THE MARKET VALUE OF INSURANCE COMPANIES AND GREENHOUSE GAS EMISSIONS IN THE UNITED STATES

Silvia Bressan *, Sabrina Du **

* *Corresponding author,* Faculty of Economics and Management, Free University of Bozen-Bolzano, Bozen-Bolzano, Italy
Contact details: Free University of Bozen-Bolzano, Piazza Universita´1, 39100, Bozen-Bolzano, Italy
** The Donald J. Schneider School of Business and Economics, Saint Norbert College, De Pere, USA

How to cite this paper: Bressan, S., & Du, S. (2025). The market value of insurance companies and greenhouse gas emissions in the United States. *Risk Governance and Control: Financial Markets & Institutions, 15*(2), 123–133. https://doi.org/10.22495/rgcv15i2p11

ISSN Online: 2077-4303
ISSN Print: 2077-429X

Received: 20.01.2025
Revised: 27.02.2025; 05.03.2025; 05.05.2025
Accepted: 29.05.2025

JEL Classification: G12, G22, Q54
DOI: 10.22495/rgcv15i2p11

Abstract

Emissions of greenhouse gases (GHGs) are among the main causes of global warming and extreme weather events. Policymakers expect that GHG emissions lead to a higher incidence of acute and chronic climate risks. The insurance sector has a primary role in managing climate-related risks, affecting insurers on several dimensions, including their underwriting capacity, profitability, and performance (Gupta & Venkataraman, 2024). In this article, we focus on the USA to study how the stock market value of insurers is associated with the country's GHG emissions. They impact the business of insurance companies on several dimensions, including their corporate valuation. In this article, we look at the USA and study the association between the country's GHG emissions and the stock market value of insurers. We find that increasing GHG emissions and the generation of non-renewable energy are related to lower insurers' equity prices, especially in the segment of property and casualty (P&C) insurance. This effect is persistent even after considering environmental taxes and fossil fuel government subsidies and has a stronger magnitude during periods of severe climate change risk, as well as in times of frequent natural disasters. Our interpretation is that market investors discount the value of insurance companies at higher expected returns when they face increasing climate change risks. These results deliver important insights to asset managers and policymakers.

Keywords: Insurance Companies, Market Value, Climate Change, Greenhouse Gas Emissions

Authors' individual contribution: Conceptualization — S.B.; Methodology — S.B.; Formal Analysis — S.B.; Writing — Original Draft — S.B. and S.D.; Writing — Review & Editing — S.B. and S.D.; Supervision — S.B.; Funding Acquisition — S.B.

Declaration of conflicting interests: The Authors declare that there is no conflict of interest.

Acknowledgements: This work was supported by the Open Access Publishing Fund of the Free University of Bozen-Bolzano.

1. INTRODUCTION

Climate change has a considerable impact on the liabilities and assets of the insurance balance sheet. In terms of underwriting, the increased frequency and severity of natural disasters associated with climate change can make it more difficult for insurers to accurately predict the likelihood of future losses and price insurance products appropriately. The expected growth in physical risk exposures and insurance claims due to climate change will increase risk-based premium levels over time, potentially affecting the mid to long-term affordability and availability of insurance products with coverage against climate-related hazards (European Insurance and Occupational Pensions Authority [EIOPA], 2023). As a consequence, regulators and policymakers provide guidelines that encourage insurers, as ubiquitous players in the economy and society, to help shape climate policies in a responsible and effective way.

Indirectly, greenhouse gas (GHG) reductions and transformations in the energy sector offer new investment opportunities that may also influence insurers' asset portfolios. For example, the Climate-Wise Initiative, a collaborative effort of insurers launched in 2007 to drive action on climate change, is based on the principle that climate risk evaluations should be incorporated into investment decision-making[1]. The uncertainty related to changing climate conditions at the global level has also drawn closer attention from rating agencies, which conclude that the effects of climate change "will magnify the volatility for these firms and result in a number of risk management challenges" (Moody's Investors Service, 2018, p. 2).

Evidently, climate change-related issues also influence the valuation of insurance firms. Financial research has started to develop theories that explain equity prices as a function of environmental aspects. However, the evidence about the association between climate change and the market valuation of insurance companies is limited, and existing studies often focus on natural disasters (Angbazo & Narayanan, 1996; Born & Viscusi, 2006; Gupta et al., 2023; Montero et al., 2024). Therefore, it seems important for academics, portfolio managers, and regulators to conduct research aimed at understanding the effect of GHG emissions on the value of insurance companies. To contribute to filling this gap in knowledge, this article focuses on the USA market, testing whether the equity valuation of insurers is associated with the country's GHG emissions. Our main finding is that insurers' equity prices decrease with GHG emissions and non-renewable energy generation. This pattern is more evident for the subsample of property and casualty (P&C) insurers and during periods when the environmental conditions of the country are more critical. Additional outcomes explore the influence of environmental taxes and government fossil fuel subsidies (FFSUBS), thereby allowing us to draw relevant implications for policymaking.

The article is organized as follows. Section 2 relates our topic to the most recent literature and outlines the previous findings to develop our working hypothesis. Section 3 illustrates the methods, data and variables that we use in the analysis. Section 4 presents and discusses our results. Section 5 concludes the paper.

2. LITERATURE AND WORKING HYPOTHESIS

The transition to a more sustainable economy is directly related to addressing climate change issues, and insurance companies have become aware that they are impacted at multiple levels by climate-related factors and policies. Several papers outline the challenges that climate change poses to insurance companies and their responses in terms of adaptation and mitigation. For example, Herweijer et al. (2009) highlight that insurers would incur severe risks if they did not adequately adapt to the impacts of climate change. However, activities aimed at climate change mitigation, such as coverage for or investment in low-carbon technologies, offer new investment opportunities to insurers, which could benefit them by taking a leading role in the global effort to address changing climate conditions. Dlugolecki (2008) provides an overview of the main implications of climate change on European insurers. In particular, data on U.K. temperatures reveal that the frequency of extreme weather events (so-called "return period") has dramatically increased. The author argues that shrinking return periods imply serious consequences for underwriters: catastrophe models are wrongly calibrated; premiums are too low; exposures are too high; claim-handling capacity is inadequate; and credit ratings are too generous. Nevertheless, there is still a huge need for unfilled insurance (i.e. an "insurance gap") that offers opportunities for insurers, which, together with the public sector, could contribute to adaptation, disaster management, and sustainable economic development. Gupta et al. (2023) use textual analysis to study how insurance firms differentiate in their response to climate risk. The authors find that casualty insurance firms are more susceptible to acute climate risk, while life insurance firms are more prone to chronic climate risk.

Some articles focus on episodes of catastrophes to study the repercussions of natural disasters on insurers' performance. Born and Viscusi (2006) use data on homeowners' insurance coverage in the USA from 1984 to 2004 to study the effects of major catastrophes termed "blockbuster catastrophes" (p. 1). When a catastrophic event hits the insurers, firms suffer huge losses that lead them to alter their subsequent insurance rates, so that the loss ratios in the non-catastrophe years following a catastrophe are lower than they were before. In this way, insurers remain profitable despite the presence of increased assessed risks, while creating troubles in terms of insurance affordability for homeowners. Angbazo and Narayanan (1996) examine the impact of Hurricane Andrew in 1992 on the stock prices of publicly traded property-liability insurers. They find that Hurricane Andrew had a large negative effect on insurance stock returns that was ameliorated to some extent by a smaller positive effect. The interpretation is that equity valuations were factoring in losses due to payments on policyholders' claims, but at the same time, investors were expecting that insurers could recoup some of their losses from subsequent higher premiums. Thomann (2013) discovers that the most severe natural catastrophes in the USA from 1988 until 2006 increased the volatility of P&C insurance stocks while reducing their correlation with the market return. In contrast, the catastrophe events of 11 September 2001 led to increases in volatility but also, simultaneously, to an increase in the correlation with the market return. Ragin and Halek (2016) studied insurance brokers' stock returns surrounding the largest catastrophes worldwide between 1970 and 2011. They find that the brokers earned positive abnormal returns on the day of the event, in addition to persisting in the long run. They also prove that these returns are negatively related to insurers' capital, in line with economic theories predicting a negative relationship between capital and insurance prices, besides a price-inelastic demand for commercial insurance. Montero et al. (2024) investigate the impact of natural disasters from 2010 until 2020 on the volatility of property and liability insurance companies in the USA, showing that in the short post-disaster period (one month), insurer stocks

[1] https://www.cisl.cam.ac.uk/business-action/sustainable-finance/climatewise

tend to experience a decrease in volatility, influenced by factors such as reinsurance coverage and the absence of insured losses in affected areas.

Building upon this literature, the goal of the following analysis is to test whether the market valuation of insurers in the USA is related to the country's emissions of GHGs, approximating the changing climate conditions. While we focus on a specific country's (i.e. the USA) total GHS emissions, the literature has often studied companies' GHS emissions in relation to other policies, e.g., corporate social responsibility disclosure (Sariannidis et al., 2015) and climate change disclosure (Gagné & Berthelot, 2021), or the board composition (Yadav et al., 2024). In fact, previous research demonstrates that climate change is a significant disruptor for insurers. According to Stechemesser et al. (2024), climate change encompasses both direct and indirect impacts on the insurance sector. Direct impacts are the physical effects due to changing climatic conditions, such as temperature, precipitation, and storminess. These include damages from extreme weather events to the insurers' infrastructure or the buildings of the insurance companies themselves. Indirect impacts result from regulatory, economic, social, ecological, and cultural changes, and depend on the influence of climate change on insurers' stakeholders, such as suppliers, customers, employees, or policymakers The increasing uncertainty surrounding the evolution of climate conditions affects the financial stability of insurance firms. Increasing losses and claims expenses may decrease revenues, also reducing capital reserves. Eventually, the surge in operational costs, capital costs, and investment yields would lead to diminished profitability or even insolvencies.

The likelihood of extreme weather events is directly related to global warming and emissions of GHGs (Lashof & Ahuja, 1990). GHGs, such as carbon dioxide (CO_2), methane, and nitrous oxide, keep the Earth warmer than it would be without them. The so-called "greenhouse effect" is not inherently negative; without it, our planet would be too cold for life as we know it. However, if the amount of GHGs in the atmosphere changes, the strength of the greenhouse effect changes too. This is the cause of human-made climate change: by adding GHGs to the atmosphere, we are trapping more heat, and the entire planet gets warmer (Climate Portal, n.d.). Policymakers have long since recognized that mitigating climate change means reducing the flow of heat-trapping GHGs into the atmosphere (European Environment Agency, 2025).

Previous research has studied how the carbon emissions of corporations affect multiple aspects, for example, equity performance (Wen et al., 2020; Bolton & Kacperczyk, 2021, 2024), valuation (Hágen & Ahmed, 2024), investor decision-making (Krueger et al., 2020), and financing costs (Kim et al., 2015; Bui et al., 2020). Differently from the previous literature, we decide to employ the country-wide GHG emissions as a plausible indicator for a country's exposure to climate change-related risks. Environmental research demonstrates that identifying newer technologies for the reduction and mitigation of greenhouse gas emissions is essential to increase resilience and adaptability to future climate change (Krauter & Rüther, 2004; Montzka et al., 2011). Our expectation is that increasing GHG emissions within the country would widen the exposure of insurers to the negative consequences of climate change (Herweijer et al., 2009). Faced with this uncertainty, market investors perceive higher risks from investments in insurance companies, therefore, they discount the value of the firms at higher compensation rates. This argument is in line with a "damage" hypothesis like in Shelor et al. (1992) and Gangopadhyay et al. (2010), arguing that severe climate risks have a negative impact on the value of insurers, because insurers need to handle claim payments due to damages to policyholders. In summary, our working hypothesis states the following:

H1: Worsening climate change concerns related to increasing greenhouse gas emissions are associated with lower market values of insurance companies.

3. METHODS

We focus on insurers in the USA. We use data from S&P Capital IQ, which classifies insurance segments into financial guarantee, insurance broker, life and health (L&H), managed care, mortgage guarantee, multiline, P&C, reinsurance and title insurance. For the period 2008–2022, we download two measures of equity market value, namely the average stock price (P), and the price-to-book ratio (PB). P is the annual average stock price in dollar terms computed from the daily closing prices. PB is the end-of-year ratio of the market value of equity to the book value of equity. The market value of equity is the product between the average share price and the number of shares outstanding. We also obtain information on the companies' total assets and net income (in dollar terms). To control for firms' size and revenues, we use the natural logarithm of assets (ASS) and income (INC).

We relate insurers' market valuations to measures for climate change taken from the International Monetary Fund (IMF) climate change indicators dashboard[2]. Anthropogenic emissions of GHGs, particularly CO_2 from fossil fuel combustion, have been fairly strongly identified as one of the main causes of global warming since the 1990 and 1995 reports of the Intergovernmental Panel on Climate Change (IPCC), a think tank of 2500 scientists who gathered and studied evidence of global warming under the auspices of the United Nations (Houghton et al., 1990; IPCC, 1995). Montzka et al. (2011) prove that the reduction of CO_2 GHGs and the usage of non-CO_2 GHGs would contribute to lower global warming. Therefore, we decided to look at GHG emissions, using the amount of total GHG emissions (including land-use, land-use change and forestry) measured in millions of metric tons of CO_2 equivalent (GHG).

Research shows that increasing the use of renewable energy can help mitigate global warming by reducing greenhouse emissions. In contrast, the supply of electricity from non-renewable energy sources, such as fossil fuels and petroleum products, has a negative effect (increases) precipitation (Shafiei & Salim, 2014; Acaroğlu & Güllü, 2022). For this reason, we consider the total non-renewable electric energy (NREN) generated by fossil fuels measured in thousands of gigawatt-hours. NREN is inversely related to the country's ability to mitigate global warming and its detrimental consequences on the environment.

The next two variables are selected from the policy instruments for addressing climate

[2] https://climatedata.imf.org/pages/access-data

change. The first instrument is environmental-related taxes and carbon and energy taxes, which economists and environmental scientists recommend as effective tools for reducing overall pollution efflux and achieving sustainable development goals. In fact, empirical evidence supports the implementation of environmental taxes to combat climate change and reduce extreme weather events (Ghazouani et al., 2021; He et al., 2023). Zhu et al. (2023) illustrate that environmental taxes contribute substantially to carbon emissions when countries combine this tool with renewable energy consumption. Therefore, we define the variable as the total amount of environmental taxes on energy and transport (*ETAX*) (in billions of dollars) available in our dataset from 2008 to 2021.

The second instrument of climate-related policy is the total (explicit and implicit) government subsidies related to fossil fuels (coal, natural gas, petroleum and electricity). Explicit subsidies reflect underpricing due to supply costs being greater than prices paid by users. Implicit subsidies reflect the difference between supply costs and socially efficient prices (incorporating the cost of negative externalities of fossil fuel use and foregone consumption tax revenues), exclusive of any explicit subsidy. Our variable *FFSUBS* indicates the total (explicit and implicit) government subsidies (in billions of dollars) related to fossil fuels, which the IMF made publicly available in 2015.

Despite both environmental taxes and subsidies being proposed as instruments for climate change mitigation, the literature does not agree on whether the two can be effective tools in the transition to a low-carbon economy and the achievement of net-zero emissions. For example, Arzaghi and Squalli (2023) use data from worldwide countries from 1998 to 2015, showing that countries pursuing high-subsidy policies emit greater GHGs. In contrast, when countries implement high-environmental tax policies, GHG emissions diminish more effectively. Mundaca (2017) illustrates that a reduction of *FFSUBS* can lead to a significant decline in CO_2 emissions especially in countries of the Middle East and North Africa (MENA) that have relatively high *FFSUBS*. Finally, Overland (2010) argues that the most obvious measure to combat GHG emissions is to remove the vast subsidies that promote higher energy consumption in more than half of the countries in the world and that this measure should take precedence over many others. However, the main difficulty in removing energy subsidies seems to be related to political issues.

In addition, we consider two numbers that quantify the country's adaptation to climate change. Specifically, we refer to the climate-driven INFORM Risk Index. This is an adaptation of the INFORM Risk Index (i.e., a global, open-source risk assessment for crises and disasters) adjusted by the IMF staff to distil and centralize on climate-driven risks. It has three dimensions: climate-driven hazard and exposure, vulnerability, and lack of coping capacity. The three numbers range from 0 to 10, (where 10 is the highest risk), and are available from the IMF dashboard starting from 2013 until 2022. The vulnerability dimension (*VULN*) represents the economic, political, and social characteristics of the community that can be destabilized in the event of a hazard. The dimension of coping capacity (*LACKCC*) measures a country's ability to cope with disasters. This includes organized formal activities, the efforts of the country's government, and the existing infrastructure that contributes to reducing disaster risk. The climate-driven hazard and exposure dimension represents the load that the community has to deal with when exposed to a hazardous event. Nonetheless, in our analysis, we do not use this latter indicator, as we observed that it had a constant value in the Horizon 2013–2022, so it was not interesting for us to use it empirically[3]. In general, we expect that greater values of both *VULN* and *LACKCC* indicate more severe consequences from natural disasters. Plausibly, these indicators point to more severe climate-related concerns and risks.

Finally, we use information about climate-related disaster frequency. Natural disasters affect the performance of companies in different sectors, triggering the destruction of infrastructures, the disruption of the supply chain, and changes in the demand for goods and services (Montero et al., 2024). Several articles examine how the equity performance of insurers reacts to catastrophes, often referring to two alternative hypotheses (Shelor et al., 1992; Gangopadhyay et al., 2010). According to the "damage" hypothesis, catastrophes have a negative impact on the value of insurers, because insurers need to handle claim payments due to damages to policyholders. This implies that investors employ higher expected returns to assess the value of insurers, translating into declining stock prices after the shock. On the contrary, the "revenue" hypothesis states that, after catastrophes, insurers outperform because growing insurance demand raises premiums. However, the evidence is mixed as no argument seems to be dominating. For example, Lamb (1995) shows that Hurricane Andrew in 1992 produced a significant negative stock price reaction on property-liability insurers with direct premiums written in Florida or Louisiana. Yamori and Kobayashi (2002) find that stock prices of insurers reacted in a negative way to the 1995 Hanshin-Awaji earthquake in Japan, while Benali and Feki (2017) prove that unexpected severe catastrophes during the period 2008–2012 decreased the performance of the USA P&C insurers. Schuh and Jaeckle (2023) study the major hurricanes that occurred in the USA between 2004 and 2018, showing that stock prices of insurers diminished considerably after all these events. In contrast to this literature, some previous studies dealing with large earthquakes in the USA have commonly provided evidence that insurers' stock prices increase after catastrophes, for example, the 1989 San Francisco earthquake (Shelor et al., 1992), and the Loma Prieta earthquake in the San Francisco Bay Area (Aiuppa et al., 1993). Finally, Montero et al. (2024) examine how the variability of insurance stock prices changed due to natural disasters that occurred in the USA from 2010 until 2020. The analysis reveals that stock returns were less volatile in the short period surrounding the natural disaster, mainly due to reinsurance coverage and the absence of coverage in the affected areas. Given that natural catastrophes are a relevant driver for the market performance of insurers, in our analysis, we define NDIS as the natural disaster frequency in the USA. In every year, the quantity NDIS is the number of disasters due to drought, extreme temperature, flood, landslide, storm, and wildfire.

Table 1 summarizes the definition of all the variables employed for the analysis. Table 2 and

[3] For the methodology followed for the index construction (https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Risk/Methodology#inline-nav-5).

Table 3 report, respectively, the composition of the sample and descriptive statistics for the variables. As P&C insurers and L&H insurers are the majority of firms in the sample, to test the robustness of the baseline outcomes we will also provide results for these two separate sub-samples. Table 4 displays descriptive statistics over the years. GHG emissions were the lowest in 2020, most likely due to the lockdown following the COVID-19 outbreak. In 2021–2022, GHG emissions increased, but at lower levels compared to the pre-pandemic period. We also notice that the number of natural disasters was the highest in 2021, which was a year of severe weather disasters worldwide (McGrath, 2021). Finally, we notice in Table 5 a significant negative correlation between GHG and both P and PB. This sign is in line with the working hypothesis that we stated previously.

Table 1. Definition of variables

Variables	*Definition*	*Source*
GHG	The total amount of greenhouse gas emissions (including land use, land-use change and forestry) is measured in millions of metric tons of CO_2 equivalent.	https://climatedata.imf.org/pages/greenhouse-gas-emissions#gg1
NREN	Total non-renewable electric energy produced by fossil fuels measured in thousands of gigawatt-hours.	https://climatedata.imf.org/pages/mitigation#mi4
VULN	Vulnerability dimension of the climate-driven INFORM Risk Index. Scale 0–10.	https://climatedata.imf.org/pages/adaptation#ad2
LACKCC	Coping capacity dimension of the climate-driven INFORM Risk Index. Scale 0–10.	
NDIS	Number of natural disasters per year due to drought, extreme temperature, flood, landslide, storm, and wildfire.	https://climatedata.imf.org/pages/adaptation#ad1
ETAX	Environmental taxes on energy and transport in billions of dollars.	https://climatedata.imf.org/pages/mitigation#mi1
FFSUBS	Total (explicit and implicit) government subsidies related to fossil fuels (coal, natural gas, petroleum and electricity) in billions of dollars.	https://climatedata.imf.org/pages/mitigation#mi3
P	The average stock price of the company is computed from the daily closing prices in dollars.	https://www.capitaliq.spglobal.com/
PB	The price-to-book ratio of the company, namely the market value of equity divided by total book value equity. The market value of equity is calculated as the product between the average share price and the total shares outstanding.	
ASS	Total assets of the company in millions of dollars. Regressions use the logarithm of the total amount.	
INC	Total income of the company in millions of dollars. Regressions use the logarithm of the total amount.	

Table 2. Number of observations by insurance segments

Segment	*N*
Financial guaranty	15
Insurance broker	152
Life and health	319
Managed care	104
Mortgage guaranty	65
Multiline	45
Property and casualty	572
Reinsurance	30
Title insurance	58
Total	1.360

Table 3. Descriptive statistics

Variables	*Mean*	*Median*	*Min*	*Max*	*Std. deviation*
P ($)	47.24	30.24	2.129	160.5	48.92
PB	1.723	1.21	-0.80	11.53	1.81
GHG (M of metric tons CO_2)	5,942	5,983	5,239	6,525	299.6
NREN (K of gigawatt-hours)	2,845	2,882	2,573	3,101	144
ETAX (B of $)	131.9	132.5	109.6	155.5	15.57
FFSUBS (B of $)	782	777.3	724	860.1	44.08
VULN	3.08	3.05	2.4	4	0.51
LACKCC	2.12	2.1	2	2.2	0.07
NDIS	23.8	23	15	43	6.40
ASS (M of $)	58.3	59.0	0	941.0	1.43eˆ08
INC (M of $)	0.58	0.08	-99.3	20.6	3.42eˆ06

Note: M — millions; K — thousands; B — billions.

Table 4. Mean of variables over years (2008–2022)

Year	*P ($)*	*PB*	*GHG (M of metric tons CO_2)*	*NREN (K of gigawatt-hours)*	*ETAX (B of $)*	*FFSUBS (B of $)*	*VULN*	*LACKCC*	*NDIS*	*ASS (M of $)*	*INC (M of $)*
2008	36.40	1.14	6524.71	3100.55	109.59				21	57.20	-0.28
2009	28.16	0.96	6111.58	2892.88	110.96				17	62.10	0.45
2010	31.40	1.04	6303.03	3060.15	112.14				15	70.60	0.57
2011	32.96	1.06	6109.17	2960.19	115.53				23	70.40	0.55
2012	34.18	1.17	5878.11	2941.05	124.40				25	76.50	0.65
2013	39.28	1.60	6085.39	2907.72	126.78		2.40	2.20	28	81.70	0.83
2014	42.86	1.71	6124.91	2913.79	130.16		2.50	2.10	19	90.20	1.00
2015	48.12	1.66	6052.13	2882.40	134.79	729.93	2.50	2.10	29	96.10	1.08
2016	47.92	1.92	5758.08	2806.89	138.40	768.97	3.80	2.00	26	103.00	0.97
2017	54.51	2.03	5779.38	2691.53	143.39	785.69	4.00	2.00	24	118.00	1.17
2018	57.33	1.88	5982.68	2834.30	151.74	828.08	3.40	2.10	19	119.00	1.19
2019	59.37	2.18	5906.58	2745.15	155.01	860.12	3.00	2.10	20	131.00	1.48
2020	57.06	2.07	5238.86	2573.32	138.41	724.01	3.00	2.20	23	140.00	1.38
2021	63.99	2.17	5574.16	2661.78	155.51	802.54	3.10	2.20	43	150.00	1.83
2022	58.42	2.53	5705.46	2696.24		757.07	3.10	2.20	25	150.00	2.35

Table 5. Correlation coefficients

	P	*PB*	*GHG*	*NREN*	*ETAX*	*FFSUBS*	*VULN*	*LACKCC*	*NDIS*	*ASS*	*INC*
P	1.0000										
PB	0.3080***	1.0000									
	(0.000)										
GHG	-0.1638***	-0.1863***	1.0000								
	(0.000)	(0.000)									
NREN	-0.1967***	-0.2235***	0.9308***	1.0000							
	(0.000)	(0.000)	(0.000)								
ETAX	0.2273***	0.2433***	-0.6516***	-0.7855***	1.0000						
	(0.000)	(0.000)	(0.000)	(0.000)							
FFSUBS	0.0457	0.0141	0.4044***	0.1628***	0.8893***	1.0000					
	(0.201)	(0.726)	(0.000)	(0.000)	(0.000)						
VULN	0.0598*	0.0503	-0.3703***	-0.4512***	0.4690***	0.2347***	1.0000				
	(0.064)	(0.166)	(0.000)	(0.000)	(0.000)	(0.000)					
LACKCC	0.0346	0.0374	-0.2973***	-0.2460***	-0.0403	-0.1930***	-0.6166***	1.0000			
	(0.285)	(0.304)	(0.000)	(0.000)	(0.203)	(0.000)	(0.000)				
NDIS	0.1123***	0.1080***	-0.4576***	-0.4301***	0.4623***	-0.1687***	-0.0607**	0.3552***	1.0000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.043)	(0.000)			
ASS	0.1412***	-0.1382***	-0.0227	-0.0211	0.0211	-0.0035	-0.0039	0.0081	0.0155	1.0000	
	(0.000)	(0.000)	(0.430)	(0.462)	(0.480)	(0.922)	(0.909)	(0.813)	(0.577)		
INC	0.1176***	0.0717**	-0.0950***	-0.0968***	0.0981***	0.0225	-0.0237	0.0757**	0.0624**	0.7260***	1.0000
	(0.000)	(0.019)	(0.001)	(0.001)	(0.001)	(0.525)	(0.488)	(0.026)	(0.023)	(0.000)	

*Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

To test this argument formally, we estimate the following equation for the market value of company j in year t on the country's *GHG* emissions at t:

$$Market\ value_{v,j,t} = \alpha + \beta GHG_{j,t} + \gamma SIZE_{y,t} + \delta INC_{j,t} + \eta_t + \epsilon_{j,t} \tag{1}$$

The subscript v denotes the measure of market value, which is alternatively, *P* or *PB*. η are year (t) fixed effects, while ϵ is an error term[4]. Standard errors are clustered at the firm level.

Our working hypothesis predicts that the coefficient β is negative, which means that the value of insurance equity decreases with increasing *GHG* emissions. To test the robustness of the hypothesis, we estimate the models using *NREN* instead of *GHG*. Again, we expect a negative coefficient, as the generation of non-renewable energy would increase *GHG* emissions, thereby exacerbating climate change risks and its consequences on insurers' value.

4. RESULTS AND DISCUSSION

Table 6 estimates Eq. (1). We observe that *GHG* has a negative and significant sign on the market value of insurers, especially on *P*, where the estimated coefficient is a negative 0.0453. The effect of *NREN* is stronger, as the coefficient equals a negative 0.0918. The variance inflation factors, which measure the correlation and strength of correlation between the predictor variables in the models, are all below five, pointing to a moderate correlation between each of our regressors and the other predictor variables.

Therefore, our results reveal that the value of USA insurers declines with the country's *GHG* emissions and non-renewable energy production. This suggests that, when climate risk exposure becomes wider, investors apply higher discount rates to insurers' equity value. These findings can be linked to the recent debate in the USA about companies with high carbon emissions also earning higher stock returns. Atilgan et al. (2024) argue that carbon premiums mainly represent unexpected returns that follow earnings surprises. In contrast, Bolton and Kacperczyk (2024) claim that investors apply a greater discount (i.e., a high expected return) to the value of companies with high emissions, as they demand compensation for carbon transition risk exposure. In line with this view, our findings suggest that the wider country-wide exposure to climate change risk subtracts value from the insurance market. The outcomes are consistent with our working hypothesis in Section 2, and support the argument that environmental damages destroy value to insurers (Shelor et al., 1992; Gangopadhyay et al., 2010).

[4] The model in Eq. (1) includes fixed effects. In all the equations estimated in the analysis, we checked that the fixed effects model is preferred to the random effects model according to the test of Hausman (1978).

Table 6. Regressions of the market value of insurance companies on *GHG* emissions and *NREN* generated

Regressors	(1) P	(2) P	(3) PB	(4) PB
GHG	-0.0453***		-0.0019***	
	(0.008)		(0.001)	
NREN		-0.0918***		-0.0039***
		(0.017)		(0.001)
ASS	-2.4125	-2.4125	-0.4875***	-0.4875***
	(2.324)	(2.324)	(0.110)	(0.110)
INC	8.7877***	8.7877***	0.4356***	0.4356***
	(2.341)	(2.341)	(0.103)	(0.103)
Time fixed effects	yes	yes	yes	yes
Observations	901	901	854	854
R-squared	0.309	0.309	0.199	0.199
Variance inflation factors				
GHG	4.85		4.94	
NREN		4.67		4.77
ASS	4.67	4.57	3.79	3.79
INC	4.55	4.65	3.86	3.86

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01.*

Natural disasters and situations of extreme climate change risks tend to have stronger repercussions on P&C insurance firms, compared to other types of insurance, like L&H insurance. Indeed, the role of P&C insurers goes beyond the provision of the financial coverage needed at such critical times. These firms play a key role in preventing situations of extreme stress, and allow citizens and companies to more quickly rebuild their real estate, lives and overall recovery from environmental shocks (Montero et al., 2024).

Our data source classifies insurance firms into multiple segments. To verify differences across segments, we isolate the P&C insurers and L&H insurers, to test if there are considerable differences between the two groups concerning the effect of *GHG* emissions on market values. Table 7 and Table 8 show that the signs of *GHG* and *NREN* are significant only in the sub-sample of P&C insurers, while in the sub-sample of L&H insurers, the signs are not statistically significant. Therefore, we conclude that, with respect to market valuation, the segment of insurance most impacted by climate change issues is the P&C business.

Table 7. Regressions of insurers' stock price on *GHG* emissions and *NREN* generated —P&C versus L&H

Regressors	P&C	L&H	P&C	L&H
	P			
GHG	-0.0347***	-0.0024		
	(0.009)	(0.013)		
NREN			-0.0704***	-0.0048
			(0.019)	(0.027)
Time fixed effects	yes	yes	yes	yes
Observations	572	319	572	319
R-squared	0.099	0.005	0.099	0.005

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01.*

Table 8. Regressions of insurers' *PB* on *GHG* emissions and *NREN* generated — P&C versus L&H

Regressors	P&C	L&H	P&C	L&H
	PB			
GHG	-0.0016***	0.0001		
	(0.001)	(0.000)		
NREN			-0.0032***	0.0001
			(0.001)	(0.001)
Time fixed effects	yes	yes	yes	yes
Observations	527	214	527	214
R-squared	0.074	0.059	0.074	0.059

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01.*

We now want to verify if *GHG* emissions and non-renewable energy generation affect the value of insurance firms especially when the exposure of the country to climate risk is more critical. For this task, we use the two dimensions of the INFORM Risk Index outlined in Section 3. In fact, *VULN* and *LACKCC* are indicators expressing to what extent the country would be negatively affected by climate-related hazard events (*VULN*), and how far it would be able to cope with these shocks (*LACKCC*). We define times t of high/low vulnerability when *VULN* is below/above the median *VULN* in the sample. Likewise, times t of high/low lack of coping capacity coincide with *LACKCC* being below/above the median *LACKCC* in the sample. In general, we expect that climate-related concerns are more severe during periods of high vulnerability (or high lack of coping capacity). Table 9 and Table 10 display that the coefficients of *GHG* and *NREN* are more strongly negative and significant when *VULN* and *LACKCC* are higher. Our interpretation is that, when the adaptation of the country to climate change is relatively poor, the value of insurers' equity declines, as investors demand higher premiums reflecting the uncertain climate change conditions.

Table 9. Regressions of insurers' market value on *GHG* emissions and *NREN* generated during high/low vulnerability

Regressors	P				PB			
	High VULN	Low VULN	High VULN	Low VULN	High VULN	Low VULN	High VULN	Low VULN
GHG	-0.0152***	-0.0346***			-0.0004	-0.0016***		
	(0.004)	(0.006)			(0.000)	(0.000)		
NREN			-0.0481***	-0.0741***			-0.0015*	-0.0033***
			(0.012)	(0.013)			(0.001)	(0.001)
Time fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	460	900	460	900	363	715	363	715
R-squared	0.011	0.038	0.018	0.049	0.007	0.060	0.011	0.074

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01.*

Table 10. Regressions of insurers' market value on *GHG* emissions and *NREN* generated during high/low lack of coping capacity

Regressors	P				PB			
	High LACKCC	Low LACKCC	High LACKCC	Low LACKCC	High LACKCC	Low LACKCC	High LACKCC	Low LACKCC
GHG	-0.0164***	-0.0280***			-0.0009***	-0.0012***		
	(0.006)	(0.005)			(0.000)	(0.000)		
NREN			-0.0530***	-0.0658***			-0.0021***	-0.0028***
			(0.013)	(0.012)			(0.001)	(0.001)
Time fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	552	808	552	808	438	640	438	640
R-squared	0.002	0.046	0.007	0.055	0.005	0.056	0.008	0.071

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01.*

To verify whether our findings vary with natural catastrophes, we employ information about the frequency of natural disasters. Similarly to Tables 9–10, in Table 11 we estimate regressions for periods of high/low disasters' frequency. The outcomes are consistent with the previous ones. Namely, during times in which many natural disasters occurred, insurers' equity has dropped considerably in the amounts of *GHG* emissions and non-renewable energy. Therefore, based on the evidence presented in this sub-section, we conclude that worsening concerns about climate change would destroy value in insurance equity.

Table 11. Regressions of insurers' market value on *GHG* emissions and *NREN* generated during high/low *NDIS*

Regressors	P				PB			
	High NDIS	Low NDIS	High NDIS	Low NDIS	High NDIS	Low NDIS	High NDIS	Low NDIS
GHG	-0.0222***	-0.0429***			-0.0009***	-0.0016***		
	(0.005)	(0.009)			(0.000)	(0.000)		
NREN			-0.0577***	-0.0860***			-0.0024***	-0.0034***
			(0.011)	(0.016)			(0.001)	(0.001)
Time fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	701	659	701	659	557	521	557	521
R-squared	0.029	0.022	0.039	0.034	0.040	0.019	0.055	0.034

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01.*

We now test whether our baseline results are robust to the control for environmental taxes, namely one of the tools that policymakers support to reach carbon neutrality. We use a simultaneous equation system to measure the effect of *GHG* on market values taking into account that *GHG* varies with *ETAX*. In Table 12 the second equation of each simultaneous system shows that increasing *ETAX* leads to lower *GHG* and *NREN*. These findings are in line with articles proving that environmental taxes may be an effective tool for achieving net-zero targets (Ghazouani et al., 2021; Arzaghi & Squalli, 2023; He et al., 2023). Nonetheless, even controlling for environmental taxes, we observe that insurers' prices and *PB* decline in both *GHG* and *NREN*.

Table 12. Simultaneous systems of equations (SSEs) — Effect on insurers' market value from *GHG* emissions and *NREN* generated controlling for environmental taxes

Regressors	SSE							
	P	GHG	PB	GHG	P	GHG	PB	GHG
GHG	-0.0371***		-0.0011***					
	(0.006)		(0.000)					
NREN					-0.0804***		-0.0024***	
					(0.013)		(0.001)	
ETAX		-12.6906***		-12.6389***		-7.2609***		-7.2437***
		(0.472)		(0.488)		(0.181)		(0.187)
ASS	4.4410***		-0.1203***		4.4410***		-0.1203***	
	(0.419)		(0.023)		(0.419)		(0.023)	
Time fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	1,050	1,050	975	975	1,050	1,050	975	975
R-squared	0.211	0.408	0.093	0.408	0.211	0.606	0.093	0.606

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01.*

We test a second tool of policymaking that is often debated in relation to climate change interventions, namely *FFSUBS*. As in the previous subsection, we use a simultaneous equation system to measure the effect of *GHG* on market values taking into account that *GHG* varies with *FFSUBS*. Table 13 shows that increasing *FFSUBS* leads to higher *GHG* and *NREN*. Therefore, we discover that *FFSUBS* have opposite effects on *GHG* emissions and non-renewable energy compared to environmental taxes (Table 12). These findings are consistent with the recommendation to reform or remove *FFSUBS* in order to achieve emission reductions (Mundaca, 2017; Overland, 2010; Arzaghi & Squalli, 2023). Again, insurers' prices and *PBs* decline with growing *GHG* and *NREN*. Thus, although we consider the existence of environmental taxes or *FFSUBS*, we observe a significant negative association between insurers' equity value and both *GHG* emissions and non-renewable energy production.

Table 13. Simultaneous systems of equations (SSEs) — Effect on insurers' market value from *GHG* emissions and *NREN* generated controlling for *FFSUBS*

Regressors	***SSE***							
	P	***GHG***	***PB***	***GHG***	***P***	***GHG***	***PB***	***GHG***
GHG	-0.0398*		-0.0026**					
	(0.020)		(0.001)					
NREN					-0.0741*		-0.0048**	
					(0.038)		(0.002)	
FFSUBS		2.3812***		2.3274***		0.4260***		0.4033***
		(0.194)		(0.202)		(0.082)		(0.085)
ASS	5.3657***		-0.1849***		5.3657***		-0.1849***	
	(0.627)		(0.039)		(0.627)		(0.039)	
Observations	662	662	613	613	662	662	613	613
R-squared	0.114	0.185	0.047	0.178	0.114	0.039	0.047	0.035
Time fixed effects	yes	yes	yes	yes	yes	yes	yes	yes

*Note: * p < 0.1, ** p < 0.05, *** p < 0.01.*

5. CONCLUSION

Greenhouse gas emissions are responsible for global warming and extreme weather events. As one of the major causes of climate change risk, greenhouse gas emissions are related to the value of insurers, because the insurance industry is at the forefront of managing physical and transition risks. We analyze USA insurers from 2008 until 2022, showing that their market values decrease with the country's greenhouse gas emissions and production of non-renewable energy. This pattern is robust even when considering two important policy instruments for climate change mitigation, namely environmental taxes and government fossil fuel subsidies. In addition, we illustrate that the link between insurers' stock prices and greenhouse gas emissions is more negative when the country is highly vulnerable and less capable of facing climate change-related disasters, or when natural disasters are more frequent. These findings suggest that worsening climate change conditions are associated with lower value in the insurance sector. Arguably, as equity market investors face increased climate-related concerns, they also expect that insurers will face increased uncertainty concerning future losses and claim expenses. Thus, they expect higher compensation for holding the stock of insurance companies, ultimately reducing their equity prices. Our analysis delivers important insights for asset managers, as we show that the value of asset portfolios may be affected by the level of greenhouse gas emissions in a country. Moreover, we illustrate to policymakers that the implementation of environmental taxes would decrease greenhouse gas emissions. However, to achieve low carbon targets and, at the same time, enhance equity value in the insurance sector, it seems that environmental taxes are not effective. In contrast, our data shows that the amount of fossil fuel subsidies is positively related to greenhouse gas emissions. Therefore, subsidies would not have a positive influence on the valuation of insurers. These findings deserve the attention of regulators because the growing value of insurance companies would eventually have positive benefits on insurance affordability in critical areas, curbing the consequences of extreme weather shocks.

We acknowledge that our study presents some limitations and that a few aspects could be extended. First, we focus on the USA, while we could check whether the outcomes are robust in other markets. Second, one could explore more carefully whether insurers manage their policy reserves to mitigate the negative effect of greenhouse gas emissions on valuation. Moreover, to verify the influence of climate change on insurers' value, one could test the effects of measures for aggregate renewable energy consumption/production. Indeed, using gas emissions and non-renewable energy, we employed measures that reflect more closely "worsening" climate change conditions. Instead, using figures of renewable energy, we could have an approximation for "improving" climate change. Testing the separate effects from positive/negative environmental aspects would be a way to develop arguments that explain more broadly the perception of (insurance) investors against climate change.

REFERENCES

Acaroğlu, H., & Güllü, M. (2022). Climate change caused by renewable and non-renewable energy consumption and economic growth: A time series ARDL analysis for Turkey. *Renewable Energy, 193,* 434–447. https://doi.org/10.1016/j.renene.2022.04.138

Aiuppa, T. A., Carney, R. J., & Krueger, T. M. (1993). An examination of insurance stock prices following the 1989 Loma Prieta earthquake. *Journal of Insurance Issues, 16*(1), 1–14. https://www.jstor.org/stable/41946350

Angbazo, L. A., & Narayanan, R. (1996). Catastrophic shocks in the property-liability insurance industry: Evidence on regulatory and contagion effects. *Journal of Risk and Insurance, 63*(4), 619–637. https://doi.org/10.2307/253474

Arzaghi, M., & Squalli, J. (2023). The environmental impact of fossil fuel subsidy policies. *Energy Economics, 126*, Article 106980. https://doi.org/10.1016/j.eneco.2023.106980

Atilgan, Y., Demirtas, K. O., Edmans, A., & Gunaydin, A. D. (2024). *Does the carbon premium reflect risk or outperformance?* (Finance Working Paper No. 940). ECGI. https://doi.org/10.2139/ssrn.4573622

Benali, N., & Feki, R. (2017). The impact of natural disasters on insurers' profitability: Evidence from property/casualty insurance company in United States. *Research in International Business and Finance, 42*, 1394–1400. https://doi.org/10.1016/j.ribaf.2017.07.078

Bolton, P., & Kacperczyk, M. (2021). Do investors care about carbon risk? *Journal of Financial Economics, 142*(2), 517–549. https://doi.org/10.1016/j.jfineco.2021.05.008

Bolton, P., & Kacperczyk, M. (2024). Are carbon emissions associated with stock returns? Comment. *Review of Finance, 28*(1), 107–109. https://doi.org/10.1093/rof/rfad019

Born, P., & Viscusi, W. K. (2006). The catastrophic effects of natural disasters on insurance markets. *Journal of Risk and Uncertainty, 33*, 55–72. https://doi.org/10.1007/s11166-006-0171-z

Bui, B., Moses, O., & Houqe, M. N. (2020). Carbon disclosure, emission intensity and cost of equity capital: Multi-country evidence. *Accounting & Finance, 60*(1), 47–71. https://doi.org/10.1111/acfi.12492

Climate Portal. (n.d.). *Greenhouse gases.* https://climate.mit.edu/explainers/greenhouse-gases

Dlugolecki, A. (2008). Climate change and the insurance sector. *The Geneva Papers on Risk and Insurance: Issues and Practice, 33*, 71–90. https://doi.org/10.1057/palgrave.gpp.2510152

European Environment Agency. (2025, April 16). *Climate change mitigation: Reducing emissions.* https://www.eea.europa.eu/en/topics/in-depth/climate-change-mitigation-reducing-emissions

European Insurance and Occupational Pensions Authority (EIOPA). (2023, April 26). *The role of insurers in tackling climate change: challenges and opportunities.* https://www.eiopa.europa.eu/publications/role-insurers-tackling-climate-change-challenges-and-opportunities_en

Gagné, V., & Berthelot, S. (2021). The evolution of corporate reporting on GHG emissions: A Canadian portrait. *Corporate Governance and Sustainability Review, 5*(2), 22–34. https://doi.org/10.22495/cgsrv5i2p2

Gangopadhyay, P., Haley, J. D., & Zhang, L. (2010). An examination of share price behavior surrounding the 2005 hurricanes Katrina and Rita. *Journal of Insurance Issues, 33*(2), 132–151. https://surl.li/egpscr

Ghazouani, A., Jebli, M. B., & Shahzad, U. (2021). Impacts of environmental taxes and technologies on greenhouse gas emissions: Contextual evidence from leading emitter European countries. *Environmental Science and Pollution Research, 28*, 22758–22767. https://doi.org/10.1007/s11356-020-11911-9

Gupta, A., & Venkataraman, S. (2024). Insurance and climate change. *Current Opinion in Environmental Sustainability, 67*, Article 101412. https://doi.org/10.1016/j.cosust.2023.101412

Gupta, A., Owusu, A., & Wang, J. (2023). Assessing U.S. insurance firms' climate change impact and response. *The Geneva Papers on Risk and Insurance: Issues and Practice, 49*, 571–604. https://doi.org/10.1057/s41288-023-00297-7

Hágen, I., & Ahmed, A. M. (2024). Carbon footprint, financial structure, and firm valuation: An empirical investigation. *Risks, 12*(12), Article 197. https://doi.org/10.3390/risks12120197

Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica, 46*(6), 1251–1271. https://doi.org/10.2307/1913827

He, P., Zhang, S., Wang, L., & Ning, J. (2023). Will environmental taxes help to mitigate climate change? A comparative study based on OECD countries. *Economic Analysis and Policy, 78*, 1440–1464. https://doi.org/10.1016/j.eap.2023.04.032

Herweijer, C., Ranger, N., & Ward, R. E. T. (2009). Adaptation to climate change: Threats and opportunities for the insurance industry. *The Geneva Papers on Risk and Insurance: Issues and Practice, 34*, 360–380. https://doi.org/10.1057/gpp.2009.13

Houghton, J. T., Jenkins, C. J., & Ephraums, J. J. (1990). *Climate change: The IPCC scientific assessment.* Intergovernmental Panel on Climate Change (IPCC). https://www.ipcc.ch/site/assets/uploads/2018/03/ipcc_far_wg_I_full_report.pdf

Intergovernmental Panel on Climate Change (IPCC). (1995). *IPCC second assessment: Climate change 1995.* https://archive.ipcc.ch/pdf/climate-changes-1995/ipcc-2nd-assessment/2nd-assessment-en.pdf

Kim, Y.-B., An, H. T., & Kim, J. D. (2015). The effect of carbon risk on the cost of equity capital. *Journal of Cleaner Production, 93*, 279–287. https://doi.org/10.1016/j.jclepro.2015.01.006

Krauter, S., & Rüther, R. (2004). Considerations for the calculation of greenhouse gas reduction by photovoltaic solar energy. *Renewable Energy, 29*(3), 345–355. https://doi.org/10.1016/S0960-1481(03)00251-9

Krueger, P., Sautner, Z., & Starks, L. T. (2020). The importance of climate risks for institutional investors. *The Review of Financial Studies, 33*(3), 1067–1111. https://doi.org/10.1093/rfs/hhz137

Lamb, R. P. (1995). An exposure-based analysis of property-liability insurer stock values around Hurricane Andrew. *Journal of Risk and Insurance, 62*(1), 111–123. https://doi.org/10.2307/253695

Lashof, D. A., & Ahuja, D. R. (1990). Relative contributions of greenhouse gas emissions to global warming. *Nature, 344*, 529–531. https://doi.org/10.1038/344529a0

McGrath, M. (2021, December 27). Climate change: Huge toll of extreme weather disasters in 2021. *BBC.* https://www.bbc.com/news/science-environment-59761839

Montero, J.-M., Naimy, V., Abi Farraj, N., & El Khoury, R. (2024). Natural disasters, stock price volatility in the property-liability insurance market and sustainability: An unexplored link. *Socio-Economic Planning Sciences, 91*, Article 101791. https://doi.org/10.1016/j.seps.2023.101791

Montzka, S. A., Dlugokencky, E. J., & Butler, J. H. (2011). Non-CO_2 greenhouse gases and climate change. *Nature, 476*, 43–50. https://doi.org/10.1038/nature10322

Moody's Investors Service. (2018, March 15). *Climate change risks outweigh opportunities for P&C (re)insurers.* https://www.law.berkeley.edu/wp-content/uploads/2018/06/Moodys-Climate-change-risks-outweigh-opportunities-for-PC-reinsurers.pdf

Mundaca, G. (2017, March 10). *How much can CO_2 emissions be reduced if fossil fuel subsidies are removed?* World Bank Group. https://doi.org/10.1596/29237

Overland, I. (2010). Subsidies for fossil fuels and climate change: A comparative perspective. *International Journal of Environmental Studies, 67*(3), 303–317. https://doi.org/10.1080/00207233.2010.492143

Ragin, M. A., & Halek, M. (2016). Market expectations following catastrophes: An examination of insurance broker returns. *Journal of Risk and Insurance, 83*(4), 849–876. https://doi.org/10.1111/jori.12069

Sariannidis, N., Konteos, G., & Giannarakis, G. (2015). The effects of greenhouse gas emissions and governance factors on corporate socially responsibility disclosure. *Corporate Ownership & Control, 12*(2), 92–106. https://doi.org/10.22495/cocv12i2p8

Schuh, F., & Jaeckle, T. (2023). Impact of hurricanes on US insurance stocks. *Risk Management and Insurance Review, 26*(1), 5–34. https://doi.org/10.1111/rmir.12230

Shafiei, S., & Salim, R. A. (2014). Non-renewable and renewable energy consumption and CO_2 emissions in OECD countries: A comparative analysis. *Energy Policy, 66*, 547–556. https://doi.org/10.1016/j.enpol.2013.10.064

Shelor, R. M., Anderson, D. C., & Cross, M. L. (1992). Gaining from loss: Property-liability insurer stock values in the aftermath of the 1989 California earthquake. *The Journal of Risk and Insurance*, *59*(3), 476–488. https://doi.org/10.2307/253059

Stechemesser, A., Koch, N., Mark, E., Dilger, E., Klösel, P., Menicacci, L., Nachtigall, D., Pretis, F., Ritter, N., Schwarz, M., Vossen, H., & Wenzel, A. (2024). Climate policies that achieved major emission reductions: Global evidence from two decades. *Science, 385*(6711), 884–892. https://doi.org/10.1126/science.adl6547

Thomann, C. (2013). The impact of catastrophes on insurer stock volatility. *Journal of Risk and Insurance, 80*(1), 65–94. https://doi.org/10.1111/j.1539-6975.2012.01478.x

Wen, F., Wu, N., & Gong, X. (2020). China's carbon emissions trading and stock returns. *Energy Economics, 86*, Article 104627. https://doi.org/10.1016/j.eneco.2019.104627

Yadav, R., Sharma, P., Hiremath, R. B., & Patil, A. A. (2024). Environmental responsibility and corporate governance: Assessing the impact of gender diversity on greenhouse gas (GHG) emissions in German listed companies. *Corporate Ownership & Control, 21*(1), 158–167. https://doi.org/10.22495/cocv21i1art13

Yamori, N., & Kobayashi, T. (2002). Do Japanese insurers benefit from a catastrophic event?: Market reactions to the 1995 Hanshin-Awaji earthquake. *Journal of the Japanese and International Economies, 16*(1), 92–108. https://doi.org/10.1006/jjie.2001.0477

Zhu, Y., Taylor, D., & Wang, Z. (2023). The role of environmental taxes on carbon emissions in countries aiming for net-zero carbon emissions: Does renewable energy consumption matter? *Renewable Energy, 218*, Article 119239. https://doi.org/10.1016/j.renene.2023.119239