual average of the credit quality. This is a derivative that allows the transfer of credit risk exposures of the government bonds, the payments being related to the changes in the credit quality.
<b>Stock market capitalisation (MC)</b>	Dependent variable	Bloomberg	Stock market capitalisation as percentage of GDP.
<b>Global competitiveness (GCI)</b>	Dependent variable	Knoema	It is composed of 12 subindices of competitiveness. We used a dummy variable equal to 1 if a country in a certain year ranks in the top 25% of the considered economies.
<b>GDP per capita (GDPC)</b>	Explanatory variable	The Global Economy	Gross domestic product considered in real terms divided by the number of residents living in a country in a given year.
<b>Inflation rate (INF)</b>	Explanatory variable	The Global Economy	Is the annual percentage change in the consumer price index.
<b>Unemployment rate (UNE)</b>	Explanatory variable	The Global Economy	Refers to the share of the labour force that is without a commitment, but also available in search of a job.
<b>The Corruption Perceptions Index (CPI)</b>	Explanatory variable	The Global Economy	Is an indicator of perceptions of public sector corruption, i.e. administrative and political corruption. Are determined by using information from surveys and assessments of corruption, collected by a variety of reputable institutions.
<b>Political Stability Index (PSI)</b>	Explanatory variable	The Global Economy	Measures perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism.
<b>Financial Freedom Index (FFI)</b>	Explanatory variable	Heritage Foundation	Evaluates the extent of government regulation of financial services, the degree of state intervention in banks and other financial entities, government influence on the allocation of credit and openness to foreign competition.

Variables	Type	Source	Description
<b>Climate Risk Index (CRI)</b>	Explanatory variable	German Watch	The index includes data that reflect the direct impact of extreme weather events, i.e., direct economic losses as a share of GDP and the number of deaths. Indicates the level of exposure and vulnerability to extreme weather events such as storms, floods, and heat waves.

To avoid the risk of estimating spurious regressions, it is necessary to use only stationary variables in the empirical analysis. In table no. 2 we present the results of the stationarity test proposed by Levin, Lin and Chu (2002) for all variables except the global competitiveness index, which has a dummy structure.

As can be seen in table no. 2, all variables included in the analysis are stationary in both the level and in the first difference, allowing us to perform a rigorous quantitative analysis without the risk of misleading conclusions.

**Table no. 2. Unit root tests**

Variable (Null – the series has a unit root)	Level		First difference	
	Test	Prob.	Test	Prob.
<b>Sovereign Risk (CDS)</b>	-2.8238	0.0024	-15.9439	0.0000
<b>Stock market capitalisation (MC)</b>	-2.2697	0.0116	-16.2642	0.0000
<b>GDP per capita (GDPc)</b>	-7.5011	0.0000	-6.5838	0.0000
<b>Inflation rate (INF)</b>	-11.3455	0.0000	-10.3825	0.0000
<b>Unemployment rate (UNE)</b>	-2.6614	0.0039	-10.0031	0.0000
<b>The Corruption Perceptions Index (CPI)</b>	-2.8739	0.0020	-8.5449	0.0000
<b>Political Stability Index (PSI)</b>	-1.8215	0.0343	-2.8639	0.0021
<b>Financial Freedom Index (FFI)</b>	-7.0251	0.0000	-4.3759	0.0000
<b>Climate Risk Index (CRI)</b>	-5.5757	0.0000	-8.4705	0.0000

Also, the correlation matrix of the explanatory variables presented in table no. 3 indicates the absence of significant correlations (greater than 50%), so that the multicollinearity problem is a minor one, a result we get if we use the Variance Influence Factor (VIF) approach. All coefficients associated with each explanatory variable range from 1 to 5, which confirms the conclusions reached based on the correlation matrix.



Table no. 3. Correlation matrix (%)

	GDPc	INF	UNE	CPI	PSI	FFI	CRI
GDPc	100	-5	-37	61	44	37	8
INF	-5	100	-4	-7	-7	1	0
UNE	-37	-4	100	-36	-38	-20	-3
CPI	61	-7	-36	100	44	45	10
PSI	44	-7	-38	44	100	23	10
FFI	37	1	-20	45	23	100	3
CRI	8	0	-3	10	10	3	100

As can be seen from the correlation matrix, the climate risk index is independent of the other explanatory factors included in the analysis, which shows that some macroeconomic variables such as GDP, inflation, or unemployment, are unconditioned by climate events.

## 2.2. Econometric approach

Further, we will present the methodologies used to study the impact that climate risk has on sovereign risk, the capital market, and the degree of competitiveness in a given country.

### 2.2.1. Quantile regression

In the first stage of the analysis, we investigate the impact of climate risk on sovereign CDS and on the evolution of stock market capitalization. Since there are significant heterogeneity between countries, a linear econometric framework could overlook some links, and for this reason we will use the quantile regression for panel data proposed by Koenker (2004). Note that we use quantile regression as is recommended when the dependent variable has an asymmetric distribution, in which case the explanation targeting of the conditional mean is not sufficient to create a clear picture regarding the relationship between the factors, or when it is desired to explain the values in the upper or lower tails of the distribution.

Mathematically, for any quantile  $\tau$  related to the probability distribution of the dependent variable denoted  $\mathbf{Y}$  (sovereign risk or stock index value), conditioned by the realisation of the explanatory variables, denoted by  $\mathbf{X}$  (climate risk and other independent variables), the quantile regression has the following specification given in equation (1):

$$Q_{y_t}(\tau|x_t) = \alpha + x_t^T \beta(\tau) \quad (1)$$

Where  $\beta(\tau)$  show us the sensitivity of the dependent variable to the variations of the explanatory factors depending on different quantiles. The above relationship can be estimated on the basis of the following algorithm, outlined in equation (2):

$$\hat{\beta}(\tau) = \arg \min_{\beta \in \mathbb{R}} \sum_{i=1}^n \rho_{\tau}(Y_i - X_i \beta)^2 \quad (2)$$

regardless of the chosen  $\tau$  and the loss function  $\rho_{\tau}$ .

### 2.2.2. Logistic regression

In what follows, we will use a LOGIT model to identify the determinants of competitiveness and the extent to which climate risk influences its level. We consider that the binary variable  $Y_i$  is 0 if the competitiveness index of a country in a given year is in the first 25% of observations and zero otherwise. Let  $X_i = (X_{i1}, X_{i2}, \dots, X_{in})$  a matrix containing qualitative and quantitative information on the explanatory factors, including climate risk. In order to capture the competitiveness – climate risk nexus, we estimate the following equation denoted Eq. (3):

$$E[Y_i] = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_n X_{in} + \varepsilon_i \quad (3)$$

Unfortunately, the coefficients of equation (1), estimated via ordinary least squares (OLS), are not reliable since the hypothesis regarding the normality of errors is not true. In order for  $\varepsilon_i$  to show the properties required by Gauss-Markov theorem  $Y_i$  should not be discrete as in this situation. However,  $\beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_n X_{in}$  is ranging in  $(-\infty; \infty)$  interval while  $E[Y_i]$  can be zero or one. To solve this problem, we use a function  $f(\bullet)$  which applied to  $E[Y_i]$  can handle this binary model. Thus, we rely on a LOGIT type model highlighted in equation (4):

$$f(E[Y_i]) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_n X_{in} \quad (4)$$

Let  $p_i$  be the probability of  $Y_i$  to equal one. Obviously, the probability that a country will be below the 25% threshold is  $1 - p_i$ . The odds ratio,  $\pi_i = \frac{p_i}{1-p_i}$  will range in  $(0; \infty)$  interval, conditioned by  $p_i \neq 0$ . Eq. (4) relies on LOGIT transform for  $\pi_i = \frac{p_i}{1-p_i}$  and is presented in equation (5):

$$\ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_n X_{in} \quad (5)$$

After obtaining the coefficients  $\hat{\beta}_i$  we will be able to assign a probability so that the competitiveness index of a certain country and year will be at higher levels, conditioned by the matrix of explanatory variables  $X_i = (X_{i1}, X_{i2}, \dots, X_{in})$ .

## 3. Results

Table no. 4 presents the results of quantile regression with the sovereign CDS as a dependent variable. As representative quantiles we chose q10, q25, q50, q75, and q90. Conventionally, the lower quantiles describe the situations when CDS are low (sovereign risk is reduced), and the upper quantiles describe those situations when CDS have high values (sovereign risk is high).

Table no. 4 indicates the evolution of sovereign CDS which is influenced by macroeconomic factors such as economic growth (at the 90<sup>th</sup> quantile), inflation rate (for all quantiles except the 90<sup>th</sup> one), the control of corruption (at all quantiles), political stability (the 75<sup>th</sup> quantile) or financial freedom (the 50<sup>th</sup> quantile).

Thus, the country risk is sensitive to a wide range of economic, financial, and political factors, and the value of  $R^2$  shows that the sensitivity is stronger when sovereign CDS are extremely high (the 90<sup>th</sup> quantile).

However, we note that in a situation where the country risk is low (q10), CDS quotes are positively related to the climate risk. In the context that leads to an increase in climate risk, there will be an increase in country risk when the latter is already low. These results allow us to conclude that the impact of climate risk on CDS quotes is manifested only in countries with very low sovereign risk, such as the Netherlands, Germany, Switzerland, Sweden, or Denmark.

From our point of view, show that the impact of climate risk on sovereign risk is much better identified in the case of countries with a very high degree of economic and financial complexity and which have an increased stability of the political environment.

**Table no. 4. Quantile regression results (sovereign CDS as dependent)**

	q10	q25	q50	q75	q90
<b>GDPc</b>	-0.0733	-0.0492	-0.0694	0.0699	0.9176*
<b>INF</b>	0.0590**	0.0422*	0.0817***	0.1273**	0.2061
<b>UNE</b>	0.0329***	0.0456***	0.1191***	0.2320***	0.4774***
<b>CPI</b>	-0.0161**	-0.0152***	-0.0147***	-0.0227***	-0.0610***
<b>PSI</b>	-0.0762	-0.0760	0.0928	0.3547**	0.7054
<b>FFI</b>	-0.0021	-0.0034	-0.0061*	-0.0189	-0.0218
<b>CRI</b>	0.0017*	0.0016	0.0005	0.0016	0.0022
<b>Obs.</b>	263	263	263	263	263
<b>R<sup>2</sup></b>	0.1233	0.1479	0.1855	0.2503	0.3028

Note: \*, \*\*, \*\*\* indicates statistical significance at an error threshold of 1%, 5%, and 10% levels. The intercepts were estimated but not reported

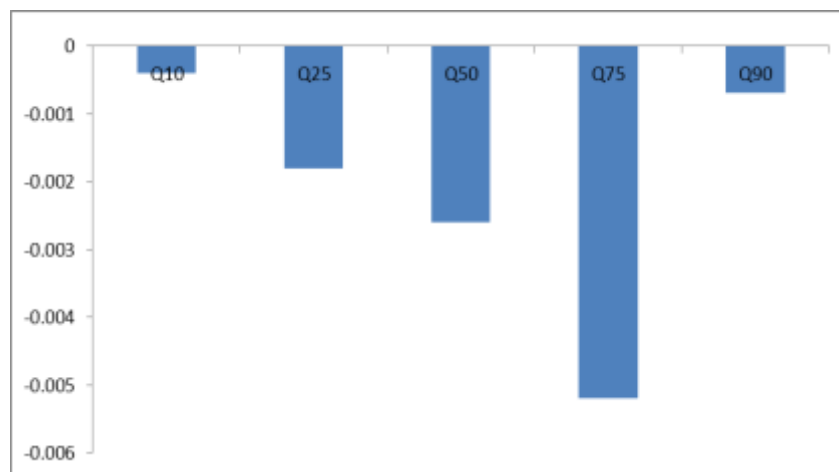
Table no. 5 shows the results of the quantile regression, using as a dependent variable the market capitalisation as a percentage of GDP. We chose as representatives the quantiles q10, q25, q50, q75, and q90. Conventionally, the lower quantiles describe the situations in which the market capitalization as a ratio of GDP is low, and the upper quantiles describe those situations when it is high.

**Table no. 5. Quantile regression results (market capitalisation as dependent)**

	q10	q25	q50	q75	q90
<b>GDPc</b>	0.0304	0.1119**	0.1665***	0.2286**	0.5727***
<b>INF</b>	-0.0188*	-0.0169	-0.0206*	-0.0101	0.0193
<b>UNE</b>	-0.0093	-0.0001	0.0015	-0.0026	-0.0074
<b>COR</b>	0.0022	0.0066***	0.0127***	0.0148***	0.0121
<b>POL</b>	-0.0688	-0.1716***	-0.2729***	-0.2180***	-0.0570
<b>FINF</b>	-0.0056**	0.0024	0.0072***	0.0082***	0.0039
<b>CRI</b>	-0.0004	-0.0018*	-0.0026**	-0.0052***	-0.0007
<b>Obs.</b>	263	263	263	263	263
<b>R<sup>2</sup></b>	0.0684	0.1234	0.2388	0.2938	0.3348

Note: \*, \*\*, \*\*\* indicates statistical significance at an error threshold of 1%, 5%, and 10% levels. The intercepts were estimated but not reported

Stock market capitalization is sensitive to several economic, financial, or political factors regardless of the targeting quantile. However, we note that the capital market reacts much more substantially to climate risk across the 25th to 75th quantiles. Increasing climate risk will have a negative impact on market capitalization, which means that several climate phenomena have an effect on investor preferences, as well as on the evolution of the stock market. The impact is not significant for countries with low market capitalization such as the Czech Republic, Turkey, or Greece, nor for those with very high values such as the USA or Switzerland. For the rest, increasing climate risk leads to a reduction in the market value of stocks. The impact is monotonically decreasing from small quantiles (q25) to large quantiles (90) as can be seen in figure no. 1.



**Figure no. 1. Quantile estimates for climate risk (market capitalisation as dependent)**

Given this, we can argue that traders' expectations about the volume of stock market transactions depend on how they perceive climate risk. There are a number of companies operating in the capital market who are more exposed to climate risk, and from this perspective one could explain the wider range of significant coefficients at different selected quantiles.

The last part of the analysis aims to assess the impact of climate risk on competitiveness, i.e. the ability of countries to deliver goods and services to competitive markets. In this approach, the structure of the data regarding competitiveness is based on a binary approach of LOGIT type, as given in table no. 6.

**Table no. 6. LOGIT estimates**

Variables	Coefficients
GDPc	0.00002
INF	0.03697
UNE	0.16519***
COR	0.13538***
POL	-1.26508**
FINF	-0.06868
CRI	-0.00524

Variables	Coefficients
C	-7.32689***
Obs.	242
McFadden R <sup>2</sup>	0.1287

Note: \*, \*\*, \*\*\* indicates statistical significance at an error threshold of 1%, 5%, and 10% levels.

According to the results in table no.6, there is a negative relationship between climate risk and the level of competitiveness. The value of the negative coefficient

- 0.00524 suggests that an increase in climate risk reduces the probability that a country, in a given year, will enter the top 25% of countries depending on the level of global competitiveness. However, given the probability associated with the negative coefficient, which is higher than 10%, the result cannot be considered statistically relevant.

## Conclusions

The results of the study confirm the need to involve all decision-makers and financial regulators in the adoption of specific measures to reduce the financial and macroeconomic risks caused by climate change. Quantile regressions show that the level of market capitalization incorporates information on climate risks, with effects on the financial market. The results are consistent with other studies (Furukawa, Ichiue and Shiraki, 2020; Görden et al., 2020; Faccini, Matin and Skiadopoulos, 2021) which support the idea that investors react to climate risks and reward companies involved in proper management of climate change through price.

In this paper, we contribute to literature by reporting that the climate risk does not strongly impact countries with low or very high levels of market capitalization, which means either the existence of a high level of banking intermediation (for the first case) or the existence of proper management policies for climate risk (in the case of countries with increased market capitalization). Furthermore, the use of sovereign CDS quotations as a proxy variable of sovereign risk is leading to the conclusion that effects of climate risk appear only in cases of very low country risk, respectively, climate risk leads to increased country risk, only in cases of low budget deficit, it is not possible to identify the effects of climate risk on the example of countries with budgetary vulnerabilities.

Since it was impossible to accurately estimate the impact of climate change on sovereign risk in all countries or those with high sovereign risk, we identify this as a limitation of the study and the possibility of using a dependent variable such as external debt.

The study also highlights the impact of climate risk on the global competitiveness of a country using logistic regression. The results show the existence of a negative correlation but statistically insignificant. Given the increasing climate risk, the result shows that the probability of a country falling into the top 25% is reduced, which indicates that climate change has an effect on long-term competitiveness. However, climate risk management policies do not provide tools to accurately quantify losses in terms of competitiveness, apart from the price of CO<sub>2</sub> emissions. From this perspective, we propose, in the following studies, to develop an indicator that would allow a significant assessment of the impact of climate risk at the level of competitiveness.

Thus, the results of the study confirm the need to involve all economic and political decision – makers, as well as financial regulators, in the adoption of specific measures to reduce the financial and macroeconomic risks caused by climate change.

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