Risk and Financial Management; Vol. 4, No. 1; 2022
ISSN 2690-9790 E-ISSN 2690-9804
https://doi.org/10.30560/rfm.v4n1p1

Do Financial Markets Price Risks to Climate Change?

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Received: June 15, 2022 Accepted: June 21, 2022 Online Published: June 21, 2022

Abstract

Financial markets represent a powerful means to incentivize governments and corporates to take action against climate change. When climatic risks are reflected in the valuation of financial instruments, firms and governments acting in their own self-interest will reorient decisions toward climate-friendly activities. While the literature has found scant evidence that climate change risks are priced into equity share prices, recent work suggests that climate risks are priced into sovereign bonds. I re-examine the link between climate change and sovereign bonds and find that, as with share prices, sovereign bonds do not price in a climate risk premium. This paper thus resolves the anomalous finding that investors would demand a climate risk premium from sovereign bonds but not stocks. I find that, by virtue of their construction, measures of climate change vulnerability and resilience are highly rigid over time, and thus empirically capture country-specific risk premia rather than a climate-specific risk premium.

Keywords: financial markets, risk pricing, climate change, climatic risks, sovereign bond spreads, risk premium

I. Introduction

Climate change is the defining challenge for policymakers of our generation. Yet, despite repeated commitments to arrest the emissions of greenhouse gases (GHGs) in successive rounds of international climate treaties, promises to accelerate transition to greener economic activities and invest in resilient physical infrastructure, GHGs continue to rise and reached their highest level in recorded history in 2021 (National Oceanic and Atmospheric Administration, 2021). Costly investment in green infrastructure as well as chronically low emission standards are a leading explanation of why private and public entities do not sufficiently internalize the externalities of polluting activities.

Financial markets represent one of the most powerful ways in which nations can be driven to act on climate resilience. If the risks from floods, hurricanes, and storms are reflected in the valuation of financial instruments then, acting in their own self-interest, firms and policymakers are likely to incorporate climate change effects into their decisions. When climate change risks are priced in, share prices of firms in nations more exposed to hurricanes or flooding would trade at a discount, while those in less exposed nations would trade at a premium. This would spur individual firms to reorient their activities toward climate-friendly investment and, in the aggregate, improve national resilience and reduce vulnerabilities to the detrimental effects of climate change.

The question of whether financial markets price climate change risk has become of rising interest to practitioners. The focus thus far has been predominantly on stock prices (e.g., Daniel, Litterman and Wagner 2017, Kumar, Xin and Zhang 2019, Hong, Liu and Xu 2019, IMF 2020, Ehlers, Packer and de Greiff 2021, Bolton and Kacperczyk 2021, Faccini, Matin and Skiadopoulos 2022). The overwhelming evidence is that judged by risk premia, share price valuations, and price-earnings ratios, financial markets do not price in climate risks. As two sobering examples: IMF (2020) reports that in 2005 Hurricane Katrina exacted losses of more than 1 percent of GDP in the United States, but the major U.S. equity indices had nearly no reaction, while immediately following the devastating floods in Thailand in 2005, which cost nearly 10 percent of GDP, share prices lost only 1 percent.

To date, there is less research on whether climate change risks are priced into sovereign borrowing costs. The consequences of climate change for sovereign risk premia is arguably of systemic importance due to its implications for public finance and interest payments, especially since the rapid acceleration of public debt during the COVID-19 pandemic. Thus far, however, the literature has focused predominantly on whether environmental, social and governance (ESG) achievements affect sovereign bond yields (e.g., Berg et al. 2018, Capelle-Blancard, Crifo, Diaye, Oueghlissi and Scholtens 2019, Hubel 2020) and currency returns Cheema-Fox, Serafeim and Wan 2021). Sovereign credit ratings and debt market outcomes are also shown to be affected by rising temperatures

(Bohm, 2021).

Kling, Lo, Murinde and Volz (2019), who examine the response of sovereign bond yields to climate change vulnerability represents one of the first analyses of the links between climate change vulnerability and sovereign bonds. They find that in a group of developing nations, the greater the exposure to the adverse effects of climate change, the greater were the risk premia incurred on sovereign bonds. Subsequent research expands this study to a larger number of countries and also finds negative associations between climate change vulnerability and sovereign risks (ADB 2020, Beirne, Renzhi and Volz 2020, Cevik and Jalles 2020, Kling, Murinde, Volz and Ayas 2021), particularly in emerging and developing economies, with somewhat weaker impacts in industrialized countries.

A priori, it is puzzling that climate change vulnerability would be priced into sovereign bonds but not into stocks. It has been suggested that limited disclosure of climate risks lead stock market investors to inadequately assess the threat from climate change (Financial Stability Board, 2019); however, this should affect investors' ability in pricing climate risks in both sovereign bond and equity markets. Another possibility is a mismatch of horizons: stock market investors purchase claims in a firm's physical assets which are expected to depreciate over one to two decades, while climate change impacts are not expected to materialize till beyond this horizon (IMF, 2020). However, as the existing research on sovereign bonds has analyzed sovereign bonds with maturity of 1- to 10-year horizons, this does not explain the difference in stock market and sovereign bond pricing. Finally, another possible explanation is that investors simply discount or ignore the risks to the economy from climate change due to the long horizon over which they are expected to materialize, and the extreme uncertainty regarding the speed or magnitude of climate change effects; even in that case, it is improbable that investors will demand a climate-risk premium from sovereigns but not from issuers of equity.

The premise of this paper is that financial markets do not price climate risks into *either* share prices—as established in the literature—or sovereign bonds, and that existing work spuriously estimates a negative link between climate related exposure and sovereign bond spreads. Specifically, a potential shortcoming in the work on the sovereign bond-climate change nexus is that it draws on country-specific indices of climate vulnerability and climate preparedness, such as the Notre Dame Global Adaptation Indices and the FTSE Russell, to measure climate risks, and these indices are constructed using structural characteristics of countries, such as political stability, rule of law, inequality, ICT infrastructure, regulatory quality, and education that are highly invariant over time (Chen et al., 2015).

Indeed, as I show below in Section 2, these indices are virtually constant over 1996-2016, notwithstanding that this is a period over which GHGs increased 45 percent globally (Environmental Protection Agency, 2021), and would ordinarily be reflected in lower climate resilience and higher climate vulnerability. This raises the possibility that in empirical work, the ND-GAIN climate indices act similarly as country fixed-effects which absorb intrinsic country qualities—relating not just to climate characteristics, but to a wide range of slow-moving structural features of economic, social, governance, climate exposure, and technology. That is, the negative association between such indices and sovereign bond spreads found in some papers may not reflect a climate risk premium per se, but rather a country-specific risk premium.

In this paper, I analyze this premise. Utilizing the same data as in existing work on sovereign bonds and climate change risks (e.g., Kling et al. 2019, ADB 2020, Cevik and Jalles 2020, Beirne et al. 2020), I address the possibility that commonly-used climate change indices, by virtue of their construction, absorb intrinsic economic, social, governance, climate exposure and technological differences across countries. When the regression is estimated without fixed effects, these indices therefore capture all country-specific risk premia and not climate specific risk premia.

To address this potential problem, I start with a standard approach to eliminating country-specific differences, estimating a panel data model with country fixed-effects. To the extent that intrinsic country-specific qualities drive sovereign bond spreads, a fixed-effect model will eliminate these differences, so that the climate indices can accurately identify the impact of climatic risks on sovereign bond spreads. It is also possible, however, that some differences across countries are not strictly fixed over time, although they may be extremely slow moving. For example, inequality, governance, and rule of law may exhibit changes over decades, but little to no change from year to year. In that case, a fixed-effects model will not adequately eliminate these slow-moving country-specific differences, but a first-difference model will (Hsiao, 1986). To address this additional possibility, I then estimate a model with fixed-effects and first differences.

In a sample of 32 advanced economies and 21 emerging markets observed between 1996 and 2016, I find that financial markets do not price climate related risks in sovereign bonds. This result is consistent with the existing evidence that markets do not price climate risks in share prices, and it resolves the anomalous finding that investors would demand a climate-related risk premium from sovereign bonds but not stocks. The results show that whether in levels or differences, indices of climate-related vulnerabilities and resilience do not have a statistically significant relation with sovereign bond spreads.

The remainder of the paper is organized as follows. In Section II, I discuss the data used in the paper, stylized facts about the climate indices used in the literature and this paper, and the regression models that are estimated. Section III discusses the results of estimating these models. Section IV concludes.

Data and Empirical Model

The data used for this analysis are primarily from three sources. The dependent variable is the sovereign bond spread measured as the 10-year local-currency sovereign bond yield minus the U.S. 10-year Treasury bond, both of which are drawn from Bloomberg. Macroeconomic and governance data are from the International Financial Statistics (IFS), World Economic Outlook (WEO) and World Development Indicators (WDI) databases of the International Monetary Fund and World Bank respectively.

The key independent variables are drawn from the Notre Dame Global Adaptation Initiative (ND-GAIN). They are climate change *vulnerability*, which measure a country's exposure to climate-related disruption, and climate change *resilience*, which captures a country's capacity to manage the adverse impacts of climate change (Note 1). A detailed account of these indices is presented in Chen et al. (2015). The indices are based on 45 underlying variables. Of these, 9 that draw on social, economic and governance variables are inputs to the "resilience" score, measuring a country's "capacity to apply economic investments and convert them to adaptation actions". The remaining 36 based on a range of data representing the country's food, water, health, ecosystem, human habitat and infrastructure sectors, are inputs to a vulnerability score, measuring a country's "exposure, sensitivity, and capacity to adapt to the impacts of climate change". Higher values of resilience (respectively, vulnerability) denote greater (respectively, lower) ability to counter the adverse impacts of climate change.

Summary statistics of all variables used in the regression analysis are presented in Table 1. They include the variables that are traditionally understood to affect sovereign bond yields and spreads, such as the level and growth of real output, government finances (public debt, the government's fiscal balance), foreign reserves, inflation, the terms of trade, and measures bureaucratic quality (a measure of the strength of institutions, processes and governance) and government effectiveness (a composite measure of the quality of public and civil services, policy formulation and implementation, and government credibility); and the two climate variables that are the focus of this study.

Table 1. Summary Statistics

Variable	No. Obs.	Mean	Std. Dev.	Min	Max	Source
Sovereign bond spreads, %	1,017	2.3	6.5	-6.02	91.2	Bloomberg
Climate resilience (index)	1,017	56.5	14.5	19.1	80.1	ND-GAIN
Climate vulnerability (index)	1,017	35.6	5.7	25.9	57.0	ND-GAIN
Ln Real GDP	1,017	7.3	2.8	1.6	16.0	IFS
Real GDP growth rate	1,017	3.0	3.4	-16.3	22.3	IFS
CPI inflation	1,014	3.8	6.1	-1.6	85.7	IFS
Public debt (% of GDP)	1,002	57.5	34.1	3.8	236.1	IFS
Fiscal balance (% of GDP)	975	-0.04	3.5	-29.7	15.8	IFS
Foreign reserves (% of GDP)	987	6.3	11.3	.0006	91.3	IFS
Bureaucratic quality (index)	877	0.9	0.8	-2.5	2.2	WDI
Govt. effectiveness (index)	877	0.9	0.9	-2.1	2.4	WDI
Terms of trade (index)	1,017	100.2	14.3	44.6	171.2	WDI

Notes. Summary statistics are for 32 advanced and 21 emerging markets observed between 1996 and 2016.

Sources. Notre Dame Global Adaptation Index (ND-GAIN), International Financial Statistics (IFS), Bloomberg, and World Development Indicators (WDI).

In Tables 2A and 2B, I present additional details of the two climate indices. Table 2A presents the means and standard deviations of each of the climate indices over the 1996-2016 period. A first noticeable feature is that, consistent with priors, the resilience to climate change in advanced economies is generally higher than in emerging markets. While the average 1996-2016 resilience index in advanced nations is 62, it is 41 in emerging markets. Conversely, vulnerability to climate change is generally higher in emerging than advanced economies, with an average value of 40 in the former and 34 in the latter.

What is especially noticeable however, is that these values are highly rigid over time. Columns 3 and 4 of Table 2A report the standard deviation of the indices over 1996-2016. The standard deviation of climate change resilience and especially climate change vulnerability indices are extremely low. In advanced economies their averages are respectively 1.8 and 0.3, while in emerging markets they are 2.5 and 0.8. Figures 1A and 1B summarize these graphically. It is immediately apparent that these indices are nearly invariant over time and thus, likely to be conflated with other time-invariant characteristics of countries.

Second, in Table 2B, I present the correlation matrix of climate change vulnerability, climate change resilience, and structural characteristics of countries such as their bureaucratic quality and government effectiveness. The correlations of the climate change vulnerability (resilience) and these structural variables is strongly negative (positive). The stability of the indices over time and their strong correlation with slow-moving structural attributes underscores the difficulty of extracting information from these indices that is solely due to climate and not conflated with other country characteristics.

Table 2A. Key moments of Indices of Resilience and Vulnerability to Climate Change

	(1)	(2)	(3)	(4)
Country	Mean	Mean	Resilience std.	Vulnerability std.
Advanced Economies				
Australia	70.2	30.4	1.7	0.4
Austria	70.9	31.6	1.2	0.1
Belgium	59.5	36.1	0.9	0.1
Canada	67.9	30.0	1.0	0.3
Cyprus	48.3	36.4	2.4	0.3
Czech Republic	52.3	31.0	2.8	0.2
Denmark	75.2	34.0	1.2	0.4
Finland	76.3	31.4	0.9	0.5
France	60.8	29.8	2.2	0.1
Germany	69.2	29.6	1.1	0.2
Ghana	69.2	49.8	1.1	1.7
Greece	47.7	35.3	2.2	0.2
Iceland	72.0	31.6	3.0	0.4
Ireland	67.9	34.3	1.8	0.2
Israel	57.4	34.1	0.6	0.2
Italy	53.5	32.2	1.0	0.1
Japan	66.7	36.8	1.5	0.1
Korea	24.9	37.9	2.2	0.4
Latvia	56.0	40.5	3.1	0.8
Lithuania	55.1	40.3	2.7	0.8
Luxembourg	59.9	29.5	3.7	0.3
Malta	47.9	36.4	1.9	0.6
Netherlands	66.2	34.9	1.2	0.1
New Zealand	78.2	33.5	1.6	0.6
Norway	78.5	27.5	0.8	0.4
Portugal	52.6	35.0	3.0	0.3
Singapore	74.6	41.8	2.9	0.2
Slovak Republic	50.7	37.4	2.9	0.7
Slovenia	59.7	34.3	3.3	0.3
Spain	55.2	30.9	0.9	0.1
Sweden	72.5	30.4	1.8	0.1
Switzerland	69.9	27.6	1.0	0.1
Tanzania	31.2	56.4	0.7	0.5
United Kingdom	69.6	29.6	0.9	0.4
Emerging markets				
Argentina	37.8	37.5	1.2	0.4
Belarus	38.8	34.2	6.3	0.5
Brazil	37.0	38.7	2.0	0.7
Chile	54.8	35.7	2.0	0.8
China	37.9	40.7	4.6	1.1
Colombia	32.8	40.2	3.2	1.1
Croatia	46.2	39.9	3.2	0.6

Hungary	54.0	37.1	1.4	0.3
India	30.1	52.4	1.3	1.4
Indonesia	31.9	46.5	1.8	1.3
Malaysia	49.7	38.5	2.0	0.8
Mexico	36.6	38.8	1.5	0.5
Philippines	30.9	47.9	1.3	1.3
Poland	51.8	33.3	3.6	0.6
Russia	40.5	33.9	3.9	0.7
South Africa	41.0	41.4	0.5	0.8
Thailand	46.0	42.2	0.9	1.0
Turkey	42.2	35.9	3.5	1.4
Ukraine	33.0	37.5	3.1	0.8

Notes. Averages and standard deviations are calculated between 1996-2016.

Sources. ND-GAIN and author's calculation

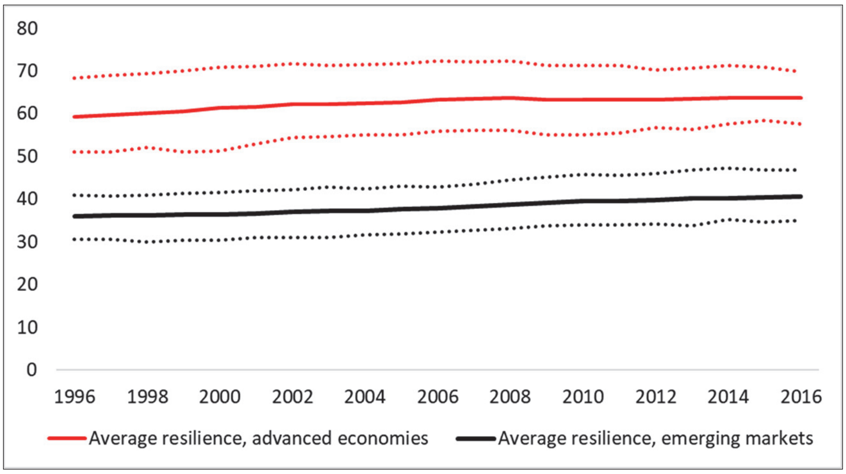

Figure 1A. Climate change resilience, inter-quartile range. 1996-2016

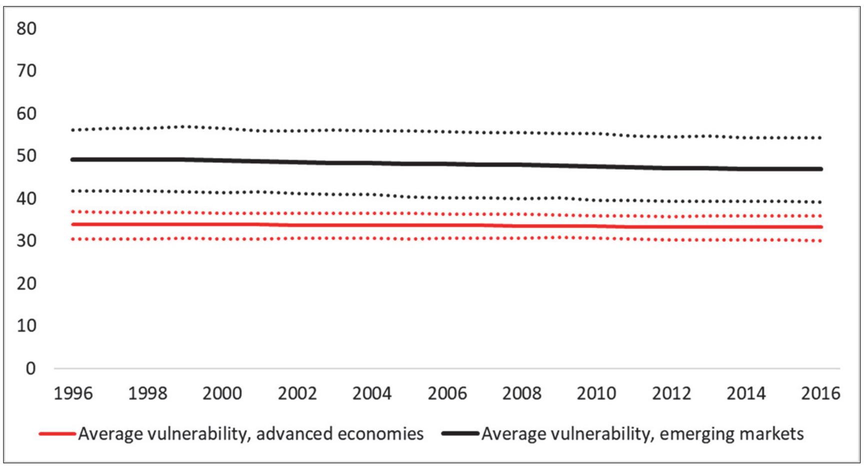

Figure 1B. Climate change vulnerability, inter-quartile range. 1996-2016

Notes. Shown in dots are the 25th and 75th percentiles (emerging markets in black, advanced economies in red).

Sources. ND-Gain and author's calculations.

Table 2B. Correlation of Climate-relate Indices with Structural Factors

	Vulnerability	Resilience	Bureaucratic quality	Govt. effectiveness
Vulnerability	1			
Resilience	-0.71	1		
	(0.000)			
Bureaucratic quality	-0.661	0.881	1	
	(0.000)	(0.000)		
Govt. effectiveness	-0.701	0.909	0.936	1
	(0.000)	(0.000)	(0.000)	

Notes. P-values are shown in parenthesis below the correlation coefficient.

Sources. ND-GAIN, IFS, WDI and author's calculations.

I next test my hypothesis that, taking account of country fixed-effects and slow-moving structural characteristics of countries, the indices of climate vulnerability and resilience are not empirically correlated with sovereign bond spreads. In order to do so, I begin with the following panel regression model:

$$spread_{it} = \beta_0 + \beta_1 RES_{it} + \beta_2 VUL_{it} + \beta_3 X_{it} + \alpha_i + \tau_t + \varepsilon_{it} \tag{1}$$

where *i* denotes country, *t* denotes year, *spread* is the 10-year sovereign bond spread, *RES* denotes the climate resilience index, *VUL* the climate vulnerability index, *X* the vector of macroeconomic controls summarized in Table 1; α_i a country-specific fixed-effect, τ_t a year fixed-effect and ε_{it} denotes an idiosyncratic error term.

I estimate the following variants of equation (1):

(a) The baseline results are obtained from estimating (1) sequentially: including only *RES*; including only *VUL*; including both *RES* and *VUL*; and including *RES*, *VUL*, and *X*. These results are reported in Table 3.

(b) I then re-estimate a version of (1) which is specified in first-differences, rather than levels. It is not *derived* from (1) (Note 2) but rather its premise is that changes in climate vulnerability, resilience and macroeconomic variables affect changes in spreads, and country and year fixed effects may affect this relationship:

$$\Delta spread_{it} = \beta_0 + \beta_1 \Delta RES_{it} + \beta_2 \Delta VUL_{it} + \beta_3 \Delta X_{it} + \alpha_i + \tau_t + \varepsilon_{it} \tag{2}$$

where Δ denotes the differences between successive time periods, e.g., $\Delta spread_{i2018} = spread_{2018} - spread_{2017}$. These results are reported in Table 4.

(c) Finally, I re-estimate equation (2) separately for advanced economies and emerging markets, reporting the results in Tables 5A and 5B.

In estimating (1) and (2), I report clustered standard errors (SEs), following the suggestion by Bertrand, Duflo and Mullainathan (2004) that observations in a cluster are likely to experience the same shocks. Previous papers (including ADB 2020, Beirne et al. 2020, Kling et al. 2019, Cevik and Jalles 2020) use robust SEs. However, unlike robust SEs, which account for only heteroskedastic error terms, clustered SEs account for both heteroskedastic and correlated errors within clusters. Clustering can arise for a number of reasons, including if errors are serially correlated *within* country (Cameron and Miller 2015). This is particularly likely in a panel sample, due to the time-series per country that is used in estimation.

2. Results

Results from estimating equation (1) are presented in Table 3. Using country and year fixed-effects, and reporting clustered SEs, initially I estimate just the effect of climate change vulnerability and resilience individually and jointly in columns (1)-(3). I then expand the regression to include a wide range of macroeconomic and governance variables in columns (4)-(6). While climate change vulnerability has a consistently positive sign and climate change resilience a consistently negative sign, both in accordance with our expectations, neither is statistically significant at a 10 percent error level in any regression.

Table 3. Bond Spreads and Climate Change Indices of Resilience and Vulnerability

	(1)	(2)	(3)	(4)	(5)	(6)
Vulnerability	2.526		2.301	0.678		0.579
	(1.758)		(1.577)	(0.603)		(0.561)
Resilience		-0.405	-0.295		-0.165	-0.151
		(0.310)	(0.236)		(0.105)	(0.100)
Ln Real GDP				2.702	1.130	2.756
				(2.050)	(1.995)	(2.191)
Real GDP growth				-0.183*	-0.192*	-0.200**
				(0.100)	(0.0997)	(0.0990)
CPI Inflation				0.358*	0.358*	0.352*
				(0.207)	(0.209)	(0.205)
Debt/GDP				0.0591***	0.0584***	0.0569***
				(0.0180)	(0.0168)	(0.0159)
Fiscal balance/GDP				0.0944	0.0833	0.0966
				(0.0632)	(0.0590)	(0.0612)
Foreign reserves/GDP				-0.00268	-0.00522	-0.00653
				(0.0229)	(0.0213)	(0.0211)
Bureaucratic quality				-0.561	-0.213	-0.271
				(1.162)	(1.106)	(1.067)
Govt. effectiveness				-1.291	-1.027	-0.910
				(0.960)	(0.867)	(0.941)
Terms of trade				0.0106	0.00991	
				(0.0290)	(0.0278)	
Constant	-74.18	28.70	-47.76	-40.42	1.333	-27.66
	(52.78)	(20.66)	(37.83)	(27.91)	(15.04)	(24.61)
Observations	995	995	995	823	823	823
# of Countries	53	53	53	52	52	52
Adj r-sq	0.488	0.469	0.494	0.722	0.723	0.725
Country fixed effects	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y

Notes. Dependent variable: 10-year local currency sovereign bond yield over 10-year U.S. Treasury yield

Table 3 reports results of estimating equation (1). Standard errors are clustered by country. *** p<0.01, ** p<0.05, * p<0.1.

However, traditional determinants of sovereign bond spreads have statistically significant associations with the bond spread. Higher inflation, characteristic of nations with weak monetary policy frameworks, and higher debt, which raise the prospect of future borrowing distress, have positive and significant association with sovereign bond spreads. Higher growth, which lowers the real debt burden for a given level of debt, has a negative and significant association with sovereign bond spreads. Better bureaucratic quality and government balances, as well as greater foreign reserves, are associated with lower sovereign bond spreads, and higher fiscal balances with higher sovereign spreads, but these coefficient estimates are statistically insignificant. Overall, the baseline results indicate that when we adequately control for fixed characteristics of countries, which may affect the sovereign risk premium for a wide range of economic, social and governance reasons, there is no additional explanatory power of the resilience or vulnerability to climate change.

We next turn to the first-difference model in (2), regressing the change in sovereign bond spreads between consecutive years on the changes in each of the covariates between successive years. As explained in Section 2, the principle motivation for this model is that country fixed-effects can control adequately for characteristics that are genuinely fixed through time. However, many structural features (including, as shown in Figures 1A-1B, the climate-related indices) are rigid but not fixed over time. If improvements in climate resiliency lower sovereign spreads, and worsening climate vulnerability raises sovereign spreads, then this should result in statistically meaningful results in a first difference model.

Results from estimating (2) are presented in Table 4. Coefficient estimates of the change in climate change vulnerability and resilience have the expected positive and negative signs. However, both of the climate change indices are consistently statistically insignificant in columns (1)-(6) of Table 4. Coefficient estimates of changes in inflation and debt retain their positive signs, although neither is statistically significant; however, changes in real GDP growth are statistically significantly associated with reducing sovereign bond spreads. Overall, the results of Table 4 confirm the broad findings of Table 3 that climate change risks are not priced into sovereign bond spreads.

Table 4. Changes in Bond Spreads and Changes in Climate Change Indices of Resilience and Vulnerability

	(1)	(2)	(3)	(4)	(5)	(6)
Δ Vulnerability	0.400		0.400	0.382		0.380
	(0.392)		(0.396)	(0.425)		(0.423)
Δ Resilience		-0.0101	-0.00767		-0.0703	-0.0696
		(0.146)	(0.146)		(0.140)	(0.139)
Δ Ln Real GDP				4.331	4.342	4.802
				(6.727)	(6.440)	(6.649)
Δ Real GDP growth				-0.157***	-0.156***	-0.158***
				(0.0561)	(0.0556)	(0.0580)
Δ CPI Inflation				0.0724	0.0725	0.0731
				(0.0705)	(0.0704)	(0.0709)
Δ Debt/GDP				0.0300	0.0303	0.0310
				(0.0358)	(0.0360)	(0.0351)
Δ Fiscal balance/GDP				-0.000212	0.000234	-0.000444
				(0.0315)	(0.0326)	(0.0332)
Δ Foreign reserves/GDP				0.0216	0.0225	0.0219
				(0.0231)	(0.0234)	(0.0233)
Δ Bureaucratic quality				-1.117	-1.011	-1.007
				(0.887)	(0.755)	(0.760)
Δ Govt. effectiveness				-0.541	-0.518	-0.500
				(0.675)	(0.643)	(0.633)
Δ Terms of trade				0.00361	0.00361	
				(0.0167)	(0.0171)	
Constant	-0.889***	-0.853***	-0.888***	-1.256	-1.264	-0.939
	(0.181)	(0.171)	(0.180)	(1.626)	(1.669)	(0.582)
Observations	942	942	942	688	688	688
# of Countries	53	53	53	52	52	52
Adj r-sq	0.123	0.123	0.123	0.257	0.256	0.257
Country fixed effects	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y

Notes. Dependent variable: 10-year local currency sovereign bond yield over 10-year U.S. Treasury yield

Table 4 reports results of estimating equation (2). Standard errors are clustered by country. *** p<0.01, ** p<0.05, * p<0.1.

I consider that the results of Table 4 may be driven by advanced economies, where climate-change resilience and vulnerabilities are significantly more rigid over time (see Table 2) than in emerging markets. This lack of variation could result in insignificant estimates for the pooled sample, drowning out potentially significant associations of climate change indicators in emerging markets. To test this hypothesis, I estimate the first-difference fixed effects model by country group.

Results are presented in Tables 5A and 5B. The estimates indicate that the insignificance of climate change vulnerability and resilience in the pooled sample of Table 4 are not due to country composition. Comparing the results for advanced economies (Table 5A) with the pooled sample in Table 4, the statistical significance of coefficients are broadly similar; in particular, climate change vulnerability and resilience remain statistically insignificant, while real GDP growth retains its statistical significance. Comparing results for emerging markets (Table 5B) with Table 4, the climate indices remain insignificant in the emerging market group just as it is in the pooled sample. However, public debt, which is widely recognized as a major determinant of sovereign bonds (e.g., Engen and Hubbard 2004, Baldacci and Kumar 2010) is found to be significant in the emerging market sample, although it was not in the pooled sample. It is also of interest that, their statistical insignificance notwithstanding, the magnitude of the coefficient of climate change vulnerability is nearly four times as large in emerging markets than in the pooled sample; and the magnitude of climate change resilience is two-four times larger (in absolute magnitude) than in the pooled sample.

Table 5A. Changes in Bond Spreads Climate Change Indices of Resilience and Vulnerability: Advanced Economies

	(1)	(2)	(3)	(4)	(5)	(6)
Δ Vulnerability	-0.275		-0.298	-0.143		-0.144
	(0.454)		(0.452)	(0.442)		(0.420)
Δ Resilience		-0.132	-0.134		-0.125	-0.127
		(0.152)	(0.151)		(0.190)	(0.189)
Δ Ln Real GDP				-4.200	-3.846	-4.028
				(7.499)	(6.739)	(6.775)
Δ Real GDP growth				-0.179**	-0.181**	-0.179**
				(0.0859)	(0.0880)	(0.0872)
Δ CPI Inflation				-0.0210	-0.0256	-0.0255
				(0.0735)	(0.0695)	(0.0708)
Δ Debt/GDP				-0.0310	-0.0312	-0.0311
				(0.0474)	(0.0458)	(0.0464)
Δ Fiscal balance/GDP				-0.00143	-0.00397	-0.00222
				(0.0313)	(0.0316)	(0.0325)
Δ Foreign reserves/GDP				0.00860	0.00888	0.00938
				(0.0178)	(0.0181)	(0.0182)
Δ Bureaucratic quality				-1.797	-1.566	-1.576
				(1.347)	(1.114)	(1.101)
Δ Govt. effectiveness				-0.278	-0.225	-0.203
				(0.579)	(0.527)	(0.518)
Δ Terms of trade				-0.0101	-0.00959	
				(0.00956)	(0.00958)	
Constant	-0.985***	-0.983***	-0.958***	1.084	0.982	0.0294
	(0.171)	(0.157)	(0.165)	(0.918)	(0.915)	(0.258)
Observations	637	637	637	432	432	432
# of Countries	32	32	32	31	31	31
Adj r-sq	0.203	0.208	0.209	0.274	0.277	0.276
Country fixed effects	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y

Notes. Dependent variable is the first-difference of 10-year local currency sovereign bond yield over 10-year U.S. Treasury yield. Table 5A reports results of estimating equation (2), for advanced economies only. Standard errors are clustered by country. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

In summary, we present results which show that sovereign bond spreads do not price in risks associated with climate change using the most commonly-utilized indices of climate change risk. These results are found for both the *levels* and *changes* in sovereign bond spreads, for advanced and emerging economies. In comparison to other papers, our results take account of the high rigidity of these indices which necessitate the use of fixed-effects models as well as first differences, to adequately distinguish the climate-related risk indices from general country-specific risk premia

3. Conclusions

Financial markets represent an opportunity to hedge risk, including long-term risks of climate change. However, there is mounting evidence that share prices, price-earnings ratios, and equity risk premia do not price in from climate change risks. In light of that evidence, the finding in some papers that sovereign bonds price climatic risk appears anomalous. In this paper, I re-examine the sovereign bond-climate risk nexus. Taking account of the fact that commonly-used indices of climate change resilience and vulnerability are highly rigid over time and may act as country fixed-effects in estimation, I employ a range of fixed effects and first-difference models to reconsider this link. My results suggest that, as with share prices, sovereign bonds do not price a climatic risk premium. An open question for future research is whether the findings of this literature are driven by the specific measures of climatic risk that researchers have used thus far, and whether they can be overturned by alternative measures that are not based on indices.

Table 5B. Changes in Bond Spreads Climate Change Indices of Resilience and Vulnerability: Emerging Markets

	(1)	(2)	(3)	(4)	(5)	(6)
Δ Vulnerability	1.156		1.138	1.202		1.146
	(0.825)		(0.839)	(0.882)		(0.835)
Δ Resilience		-0.177	-0.167		-0.115	-0.0796
		(0.357)	(0.361)		(0.264)	(0.232)
Δ Ln Real GDP				28.28***	27.41***	25.64**
				(9.549)	(9.096)	(9.802)
Δ Real GDP growth				-0.189*	-0.187*	-0.178*
				(0.0949)	(0.0939)	(0.102)
Δ CPI Inflation				0.0854	0.0848	0.0874
				(0.0752)	(0.0765)	(0.0789)
Δ Debt/GDP				0.124*	0.125*	0.109*
				(0.0644)	(0.0622)	(0.0525)
Δ Fiscal balance/GDP				-0.0126	-0.0241	-0.0326
				(0.104)	(0.104)	(0.117)
Δ Foreign reserves/GDP				-0.127	-0.0767	-0.0936
				(0.222)	(0.183)	(0.182)
Δ Bureaucratic quality				-0.413	-0.216	0.105
				(1.376)	(1.306)	(1.145)
Δ Govt. effectiveness				-0.426	-0.451	-0.635
				(1.856)	(1.824)	(1.695)
Δ Terms of trade				-0.0217	-0.0213	
				(0.0372)	(0.0387)	
Constant	-4.368***	-4.470***	-4.296***	-5.014	-5.087	-6.831***
	(0.379)	(0.532)	(0.394)	(3.323)	(3.554)	(1.661)
Observations	305	305	305	256	256	256
# of Countries	21	21	21	21	21	21
Adj r-sq	0.238	0.237	0.238	0.363	0.357	0.359
Country fixed effects	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y

Notes. Dependent variable is the first-difference of 10-year local currency sovereign bond yield over 10-year U.S. Treasury yield. Table 5B reports results of estimating equation (2), for emerging markets only. Standard errors are clustered by country. *** p<0.01, ** p<0.05, * p<0.1.

Acknowledgments

I thank Natalija Novta for her insightful comments on climate change resilience, Seruwaia Cagilaba, Nataliya Ivanyk, Hailey Ordal, attendees of the Jobs, Growth, and Structural Reforms Seminar Series held by the Structural and Climate Policies Division for comments and discussions; Gladys Cheng for assistance with the Bloomberg data and Sam Kuersteiner for research assistance.

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