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ESG Performance and Regulatory Solvency: Evidence from European Insurers under Solvency II

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Contents

Resumen

El objetivo de este artículo es investigar la influencia del desempeño ESG sobre la solvencia regulatoria de las aseguradoras europeas. A partir de un panel desbalanceado de 31 grupos aseguradores europeos cotizados entre 2016 y 2024, el artículo mide la solvencia regulatoria mediante el ratio de Capital de Solvencia Obligatorio (SCR) y analiza la relación entre ESG y solvencia con regresiones de panel de efectos fijos. Los resultados indican que el desempeño ESG se relaciona positivamente con el ratio SCR en modelos simples, pero esta relación desaparece al incorporar efectos fijos de año. Los pilares ambiental, social y de gobernanza no son significativos por separado, y el ESG no actúa como amortiguador durante los años de tensión de 2020 y 2022. En general, los efectos del ESG podrían no reflejarse en el ratio SCR principal. Este trabajo es de los primeros en examinar la relación entre el desempeño ESG y la solvencia regulatoria de las aseguradoras europeas a partir de ratios SCR de grupo recopilados manualmente.

Abstract

The purpose of this article is to investigate the influence of ESG performance on the regulatory solvency of European insurers. Using an unbalanced panel of 31 listed European insurance groups from 2016 to 2024, this article measures regulatory solvency by the Solvency Capital Requirement (SCR) ratio and explores the link between ESG and solvency using fixed-effects panel regressions. The results suggest that ESG performance is positively related to the SCR ratio in simpler models, but this relationship disappears once year fixed effects are added. The environmental, social, and governance pillars are not individually significant, and ESG does not act as a buffer during the 2020 and 2022 stress years. In general, ESG effects may not be visible in the headline SCR ratio. This paper is among the first to examine the link between ESG performance and regulatory solvency for European insurers using hand-collected Group SCR ratios.

Keywords and JEL codes

Keywords: ESG; Solvency II; SCR ratio; Insurance; regulatory solvency

JEL Classification: G22; G28; G32; Q56

1. Introduction

Over the past two decades, environmental, social and governance (ESG) performance has become an important indicator of the long-term value of enterprises and their ability to manage non-financial risks. Whether this performance is actually rewarded, however, remains unclear. In a review of more than 2,200 studies, Friede et al. (2015) report only a weak positive average link, with almost half of the studies showing no significant effect. In view of these results, the research focus of the literature has shifted from whether ESG can improve corporate performance on average to when ESG plays a role. More and more studies believe that ESG can be used as an insurance for enterprises, and its value mainly appears in times of crisis (Lins et al., 2017; Albuquerque et al., 2020).

However, for insurers, the more important question is not how the market prices ESG, but whether ESG can support its need to maintain regulatory solvency, thus determining its survival (Eling & Schmeiser, 2010). Insurance companies play a dual role in the economy: they are not only carrying their own risks but also absorbing the risks of families and enterprises; at the same time, they are also one of the largest institutional investors in the financial market. For this reason, their solvency is not only related to their own interests, but also to the protection of policyholders and financial stability (European Parliament and Council, 2009).

This double role also means that insurers face ESG risk on both sides of the balance sheet. Their investment portfolios are exposed to climate and governance shocks, while their liabilities absorb catastrophe claims, litigation, and operational losses driven by the same factors (Brogi et al., 2022). Yet existing studies of European insurers rely almost exclusively on accounting profitability (ROE, ROA), which does not capture the forward looking, risk based regulatory perspective that ultimately governs insurer survival (Brogi et al., 2022; Meral et al., 2026). However, we still know little about whether ESG performance is reflected in the regulatory solvency measure that supervisors use to assess insurers' capital strength.

Since 1 January 2016, European insurers have operated under the Solvency II framework (European Parliament and Council, 2009). The outcome of interest in this study is the Solvency Capital Requirement (SCR) ratio, which compares an insurer's available capital (Eligible Own Funds, EOF)

with the capital it is required to hold. A higher ratio means a stronger capital buffer. We use this measure because it is forward looking, disclosed every year, and reflects both sides of the insurer's balance sheet (van der Heide, 2023). This is important because the SCR ratio is used by supervisors to judge whether insurers have enough capital to protect policyholders and deal with major shocks.

The objective of this paper is to find out whether ESG performance is related to the regulatory solvency of European insurers, and whether this relationship becomes stronger in times of stress. Based on this, the paper proposes two research questions:

RQ1, Is ESG performance related to the regulatory solvency of European insurers, measured by the SCR ratio?

RQ2, Does ESG performance matter more in times of stress, so that insurers with better ESG keep a stronger and more stable solvency position when shocks hit?

To answer these questions, this paper constructs an unbalanced panel dataset of 31 listed European insurance groups from 2016 to 2024, based on LSEG workspace, Orbis and group solvency reports. This paper contributes to the literature by studying ESG performance in the European insurance sector, where evidence is still limited. Different from many previous studies, it uses the SCR ratio as the main outcome variable, rather than general accounting or market measures. This allows the paper to examine whether ESG is related to the regulatory capital position of insurers. The study also tests whether this relationship becomes stronger during stress periods and whether the findings are similar when MSCI ESG ratings are used instead of Refinitiv ratings.

The paper is structured as follows. Section 2 reviews the research on ESG and financial performance and explains the Solvency II framework and the SCR ratio. Section 3 describes the sample, the variables, and the model. Section 4 shows the descriptive statistics, the regression results, and a robustness check using another ESG rating provider. Section 5 discusses the findings, implications and compares our results with earlier studies. Section 6 concludes by discussing the contributions, the limitations, and some directions for future research.

2. Theoretical Framework and Literature Review

2.1 ESG and Financial Institutions: An Uneven Literature

In recent years, research on ESG and financial institutions has increased significantly. However, most of the existing literature is concentrated in the banking industry, while the research evidence for insurance companies is still relatively limited. The literature related to the banking industry is quite mature and bibliometrically established (Galletta et al., 2022; Curcio et al., 2024), accumulating a lot of evidence on the impact of ESG on credit risk, systemic risk, profitability and capital structure. Brogi et al. (2022) made a direct comparison of financial intermediaries and found that the relationship between ESG and profitability of insurance companies is significantly weaker than that of banks, which shows that there are structural differences in the operation of ESG factors in the two industries. This difference is crucial because banks and insurance companies face different risk structures. The stability of banks is closely related to financing, liquidity and depositor confidence, while the solvency of insurance companies depends more on underwriting risk, market risk and long-term liabilities. Therefore, the research results of the banking industry cannot be directly applied to insurance companies (Sood & Özen, 2024; Citterio & King, 2023; Bouattour et al., 2024; Otero González et al., 2023).

In contrast, the corresponding insurance empirical literature is relatively underdeveloped. Bressan (2023) identified the link between ESG-insurance-financial strength in property casualty insurance, especially through the combined ratio and Z-score. Chiaramonte et al. (2020) likewise use Z-score–based measures and record a negative relationship between ESG and insolvency risk. Meral et al. (2026) find that in the global sample, ESG factors were positively correlated with the profitability (ROA, ROE) of insurance companies and negatively correlated with costs and loss rates. The most directly related contribution recently is Miani et al. (2026) who examine 152 European insurance companies and proved that higher ESG performance is associated with lower 1-year and 5-year market implied default probability, which has a stronger impact on non-life insurance and potential nonlinear (square) dynamics. Giráldez-Puig et al. (2025) added that ESG controversies will significantly increase the insolvency risk, and governance is the strongest buffer.

Importantly, none of these studies directly examines the SCR ratio as the dependent variable. Instead, they rely on accounting-based proxies (Z-scores, ROA), market-implied default probabilities, or composite financial strength indicators. However, relatively little attention has been paid to the SCR

ratio, despite its importance as a regulatory measure of insurer capital adequacy in Europe. This is the gap our study speaks to, by examining ESG performance against the SCR ratio itself.

Finally, the relationship may also run the other way. Brogi et al. (2022) note that larger and more profitable insurers have more resources to invest in ESG, so financially stronger firms may simply score higher. Similarly, Hipólito et al. (2025) provide European evidence that ESG performance in insurance companies is related to firm characteristics such as size, profitability, leverage, board structure, and sustainability reporting. This supports the view that ESG scores may partly reflect firm resources and disclosure capacity, rather than only risk reduction. This leaves an important gap: we still know little about whether ESG performance is related to insurers' regulatory solvency, rather than to profitability, Z-scores, or market default probabilities.

2.2 The Solvency II Framework and Theoretical Foundations

This study focuses on the SCR ratio; the main measure regulators use to test whether European insurers hold enough capital. It derives from the Solvency II framework, set out in Directive 2009/138/EC and fully implemented on 1 January 2016. Solvency II replaced the earlier Solvency I regime and became the common framework for insurers across the European Union (EU) and the European Economic Area (EEA) (European Parliament and Council, 2009). Solvency II rests on three pillars. Pillar 1 sets the amount of capital insurers must hold: the SCR, calibrated so that an insurer can absorb losses severe enough to occur only once in two hundred years (a 99.5% confidence level over one year). The standard-formula SCR aggregates several risk modules, market, life underwriting, non-life underwriting, health, counterparty default and intangible asset risk, with operational risk added on top (European Commission, 2015). Pillar 2 covers risk management and supervision, including the Own Risk and Solvency Assessment (ORSA), through which insurers evaluate their own risks and capital needs. Pillar 3 covers public disclosure, notably the annual Solvency and Financial Condition Report (SFCR). Recent evidence suggests that these disclosures are useful for external users. Seretis et al. (2026) find that solvency related information disclosed after Solvency II improved analysts' forecast accuracy and reduced forecast dispersion.

The headline measure from Pillar 1 is the SCR ratio. It compares two amounts. The first is the Solvency Capital Requirement, which is the capital an insurer is required to hold to survive a very rare loss. For example, if a severe year, with a market crash and an unusually large wave of claims, could cost an insurer up to 1 billion euros, then its SCR is about 1 billion euros. The second amount is the Eligible Own Funds, the capital the insurer actually has available to absorb such losses. It is made up of items such as share capital, retained profits and reserves, and certain types of long-term debt, after the regulatory rules on what counts as own funds are applied. For example, this insurer with 1.5 billion euros of this kind of capital has 1.5 billion euros of eligible own funds. The SCR ratio is the second amount divided by the first:

$$\text{SCR ratio} = \frac{\text{Eligible Own Funds (EOF)}}{\text{Solvency Capital Requirement (SCR)}}$$

In this example, the insurer's ratio is 1.5 billion divided by 1 billion equal to 1.5 or 150%, which means it holds one and a half times the capital it is required to hold. A ratio above 100% shows a buffer above the minimum, and a higher ratio means a stronger buffer. In fact, the capital held by European insurance companies is much higher than this minimum standard, and the comprehensive SCR ratio is usually around 200% to 250% (EIOPA, 2023).

Some studies have explored the factors affecting the SCR ratio. Poufinas and Siopi (2024) and Siopi et al. (2023) took the EU insurance group as an example and found that the ratio mainly depends on the investment methods of insurance companies, such as their holdings of bonds, real estate and stocks, and their cash reserves. Research by Sheehan et al. (2023) shows that the ratio also depends on the degree of dispersion of insurance company business: insurance companies that sell a variety of different types of insurance policy and operate in multiple countries can spread risks more widely, thus reducing the capital they need to hold. Finally, Grochola and Schlütter (2025) pointed out that insurance companies have some control over the ratio they report. They can use the special adjustment measures allowed by the rules, that is, long-term guarantee (LTG) measures, and can choose how to calculate SCR, both using standard formulas and their internal models. Therefore, the ratio is not a simple figure, and its meaning is not exactly the same for each company; it is partly determined by the choice of reporting.

2.3 ESG Mechanisms and Hypothesis Development

Our study rests on three theoretical ideas. The first is the Resource Based View (RBV) (Barney, 1991), which was later expanded by Hart (1995) to incorporate environmental capabilities. From this point of view, ESG capability is a valuable resource that can help enterprises adapt to the environment and maintain strong development in the long run. The second view is the stakeholder theory (Freeman, 2010), which believes that enterprises create value through relationships with different groups, such as customers, employees and regulators. The third is capital targeting theory (Flannery & Rangan, 2006), which says that firms do not let their capital ratios move freely, but actively manage them toward a target level. Industry practice shows that insurers set and manage toward such target ranges rather than the 100% minimum (EIOPA, 2018).

As explained in Section 2.2, the SCR ratio is Eligible Own Funds divided by the SCR, so ESG can support it from either side. These two sides map onto two of our theoretical lenses: the RBV (Barney, 1991), under which ESG is a valuable firm capability, and stakeholder theory (Freeman, 2010), under which strong stakeholder relationships preserve firm value. On the own funds side, firms with stronger ESG tend to face a lower cost of capital and to earn steadier profits, which help them build and keep more own funds (Meral et al., 2026), and they run into fewer costly controversies that would eat into that capital (Giráldez-Puig et al., 2025). On the SCR side, stronger ESG is linked to lower overall firm risk in financial companies, so a better ESG profile should reduce the capital an insurer needs to hold against its risks (Monti et al., 2022; Lee & Koh, 2024). Because ESG can lift the numerator and lower the denominator at the same time, we expect:

H1: *ESG performance is positively associated with the SCR ratio of European insurance companies.*

To examine whether this aggregate prediction reflects uniform or heterogeneous effects across the three constituent ESG dimensions, we further disaggregate the composite score into its environmental, social, and governance pillars.

In the Refinitiv framework, the environmental score reflects the environmental behavior of insurance companies themselves - including their resource use, emissions and environmental innovation - rather than the carbon emissions of their portfolios. Therefore, we avoid asset-based transition risk argument. Following the RBV (Hart, 1995), we regard environmental management as an important capability

(Barney, 1991), which reflects the ability of insurance companies to predict and assess climate risks. This is very important: Alokla et al. (2025) find in a sample of global insurance companies that the higher the risk of climate change, the greater the risk of default.

This channel mainly plays a role through underwriting and the second pillar. Insurance companies with better environmental performance, especially those with better performance in environmental innovation, tend to pay more attention to climate risk exposure and incorporate it into their ORSA and risk pricing; the industry has developed special tools for this purpose (UNEP FI, 2022). European Insurance and Occupational Pensions Authority (EIOPA) also pointed out that climate-conscious insurance companies can design products and adaptive incentives to reduce insurance losses and are reviewing the treatment of natural disaster risks in the standard formula (Hielkema, 2023). Regulators and policyholders increasingly require insurance companies to have this resilience (Freeman, 2010), and since the goal of insurance companies to manage capital is to reach the target level rather than the minimum level (Flannery & Rangan, 2006), stronger climate awareness should help manage the SCR more carefully.

However, the expected results are not obvious. More climate-related underwriting will also increase the risk exposure of disasters in the non-life insurance underwriting risk module (European Commission, 2015), thus having the opposite effect. In general, we expect that there is a positive correlation between the two, but at the same time, we also regard it as the most uncertain of the three pillar assumptions:

H1.1: *The environmental pillar is positively associated with the SCR ratio.*

The pillar of social covers the workforce, human rights, community relations and product responsibility. The stakeholder theory (Freeman, 2010) believes that enterprises maintain value through relationships with employees, customers and communities, and we believe that there are two channels that affect the SCR.

The first channel is reputation and policyholder loyalty. A good social and community image can make insurers more attractive to customers, and because insurance policies are usually held for a long time - policyholders are more "sticky" than bank depositors who can transfer funds at will - a good reputation

can reduce policy inefficiency and withdrawal rates. This helps to reduce the risk of life insurance and stabilize eligible own funds (Hanika, 2025; Giráldez-Puig et al., 2025).

The second is workforce quality and conduct. A well-trained and stable workforce, coupled with fair treatment of customers, can reduce false sales, complaints, fines and lawsuits, thus reducing the operational risk part of the SCR and protecting own funds (Giráldez-Puig et al., 2025). Therefore, a stronger social image should help improve the SCR ratio. This leads to:

H1.2: *The social pillar is positively associated with the SCR ratio.*

Refinitiv builds its governance pillar from management, shareholder, and corporate social responsibility (CSR) strategy — the same elements insurers rely on to set their risk appetite and monitor their risk exposure. Among the three dimensions, the connection between governance and solvency is the clearest, because corporate governance arrangements shape risk management practices, and these practices affect the inputs to the SCR.

Otero González et al. (2023) show this link directly. Studying Spanish insurers, they find that firms with better-run risk management, stronger risk governance and a more robust ORSA process achieve better risk-adjusted performance. In other words, good governance improves how insurers manage and assess their own risks (the focus of Pillar 2), and this in turn feeds into the capital they are required to hold under Pillar 1.

Corporate governance also operates through the mechanics of the capital formula. Well-governed insurers are also better placed to run diversified portfolios, and the standard formula rewards diversification by granting capital relief when the SCR is aggregated (Kouwenberg, 2017). They are also better placed to develop internal models and obtain supervisory approval for them, models that typically produce an SCR well below the standard formula (Grochola & Schlütter, 2025). Brogi et al. (2022) add that governance maturity is a prerequisite for the strategic resource allocation that turns ESG capabilities into financial performance. This yields:

H1.3: *The governance pillar is positively associated with the SCR ratio.*

In addition to the horizontal effect, another research direction in the literature is dynamic stability. The mainstream approach adopts accounting-based proxy indicators, the most prominent is the Z-score. Moreno et al. (2022) establish a standard construction method for Z-score in insurance research, defining it as the sum of ROA and equity-to-assets divided by the rolling standard deviation of ROA. Chiaramonte et al. (2020), Bressan (2023), and Miani et al. (2026) all adopted Z-score-based measures and record negative correlation between ESG and insolvency risk. However, the Z-score is inherently backward-looking, IFRS-dependent, and is not the metric used by supervisors. We therefore extend the literature by examining whether the documented accounting-based ESG-stability relationship persists when the dependent variable is shifted to the regulatory measure — the three-year rolling standard deviation of the SCR ratio:

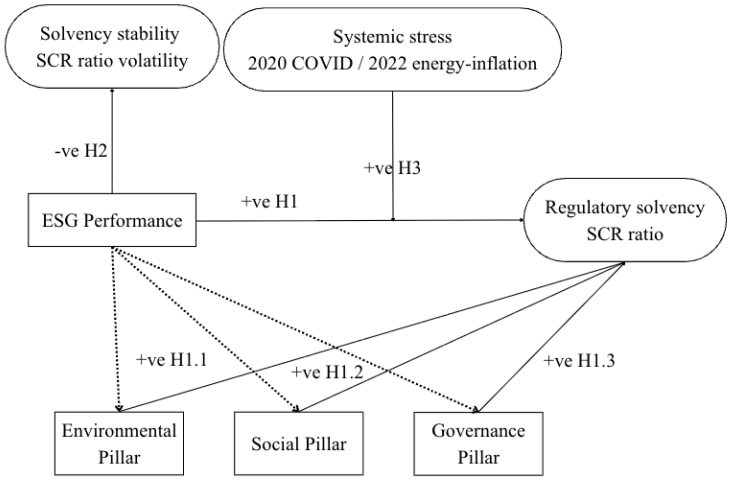
H2: *ESG performance is negatively associated with the volatility of the SCR ratio.*

Finally, ESG may matter most in times of crisis. The idea that ESG works like insurance, showing its value mainly under stress, has been documented outside the insurance sector: Lins et al. (2017) find that US firms with higher CSR proved more resilient during the 2008–2009 global financial crisis, and Engelhardt et al. (2021) report a similar pattern for European firms during the 2020 COVID-19 market crash. Our sample covers two major shocks in European insurance, the COVID-19 shock in 2020 and the energy and inflation crisis in 2022. If ESG really acts as a buffer, its link with the SCR ratio should be stronger in these stress years (Giráldez-Puig et al., 2025). This leads to:

H3: *The positive association between ESG performance and the SCR ratio is stronger during periods of systemic stress.*

Figure 1 presents the conceptual framework of this study.

Figure 1. Conceptual Framework



Source: Author's own elaboration.

3. Methodology

3.1 Sample and data collection

This empirical analysis is based on manually collected data panels of European listed insurance companies, which operate under the Solvency II regulatory framework. We focus on the EU and EEA. Since the full implementation of Solvency II on January 1, 2016, the framework has been a binding prudential regulatory system in these regions. We follow the research of Müller and Reuse (2023) to keep the British insurers in the benchmark sample. They pointed out that the solvency system after Brexit is still closely related to the EU Solvency II system, and the exclusion of British insurance companies may lead to the loss of important differences. Similarly, the Swiss insurance companies in our sample follow the Swiss Solvency Test (SST), which is an independent prudential regulatory framework managed by the Swiss Financial Market Regulatory Authority (FINMA), rather than the Solvency II system (EIOPA, 2011).

SST and Solvency II share a wide range of architectural principles - risk-based capital requirements, calibration based on a one-year confidence period, market-consistent valuation, and a three-pillar disclosure architecture - but there are differences in several technical details, the most notably the confidence level used by SCR (the expected gap under SST is 99%) and the specific calibration

assumptions of the market and underwriting risk modules. Despite these technical differences, large Swiss insurance groups in our sample (Swiss Life Holding AG, Zurich Insurance Group AG) voluntarily disclose SCR ratios for their international operations and group-level reporting.

The sample period spans 2016 to 2024. Sequential inclusion criteria are applied: (i) the firm is a publicly listed insurance holding company headquartered in Europe; (ii) the firm is subject to consolidated Solvency II reporting and discloses Group SCR ratios in its annual SFCR; (iii) the firm has non-missing Refinitiv ESG scores for at least two years; (iv) the firm has non-missing financial data; (v) country-level macroeconomic data are available. These criteria yield a final unbalanced panel of 31 insurers across thirteen European countries and 269 firm-year observations. Table 1 presents the distribution of the sample across countries.

Table 1. Sample Description by Country.

Country	Number of Insurers	Percentage
United Kingdom	7	22.58%
Germany	4	12.90%
France	4	12.90%
Austria	2	6.45%
Denmark	2	6.45%
Netherlands	2	6.45%
Norway	2	6.45%
Spain	2	6.45%
Switzerland	2	6.45%
Belgium	1	3.23%
Finland	1	3.23%
Italy	1	3.23%
Poland	1	3.23%

Source: Author's own elaboration based on LSEG workspace, Orbis and SFCR disclosures.

3.2 Variable Definitions

Our dependent variable is the SCR ratio, which is measured at the group level on the year-end reporting date and collected manually from the SFCR disclosure of the insurers. As explained in Section 2.2, we prefer this regulatory measure to alternatives such as Z-scores or market-based default probabilities because it directly shows the prudential capital position of European insurers under Solvency II. Using the SCR ratio in this way also follows earlier studies on European insurers (Poufinas & Siopi, 2024;

Siopi et al., 2023). For the volatility hypothesis (H2), we use the three-year rolling standard deviation of the SCR ratio as a regulatory-based measure of stability:

$$SolVol_{it} = \sqrt{\frac{1}{2}\sum_{\tau=t-2}^{t}\left(SCR_{i\tau} - \overline{SCR}_{it}\right)^2}, \qquad \overline{SCR}_{it} = \frac{1}{3}\sum_{\tau=t-2}^{t} SCR_{i\tau} \quad (1)$$

The main independent variable is ESG performance, which reflects a company's commitment to environmental, social, and governance practices. This composite score is sourced from LSEG (Refinitiv) Workspace, ranging from 0 to 100, with higher scores indicating better ESG performance. To separate the effects across different dimensions, we further examine three ESG sub-pillars: Environmental score (ENV), Social score (SOC), and Governance score (GOV). Our use of these scores is consistent with prior ESG research on European insurers (Miani et al., 2026; Giráldez-Puig et al., 2025). For robustness, we also collect MSCI ESG ratings from the WRDS database and repeat our main analysis with this alternative measure.

We include both firm-level and macroeconomic control variables. At the firm level, we first control for firm size, measured as the natural logarithm of total assets. Larger insurers usually have more resources to develop ESG practices and disclose ESG information, so controlling for size helps reduce possible reverse causality concerns (Brogi et al., 2022; Brasch & Eckert, 2025). We also include profitability, measured by return on assets (ROA). More profitable insurers may be able to retain more earnings, which can increase own funds and support the SCR ratio. ROA is also commonly used as a profitability control in insurance ESG studies (Bressan, 2023; Meral et al., 2026).

We then include three macroeconomic controls for each insurer's home country. The first is the ten-year government bond yield, which captures the long-term interest rates that affect the value of liabilities and the market risk part of the SCR (Poufinas & Siopi, 2024; Siopi et al., 2023). We expect higher interest rates to be associated with a higher SCR ratio. The second is real GDP growth, which reflects the economic cycle and affects premiums, claims, and investment returns (Eling & Schmeiser, 2010). We expect stronger GDP growth to be associated with a higher SCR ratio. The third is consumer price inflation, which raises the cost of claims and expenses (Poufinas & Siopi, 2024). We expect higher inflation to be associated with a lower SCR ratio. Finally, to test whether the ESG and solvency

relationship changes under stress (H3), we add a stress dummy equal to one in 2020 and 2022, the years of the COVID shock and the 2022 energy and inflation crisis, and zero otherwise (Lins et al., 2017). We enter this dummy on its own and also multiply it with ESG performance.

Table 2 summarises the variables used in this analysis.

Table 2. Summary of Variables

Variable	Description	Source	Expected Effect
Dependent variables			
SCR Ratio	Eligible Own Funds / SCR, Group-level, year-end	SFCR (hand-collected)	
Solvency volatility	3-year rolling standard deviation of SCR ratio	Constructed	
Main explanatory variables			
ESG Score	Refinitiv Composite ESG Score, 0–100	LSEG Workspace	+
ENV	Refinitiv Environmental Pillar Score, 0–100	LSEG Workspace	+
SOC	Refinitiv Social Pillar Score, 0–100	LSEG Workspace	+
GOV	Refinitiv Governance Pillar Score, 0–100	LSEG Workspace	+
MSCI ESG	MSCI ESG Rating, converted to numeric (1–10)	WRDS (robustness only)	+
Firm-level control			
Size	Natural logarithm of total assets	Orbis	Ambiguous/-
ROA	Net income divided by total assets	Orbis	+
Country-year macroeconomic controls			
Interest rate	10-year government bond yield (%)	Eurostat	+
GDP growth	Real GDP growth rate (%)	Eurostat	+
Inflation	Consumer price inflation rate (%)	World Bank WDI	-
Stress indicator			
Stress	Dummy = 1 in 2020, 2022 0 otherwise	Constructed	+

Source: Author's elaboration based on LSEG Workspace, Orbis, WRDS, SFCR disclosures, Eurostat, and World Bank databases.

3.3 Empirical Model and Estimator Choice

Our principal specification is a two-way fixed-effects panel model with firm and year fixed effects and standard errors clustered at the firm level. Before specifying the model, we justify our choice of the fixed-effects (FE) estimator over the random-effects (RE) alternative through the standard Hausman specification test.

The Hausman test compares the FE and RE estimators under the null hypothesis that firm-specific effects are uncorrelated with the regressors — the orthogonality condition required for RE consistency. Rejection of the null indicates that the RE estimator is inconsistent and that FE is the appropriate estimator. Table 3 reports the results of the Hausman test applied to the principal specification.

Table 3. Hausman Test for Fixed Effects versus Random Effects

Test	Null Hypothesis	χ^2 Statistic	p-value	Decision
Hausman test	RE is consistent and efficient	15.64	0.0158	Reject H_0 → use Fixed Effects

Source: Author's own calculation using Stata.

3.4 Hypothesis Testing Model

To test the hypotheses, this study uses panel data regressions based on a firm-year panel of European insurers. The Hausman test rejects the random-effects estimator ($\chi^2 = 15.64$, $p = 0.0158$), so the fixed-effects model is preferred. The main specification includes both firm fixed effects and year fixed effects. Standard errors are clustered at the firm level to control for heteroskedasticity and serial correlation within firms.

Firm fixed effects control for time-invariant differences across insurers, such as business model, country background, and long-term risk profile. Year fixed effects control for common shocks over time, including the general upward trend in ESG ratings and the IFRS 17 transition. For H1, the analysis uses a progressive specification. The first model includes ESG only, the second

model adds control variables, and the third model adds year fixed effects. This structure allows us to examine whether the ESG and solvency relationship reflects firm-level variation or common time trends.

The analysis then decomposes the ESG score into three pillars of environment, society and governance to test the hypothesis H1.1 to H1.3. For the hypothesis H2, the dependent variable is replaced by the three-year rolling volatility of the SCR ratio. For H3, a stress dummy and its interaction with ESG are added to test whether the relationship becomes stronger during the 2020 and 2022 stress episodes. Finally, the baseline model is repeated using MSCI ESG ratings as a robustness check.

H1 — Composite ESG and the SCR ratio. We estimate three models:

$$\textbf{Model 1}: SCR_{it} = \alpha_i + \beta_1 ESG_{it} + \varepsilon_{it} \quad (2)$$

$$\textbf{Model 2}: SCR_{it} = \alpha_i + \beta_1 ESG_{it} + \beta_2 Size_{it} + \beta_3 ROA_{it} + \beta_4 IntRate_{ct} + \beta_5 GDP_{ct} + \beta_6 CPI_{ct} + \varepsilon_{it} \quad (3)$$

$$\textbf{Model 3}: SCR_{it} = \alpha_i + \delta_t + \beta_1 ESG_{it} + \beta_2 Size_{it} + \beta_3 ROA_{it} + \beta_4 IntRate_{ct} + \beta_5 GDP_{ct} + \beta_6 CPI_{ct} + \varepsilon_{it} \quad (4)$$

H1.1-H1.3 — ESG pillar models (estimated separately for each pillar)

$$SCR_{it} = \alpha_i + \delta_t + \beta_1 Pillar_{it} + \beta_2 Size_{it} + \beta_3 ROA_{it} + \beta_4 IntRate_{ct} + \beta_5 GDP_{ct} + \beta_6 CPI_{ct} + \varepsilon_{it} \quad (5)$$

where Pillar ∈ {Environmental, Social, Governance}.

H2 — ESG and solvency volatility

$$SolVol_{it} = \alpha_i + \delta_t + \beta_1 ESG_{it} + \beta_2 Size_{it} + \beta_3 ROA_{it} + \beta_4 IntRate_{ct} + \beta_5 GDP_{ct} + \beta_6 CPI_{ct} + \varepsilon_{it} \quad (6)$$

where $SolVol_{it}$ is the three-year rolling standard deviation of the SCR ratio.

H3 — Moderating effect of systemic stress

$$SCR_{it} = \alpha_i + \delta_t + \beta_1 ESG_{it} + \beta_2 Stress_t + \beta_3 (ESG_{it} \times Stress_t) + \beta_4 Size_{it} + \beta_5 ROA_{it} + \beta_6 IntRate_{ct} + \beta_7 GDP_{ct} + \beta_8 CPI_{ct} + \varepsilon_{it} \quad (7)$$

where $Stress_t = 1$ for 2020 and 2022, and 0 otherwise; β_3 is the core test of H3.

Where:

- SCR_{it}: Group SCR ratio (EOF / SCR) for firm i at year t
- $SolVol_{it}$: Three-year rolling standard deviation of the SCR ratio
- ESG_{it}, ENV_{it}, SOC_{it}, GOV_{it}: Composite and pillar (Environmental, Social, Governance) ESG scores, 0–100
- $Size_{it}$: Firm size, natural logarithm of total assets
- ROA_{it}: Return on assets, net income divided total assets
- $IntRate_{ct}$: Ten-year government bond yield (%) in firm i's country c
- GDP_{ct}: Real GDP growth rate (%)
- CPI_{ct}: Consumer price inflation rate (%)
- $Stress_t$: Dummy variable equal to 1 for 2020 and 2022, 0 otherwise
- $\beta_1, \beta_2, \ldots$: Regression coefficients
- α_i: Firm fixed effects
- δ_t: Year fixed effects
- ε_{it}: Error term

Standard errors are clustered at the firm level.

4. Results

4.1 Descriptive Statistics

Table 4 reports the descriptive statistics. The mean SCR ratio is 2.09, which means that the average insurer in the sample holds eligible own funds equal to about 209% of its SCR. This level is above the 100% regulatory minimum and falls within the normal range for European insurers discussed in Section 2.2. The minimum value is 1.28, meaning that even the lowest observation remains above the regulatory threshold.

The standard deviation of the SCR ratio is 0.34, which shows that solvency levels vary across firms and years, but not extremely. This is consistent with the idea that insurers usually keep their SCR ratios within a relatively stable capital range, rather than allowing them to move freely. By comparison, ESG scores show greater variation, with a mean of 65.77 and a standard deviation of 16.74. This suggests that ESG performance differs more widely across insurers than the SCR ratio.

The three-year rolling solvency volatility has a mean of 0.13, based on 210 firm-year observations. This lower number of observations is expected because the first two years of each firm cannot be used to

calculate a three-year rolling measure. The maximum value is 0.56, which shows that some insurers experienced more changes in their SCR ratio than others.

The average Refinitiv ESG score is 65.77, with a standard deviation of 16.74. The scores range from 14.66 to 94.88, which means that the sample includes firms with very different levels of ESG performance. Among the three ESG pillars, the environmental score has the largest standard deviation, followed by governance and social scores. This suggests that environmental performance varies most across the insurers in the sample.

Firm size has a mean of 11.11. The macroeconomic variables also show the special conditions during the sample period. GDP growth reaches a minimum of -10.90, reflecting the COVID-19 shock in 2020. The ten-year interest rate is negative in some observations, with a minimum of -0.55. Inflation also rises sharply, reaching a maximum of 14.43%. These patterns show why it is important to include macroeconomic controls and year fixed effects in the regression models.

Table 4. Descriptive Statistics of Variables.

Variable	Observation	Mean	Std.Dev	Minimum	Maximum
SCR ratio	279	2.09	0.34	1.28	3.28
Solvency volatility	210	0.13	0.10	0.00	0.56
ESG score	269	65.77	16.74	14.66	94.88
ENV	269	68.06	23.59	4.06	99.06
GOV	269	68.98	19.88	4.73	97.85
SOC	269	64.68	18.54	17.04	93.37
MSCI ESG	263	5.53	0.95	3.0	7.5
ROA	279	0.02	0.03	-0.04	0.14
CPI	279	2.68	2.45	-0.73	14.43
GDP growth	279	1.47	3.52	-10.90	8.90
10-year interest rate	279	1.30	1.36	-0.55	6.05

Firm size	279	11.11	1.85	6.39	13.95

Source: Author's own calculation using Stata

Table 5 reports the correlations matrix among the main variables. The SCR ratio is positively and significantly correlated with the composite ESG score ($\rho = 0.294$, $p < 0.01$), and also with the environmental, governance, and social pillars. Among the three pillars, the social score has the strongest correlation with the SCR ratio ($\rho = 0.260$), followed by the environmental score ($\rho = 0.229$) and the governance score ($\rho = 0.214$). The MSCI ESG rating is also positively correlated with the SCR ratio ($\rho = 0.284$), so the positive link is not limited to the Refinitiv measure.

The matrix also shows that ESG scores are strongly related to firm size. The correlation between the composite ESG score and firm size is 0.760, while the correlations between firm size and the environmental, governance, and social pillars are 0.783, 0.511, and 0.684. In other words, larger insurers tend to have higher ESG scores, possibly because larger firms have more resources for ESG activities and disclosure. ROA is negatively correlated with the SCR ratio ($\rho = -0.218$) and with the ESG variables. More profitable insurers therefore do not always hold higher solvency buffers, possibly because of how they manage their capital.

For the volatility measure, the results are mixed. Solvency volatility is negatively correlated with the composite ESG score ($\rho = -0.135$, $p < 0.10$), the environmental score ($\rho = -0.191$, $p < 0.01$), and the social score ($\rho = -0.140$, $p < 0.05$). This fits H2, which expects better ESG performance to be associated with lower solvency volatility. The correlation between solvency volatility and the governance score, however, is close to zero. These correlations should be treated as preliminary, because they do not control for firm fixed effects, year effects, or other variables.

Table 5. Correlation matrix of the variables.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) SCR ratio	1.000											
(2) solvency volatility	0.349***	1.000										
	(0.000)											
(3) ESGScore	0.294***	-0.135*	1.000									
	(0.000)	(0.051)										
(4) Env	0.229***	-0.191***	0.796***	1.000								
	(0.000)	(0.005)	(0.000)									
(5) Gov	0.214***	0.002	0.779***	0.465***	1.000							
	(0.000)	(0.972)	(0.000)	(0.000)								
(6) Soc	0.260***	-0.140**	0.845***	0.703***	0.359***	1.000						
	(0.000)	(0.042)	(0.000)	(0.000)	(0.000)							
(7) MSCIESG	0.284***	-0.125*	0.714***	0.592***	0.473***	0.651***	1.000					
	(0.000)	(0.073)	(0.000)	(0.000)	(0.000)	(0.000)						
(8) ROA	-0.218***	-0.008	-0.495***	-0.604***	-0.335***	-0.424***	-0.313***	1.000				
	(0.000)	(0.906)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)					
(9) CPI	0.191***	0.058	0.097	-0.003	0.141**	0.000	0.135**	0.037	1.000			
	(0.001)	(0.394)	(0.113)	(0.967)	(0.021)	(0.998)	(0.029)	(0.540)				
(10) GDP	0.072	0.030	0.023	0.075	0.012	0.025	0.007	0.033	0.249***	1.000		
	(0.232)	(0.666)	(0.702)	(0.223)	(0.845)	(0.683)	(0.910)	(0.583)	(0.000)			
(11) 10-year interest rate	0.114*	-0.016	0.063	-0.076	0.144**	-0.020	0.156**	0.152**	0.608***	0.092	1.000	
	(0.057)	(0.819)	(0.300)	(0.216)	(0.018)	(0.748)	(0.011)	(0.011)	(0.000)	(0.124)		
(12) size	0.285***	-0.059	0.760***	0.783***	0.511***	0.684***	0.662***	-0.673***	-0.046	-0.030	-0.088	1.000
	(0.000)	(0.390)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.441)	(0.616)	(0.143)	

**** p<0.01, ** p<0.05, * p<0.1 Source: Author's own calculation using Stata.*

4.2 ESG performance and the level of the SCR ratio (H1)

Table 6 presents the regression results for the effect of ESG score on the SCR ratio. Model 1 includes only ESG score and firm fixed effects. The coefficient of ESG score is positive and statistically significant at the 1% level ($\beta = 0.00537$, SE = 0.00161). This suggests that, before adding control variables, insurers with higher ESG scores tend to have higher SCR ratios.

Model 2 adds firm-level and macroeconomic control variables, including firm size, ROA, the ten-year interest rate, GDP growth, and CPI. The ESG coefficient remains positive and significant at the 5% level ($\beta = 0.00369$, SE = 0.00156). This means that a higher ESG score is still associated with a higher SCR ratio after controlling for firm and macroeconomic characteristics. Among the control variables, firm size is negative and significant ($\beta = -0.132$, $p < 0.05$), indicating that larger insurers tend to have lower SCR ratios. ROA is positive but not statistically significant, suggesting that profitability does not have a clear relationship with the SCR ratio in this model. The ten-year interest rate is positive and weakly significant at the 10% level, while GDP growth and CPI are not significant.

Model 3 adds year fixed effects. After controlling for common year effects, the ESG coefficient becomes very small and statistically insignificant ($\beta = -0.0004$, SE = 0.00190). Firm size remains negative and significant ($\beta = -0.178$, $p < 0.01$), while ROA and the macroeconomic controls are not significant. The R-squared increases from 0.171 in Model 2 to 0.243 in Model 3, showing that year effects explain part of the variation in the SCR ratio. Overall, the positive ESG association found in Models 1 and 2 does not remain significant once year fixed effects are included. Therefore, H1 is not supported in the preferred two-way fixed-effects model. Figure 2 shows that both ESG scores and SCR ratios rose over the sample period, which helps explain why the association weakens once year effects are added.

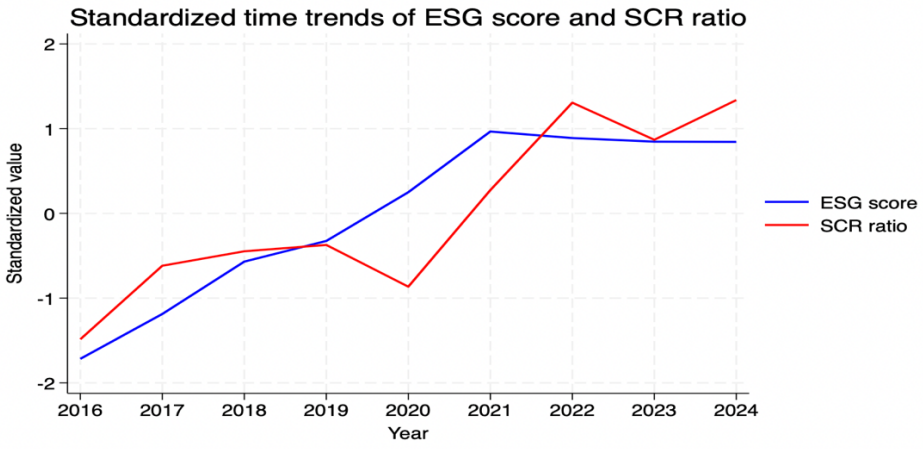
Table 6. Regression results for the effect of ESG score on SCR ratio.

Variables	**Model 1** **SCR ratio**	**Model 2** **SCR ratio**	**Model 3** **SCR ratio**
ESG score	0.00537***	0.00369**	-0.0004
	(0.00161)	(0.00156)	(0.00190)
Firm size		-0.132**	-0.178***
ROA		1.449	1.032

		(0.896)	(1.164)
10-year interest rate		0.0334*	0.0048
		(0.0167)	(0.0411)
GDP growth		0.0048	0.0064
		(0.0035)	(0.0075)
CPI		0.0088	-0.0118
		(0.0076)	(0.0103)
Constant	1.747***	3.222***	3.901***
	(0.106)	(0.654)	(0.751)
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	No	No	Yes
Observations	269	269	269
R-squared	0.042	0.171	0.243

Note: *Standard errors clustered at the firm level are reported in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Model 1 includes ESG score only; Model 2 adds control variables; Model 3 further includes year fixed effects.*

Figure 2. Standardized Time Trends of ESG Score and SCR Ratio



Source: Author's own calculation using Stata.

Table 7 reports the results for the three ESG pillar scores. The environmental score has a negative but insignificant coefficient (β = -0.0008, SE = 0.0016), so H1.1 is not supported. The social score is also negative and insignificant (β = -0.0007, SE = 0.0019), indicating that H1.2 is not supported. The

governance score is close to zero and not statistically significant (β = 0.0001, SE = 0.0015), so H1.3 is also not supported.

Across the three pillar models, firm size remains negative and statistically significant. This is consistent with the main model and suggests that larger insurers tend to report lower SCR ratios after controlling for firm and year effects. ROA is positive in all three models but not statistically significant. The ten-year interest rate, GDP growth, and CPI are also not significant. The R-squared values are very similar across the three models, ranging from 0.243 to 0.244. Overall, the pillar-level results show no significant evidence that any individual ESG dimension is associated with the SCR ratio.

Table 7. Regression results for ESG pillar scores.

Variable	**(1)** **Environmental**	**(2)** **Social**	**(3)** **Governance**
ENV	-0.0008		
	(0.0016)		
SOC		-0.0007	
		(0.0019)	
GOV			0.0001
			(0.0015)
Firm size	-0.173***	-0.177***	-0.177***
	(0.0601)	(0.0635)	(0.0622)
ROA	1.009	1.093	1.084
	(1.198)	(1.163)	(1.042)
10-year interest rate	0.0075	0.0029	0.0027
	(0.0382)	(0.0408)	(0.0431)
GDP growth	0.0075	0.0062	0.0061
	(0.0068)	(0.0073)	(0.0076)
Variable	**(1)** **Environmental**	**(2)** **Social**	**(3)** **Governance**
CPI	-0.0119	-0.0112	-0.0115
	(0.0102)	(0.0101)	(0.0103)

Constant	3.877***	3.914***	3.860***
	(0.714)	(0.770)	(0.676)
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	269	269	269
R-squared	0.244	0.243	0.243

Note: *Standard errors clustered at the firm level are reported in parentheses. The symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.*

4.3 ESG performance and Solvency Volatility (H2)

Table 8 reports the results for H2, which tests whether ESG performance is associated with lower solvency volatility. The coefficient of ESG score is negative, as expected, but it is not statistically significant (β = -0.0005, SE = 0.0012). Firm size, ROA, the ten-year interest rate, GDP growth, and CPI are also insignificant. The number of observations is 210 because solvency volatility is calculated as a three-year rolling standard deviation. Therefore, the results do not support H2.

Table 8. Regression results for ESG score and solvency volatility.

Variable	**Solvency volatility**
ESG score	-0.0005
	(0.0012)
Firm size	0.0003
	(0.0604)
ROA	-0.192
	(0.401)
10-year interest rate	-0.0021
	(0.0176)
GDP growth	0.0037
	(0.0036)
CPI	-0.0109
	(0.0076)
Constant	0.188
	(0.659)
Firm fixed effects	Yes
Year fixed effects	Yes
Observations	210
R-squared	0.053

*Note: Standard errors are clustered at the firm level and reported in parentheses. *, **, and ****

indicate significance at the 10%, 5%, and 1% levels, respectively.

4.4 The role of systemic stress (H3)

Table 9 presents the results for the stress interaction model. The interaction between ESG score and the stress dummy is positive but not statistically significant (β = 0.00093, SE = 0.0018). This means that the relationship between ESG performance and the SCR ratio does not become significantly stronger in the stress years 2020 and 2022. The stress dummy itself is positive and weakly significant (β = 0.285, p < 0.10), suggesting that SCR ratios were generally higher in stress years. Firm size remains negative and significant, while ROA and the macroeconomic controls are not significant. Therefore, H3 is not supported.

Table 9. Regression results for the moderating effect of systemic stress.

Variable	SCR ratio
ESG score	-0.000484
	(0.0020)
Stress	0.285*
	(0.164)
ESG score × Stress	0.00093
	(0.0018)
Firm size	-0.177**
	(0.0645)
ROA	1.068
	(1.164)
10-year interest rate	0.0039
	(0.0414)
GDP growth	0.0059
	(0.0074)
CPI	-0.0121
	(0.0102)
Constant	3.902***
	(0.755)
Firm fixed effects	Yes
Year fixed effects	Yes
Observations	269
R-squared	0.244

Note: *Standard errors are clustered at the firm level and reported in parentheses. *, **, and *** indicate*

significance at the 10%, 5%, and 1% levels, respectively. The stress dummy equals one for 2020 and 2022, and zero otherwise.

4.5 Diagnostics and Robustness

This section reports two additional checks. First, we examine whether the regression results are affected by multicollinearity. Tables 10 and 11 report the variance inflation factors for the composite ESG model and the ESG pillar model. In the composite ESG model, the mean VIF is 2.06, and the highest VIF is 3.43 for firm size. In the ESG pillar model, the mean VIF is 2.16, and the highest VIF is 3.84, again for firm size. Since all VIF values are below the common threshold of 5, multicollinearity is not a serious concern in this study.

Table 10. Results of examining multicollinearity using VIFs: ESG score model.

Variable	VIF	1/VIF
Firm size	3.43	0.291736
ESG score	2.52	0.397145
ROA	1.91	0.522826
CPI	1.74	0.576042
10-year interest rate	1.68	0.593544
GDP growth	1.08	0.926449
Mean VIF	2.06	

Table 11. Results of examining multicollinearity using VIFs: ESG pillar model.

Variable	VIF	1/VIF
Firm size	3.84	0.260603
ENV	3.25	0.308026
SOC	2.23	0.447683
ROA	2.00	0.499948
CPI	1.73	0.578253
10-year interest rate	1.70	0.587571

GOV	1.46	0.684073
GDP growth	1.10	0.906163
Mean VIF	2.16	

Note: VIF values below common thresholds indicate that multicollinearity is not a serious concern.

Second, we test whether the results depend on the ESG rating provider. Table 12 repeats the baseline model using MSCI ESG ratings instead of Refinitiv ESG scores. The MSCI ESG coefficient is negative and statistically insignificant (β = -0.0190, SE = 0.0402). Firm size remains negative and significant, while ROA, the ten-year interest rate, GDP growth, and CPI are not significant. This result is consistent with the main Refinitiv model and suggests that the null finding is not specific to one ESG rating provider.

Table 12. Robustness check using MSCI ESG score.

Variable	**SCR ratio**
MSCI ESG score	-0.0190 (0.0402)
Firm size	-0.166** (0.0609)
ROA	0.927 (1.140)
10-year interest rate	0.0121 (0.0430)
GDP growth	0.00672 (0.0082)
CPI	-0.0134 (0.0115)
Constant	3.833*** (0.721)
Firm fixed effects	Yes
Year fixed effects	Yes
Observations	263
Number of groups	30
R-squared (within)	0.236

*Note: Standard errors are clustered at the firm level and reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.*

5. Discussion

This study set out to examine whether ESG performance is associated with the regulatory capital

adequacy of European insurers, measured by the SCR ratio, and whether this relationship becomes stronger during periods of systemic stress. The main finding is that ESG performance is positively associated with the SCR ratio in the simpler models, but this relationship disappears once year fixed effects are added. Therefore, under the preferred two-way fixed-effects specification, we do not find a robust and statistically significant association between ESG performance and the SCR ratio.

This finding needs to be read with some caution. It does not suggest that ESG is irrelevant for insurer solvency or risk management. This only shows that in the sample of 31 European insurance companies, there is no statistical internal relationship between ESG performance and SCR ratio after controlling the ESG indicators provided by Refinitiv and MSCI. One possible explanation is the common time trend in the data. Both ESG scores and SCR ratios increased over the sample period, especially after 2020, so the positive association in the simpler models may reflect this shared upward movement rather than a direct ESG effect. The small sample size may also reduce statistical power, making small effects harder to detect.

The first hypothesis expected insurers with higher ESG performance to have higher SCR ratios. The results provide only limited support for this expectation. In the baseline model, the ESG coefficient is positive and significant at the 1% level. After adding firm-level and macroeconomic controls, including ROA, the coefficient remains positive and significant at the 5% level. However, once year fixed effects are introduced, the coefficient becomes very small and statistically insignificant. This means that a positive correlation between ESG and SCR can be observed in a simpler model, but this relationship cannot be established in the preferred two-way fixed effect model.

This finding differs from studies such as Chiaramonte et al. (2020), Bressan (2023), and Miani et al. (2026), which report a positive link between ESG performance and insurer stability using Z-scores or market-implied default probabilities. One possible reason for the difference is that this paper uses the SCR ratio, a regulatory capital measure, rather than an accounting or market-based stability proxy. The SCR ratio may respond not only to underlying risk, but also to capital management, model choice, and regulatory reporting practices.

The result also relates to the measurement concerns raised by Berg et al. (2020) and Brasch and Eckert (2025). If ESG scores tend to rise over time due to changes in information disclosure, rating methods or

retroactive revisions, then in a simpler model, the positive correlation between ESG and solvency may partly reflect the common time trend. More broadly, the results show that H1 may be too linear: it assumes that a higher ESG score should be converted into a higher SCR ratio, while in fact, insurance companies may control the SCR ratio within the target range rather than simply maximizing it.

The pillar-level results refine the main finding. None of the three ESG pillars is significantly associated with the SCR ratio. For the environmental pillar, the coefficient is small and insignificant. Refinitiv's environmental pillar mainly captures resource use, emissions, and innovation. These factors may matter for insurers through investment portfolios or climate-related risks, as suggested by Chaiyawat and Guayjarernpanishk (2025). However, our results indicate that this channel is not visible in the aggregate SCR ratio. One possible reason is that environmental effects may appear in specific SCR risk modules or asset values, rather than in the overall ratio.

The social pillar is also insignificant. Refinitiv's social pillar includes workforce, human rights, community, and product responsibility. For insurers, these areas may relate to customer treatment, reputation, and policyholder trust. This connects with Hanika (2025), Schwartze and Dobler (2026), who find that social legitimacy and disclosure can matter for policyholder behaviour and risk management. However, these effects may develop slowly and may not lead to clear changes in the SCR ratio during our sample period.

The governance pillar deserves particular attention. Refinitiv's governance pillar includes management, shareholders, and CSR strategy. In the insurance context, these areas can be linked to enterprise risk management quality, ORSA processes, diversification, and internal model approval (Otero González et al., 2023; Grochola & Schlütter, 2025). For this reason, we expected governance to have the strongest relationship with the SCR ratio. However, the coefficient is positive but very close to zero and statistically insignificant.

There are two possible explanations. First, governance quality may already be part of stable firm characteristics. Well-governed insurers may have better risk management systems, but these differences may be absorbed by firm fixed effects rather than appearing as within-firm changes over time. Second, a higher SCR ratio is not always better. If the ratio is far above the target range, it may indicate inefficient capital use. Therefore, well-governed insurers may manage capital toward an optimal range rather than

simply increasing the ratio. This means that governance could improve capital management without producing a positive linear relationship with the SCR ratio. This also suggests that the ESG-solvency relationship may be non-linear, as found in other contexts such as Karaman et al. (2025) and Bouattour et al. (2024). A linear fixed-effects model may not fully capture this type of relationship.

The volatility result gives a similar conclusion. Although the ESG coefficient is negative, as expected, it is small and statistically insignificant. This does not fully align with studies using Z-score based measures, which find that stronger ESG performance is associated with greater insurer stability (Chiaramonte et al., 2020; Bressan, 2023; Miani et al., 2026). One possible reason is that the SCR ratio and accounting measures capture different aspects of stability: the former is a regulatory capital measure, while the latter is based on profitability and balance sheet structure. Therefore, ESG effects may be less visible in the volatility of the SCR ratio. The negative correlations between ESG pillars and solvency volatility also disappear after firm and year fixed effects are included, suggesting that they mainly reflect between-firm differences. Overall, H2 is not supported.

The stress result also does not support H3. The interaction between ESG and the stress dummy is positive but insignificant, meaning that ESG performance did not have a stronger relationship with the SCR ratio during 2020 and 2022. This differs from the crisis buffer argument in Lins et al. (2017) and from Giráldez-Puig et al. (2025), who suggest that ESG may protect firms during adverse events. In our sample, SCR ratios generally increased after 2020, so any specific ESG effect during the stress years may have been absorbed by this common increase across firms. The higher solvency levels in these years therefore seem more likely to reflect industry wide or regulatory responses, such as precautionary capital retention or supervisory measures, rather than a specific ESG effect. However, this interpretation should be treated with caution, because these supervisory channels are not directly tested in the model.

Firm size provides one important way to understand the results. In all regression analysis, company size is the most stable control variable and maintains a negative correlation with the SCR ratio. At the same time, larger insurers tend to have higher ESG scores, as shown by the strong correlation between ESG score and firm size ($\rho = 0.760$). This creates a contradiction: the firms with better ESG performance are often the large insurers, and they may manage their capital more actively.

One possible explanation is that larger insurers are more likely to use internal models and other capital

management tools. These tools can help them calculate and manage their SCR more efficiently than firms using the standard formula (Grochola & Schlütter, 2025). As a result, large insurers may not aim to maximise the SCR ratio. Instead, they may keep it within a target range that fits their risk profile and capital strategy. This helps explain why higher ESG scores do not necessarily translate into higher SCR ratios. In addition, the channels through which ESG seems to support bank stability (Chiaramonte et al., 2020; Brogi et al., 2022) may be weaker for insurers, whose risks come mainly from underwriting and markets and whose policyholders are less likely to leave than bank depositors.

This also suggests that the theoretical mechanisms developed in this study may still be relevant, even though they are not clearly visible in the regression results. ESG capabilities, stakeholder trust, and governance-based risk management may improve how insurers manage risk. However, the group level SCR ratio may be too broad and too actively managed to capture these effects directly. ESG effects may instead appear in specific SCR risk modules, in own funds, or in capital management decisions, rather than in the headline ratio itself.

Finally, the sample period is marked by strong common trends. Both ESG scores and SCR ratios increased over time, especially after 2020. This makes it difficult to separate a firm level ESG effect from broader sector wide changes in regulation, disclosure, and capital management. ESG ratings may also partly reflect how much firms disclose, rather than only real reductions in risk. For these reasons, the null result should not be read as evidence that ESG is irrelevant for insurer risk management. It should be interpreted more narrowly: in this sample, once the impact of the company and the year is controlled, the observable link between the ESG score and the group-level SCR ratio is very weak.

For insurers, the practical message is not to maximise the SCR ratio. A higher ratio is not always better if it means inefficient capital use. On the contrary, insurers should adjust the ratio to a level consistent with their risk situation and strategy. Therefore, our research results remind us that higher ESG ratings should not be directly regarded as a signal of higher regulatory solvency ratios.

For supervisors, the findings are consistent with EIOPA's view on sustainability risks under Solvency II. EIOPA (2019) notes that the SCR is based on a one-year horizon, while sustainability risks are usually longer term and may not be fully captured in capital requirements. Therefore, EIOPA recommends the use of forward-looking second-pillar tools, such as ORSA, scenario analysis and stress testing, rather

than simply changing the SCR period to one year. Our null result on the Group-level SCR ratio fits this view: a long-term ESG signal may not appear clearly in a point-in-time regulatory ratio.

EIOPA's call for greater transparency in external ESG ratings also supports the measurement concerns raised by Berg et al. (2022) and Brasch and Eckert (2025). Overall, integrating sustainability into Solvency II is unlikely to be achieved through a simple linear link between ESG scores and the headline SCR ratio.

6. Conclusion

This study examined whether ESG performance is associated with the regulatory solvency of European insurers, measured by the SCR ratio, and whether this link becomes stronger during periods of stress. Using a panel of 31 listed European insurance groups over 2016 to 2024 and a two-way fixed effects model, we find that ESG performance is positively related to the SCR ratio in the simpler models, but that this relationship disappears once year fixed effects are added. The three ESG pillars are not individually significant, ESG is not linked to the volatility of the ratio, and it does not act as a buffer during the 2020 and 2022 stress years. The same null result holds when MSCI ratings are used instead of Refinitiv scores.

The study makes three contributions. From an empirical angle, it extends the view that ESG works like a form of insurance by testing it on a new outcome, the regulatory solvency of insurers, and shows that an apparent ESG and solvency link can largely reflect common time trends rather than a within firm effect. From an industry angle, it adds to the limited evidence on ESG in European insurance by using the SCR ratio, the measure that supervisors actually rely on, together with its environmental, social, and governance pillars. From a regulatory angle, it provides empirical evidence that speaks to EIOPA on bringing ESG into Solvency II, and our results are in line with EIOPA's view that long term sustainability risks may not show clearly in a one year, point in time capital ratio (EIOPA, 2019).

There are some limitations of this research. First of all, the sample size is relatively small, containing only 31 insurance companies and 269 firm-year observations, which limits the statistical power of the tests and cannot be reliably divided into life insurance companies and non-life insurance companies. Secondly, there is noise in ESG indicators themselves, and there are differences between different insurance companies, so these indicators may reflect more information disclosure than actual risks.

Finally, the sample period spans the transition period of IFRS 17 and two major stress events, making it have an obvious trend. In this case, the year fixed effect is necessary, but because the ESG score changes slowly within the company, eliminating all common time variability may also erase some of the real and slowly accumulated ESG effects.

Future research could also extend the analysis to other countries that have adopted risk-based solvency frameworks similar to Solvency II, such as China Risk Oriented Solvency System (C-ROSS) in China and the risk-based capital regime in the United States. Comparing insurers across these regimes would show whether the ESG and solvency relationship depends on the regulatory framework. A larger and more international sample would also make it possible to study life and non-life insurers separately, since ESG may affect their balance sheets through different channels, mainly the asset side and market risk for life insurers and underwriting and catastrophe exposure for non-life insurers. The relationship may also be non-linear, so future work could use quadratic ESG terms, panel threshold models, or dynamic panel GMM rather than a linear fixed-effects model.

In summary, this study brings the SCR ratio into the debate on ESG and insurer resilience. The results suggest that the positive ESG and solvency link found in simple models does not remain once common time trends are controlled for. This does not mean that ESG is not important to insurers. On the contrary, the impact of ESG may work through channels that cannot be fully reflected in the SCR ratio. At present, ESG performance should be regarded as part of broader risk management, rather than a direct way to increase the regulatory solvency ratio.

7. Declaration on the Responsible Use of Artificial Intelligence

In the course of preparing this Master's Thesis, the author used Claude (Opus model, Anthropic) and ChatGPT (o3 model, OpenAI) in order to assist with language polishing, translation, and the restructuring of paragraphs, because the author's native language is Mandarin Chinese rather than English or Spanish; and in order to support the reading of the academic literature, for which the author first read each source independently and then consulted the AI tools to guard against misunderstandings or omissions in comprehension. ChatGPT (o3 model, OpenAI) was additionally used in order to organize and refine tables and paragraphs.

All critical thinking, analysis, interpretation, and the discussion presented in this thesis originate entirely

from the author's own brainstorming and scholarly judgment; AI tools were not used to generate these intellectual contributions. Their use has been complementary and critically supervised. The author thoroughly reviewed, edited and validated the content as necessary and takes full responsibility for the entire Master's Thesis, confirming that the work is their own and reflects the author's understanding and effort.

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Appendix I

```
. tabstat SCRratio solvency_volatility ESGScore Env Gov Soc MSCIESG ROA CPI GDP yearsr
> ates size, statistics(n mean sd min max) columns(statistics)
```

Variable	N	Mean	SD	Min	Max
SCRratio	279	2.093168	.3356487	1.28	3.28
solvency_v~y	217	.1261829	.0981419	5.51e-09	.5608327
ESGScore	269	65.77441	16.73522	14.66352	94.88335
Env	269	68.05613	23.59318	4.060576	99.06336
Gov	269	68.98159	19.88121	4.732278	97.84874
Soc	269	64.68422	18.53564	17.03724	93.37315
MSCIESG	263	5.529278	.9455895	3	7.5
ROA	279	.0209582	.0257046	-.0375	.1351
CPI	279	2.683487	2.452217	-.7258749	14.42945
GDP	279	1.470968	3.524802	-10.9	8.9
yearsrates	279	1.302401	1.357363	-.55	6.05
size	279	11.11132	1.848698	6.391917	13.94604

Appendix II

```
. xtreg SCRratio ESGScore, fe vce(cluster firm_id)

Fixed-effects (within) regression               Number of obs      =       269
Group variable: firm_id                         Number of groups   =        31

R-squared:                                      Obs per group:
     Within  = 0.0423                                         min =         2
     Between = 0.1070                                         avg =       8.7
     Overall = 0.0864                                         max =         9

                                                F(1, 30)           =     11.08
corr(u_i, Xb) = 0.0315                          Prob > F           =    0.0023

                                  (Std. err. adjusted for 31 clusters in firm_id)
------------------------------------------------------------------------------
             |               Robust
    SCRratio |      Coef.   Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
    ESGScore |   .0053741   .0016145     3.33   0.002      .002077    .0086713
       _cons |   1.747428   .1061896    16.46   0.000     1.530559    1.964296
-------------+----------------------------------------------------------------
     sigma_u |   .2534757
     sigma_e |  .21011783
         rho |  .59271464   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Appendix III

```
. xtreg SCRratio ESGScore size ROA yearsrates GDP CPI, fe vce(cluster firm_id)

Fixed-effects (within) regression               Number of obs     =       269
Group variable: firm_id                         Number of groups  =        31

R-squared:                                      Obs per group:
     Within  = 0.1706                                         min =         2
     Between = 0.1543                                         avg =       8.7
     Overall = 0.0399                                         max =         9

                                                F(6, 30)          =     13.41
corr(u_i, Xb) = -0.7610                         Prob > F          =    0.0000

                                (Std. err. adjusted for 31 clusters in firm_id)
```

SCRratio	Coefficient	Robust std. err.	t	P>|t|	[95% conf.	interval]
ESGScore	.0036912	.0015622	2.36	0.025	.0005007	.0068817
size	-.1321425	.0596412	-2.22	0.034	-.253946	-.0103389
ROA	1.449153	.8962599	1.62	0.116	-.3812544	3.279559
yearsrates	.0333892	.0166684	2.00	0.054	-.0006522	.0674306
GDP	.0048292	.0034767	1.39	0.175	-.0022712	.0119297
CPI	.0088167	.0075797	1.16	0.254	-.0066631	.0242964
_cons	3.221968	.6537492	4.93	0.000	1.886834	4.557102
sigma_u	.42384599					
sigma_e	.19762941					
rho	.82141342	(fraction of variance due to u_i)				

Appendix IV

```
. xtreg SCRratio ESGScore size ROA yearsrates GDP CPI i.Year, fe vce(cluster firm_id)

Fixed-effects (within) regression               Number of obs      =       269
Group variable: firm_id                         Number of groups   =        31

R-squared:                                      Obs per group:
     Within  = 0.2427                                         min =         2
     Between = 0.1544                                         avg =       8.7
     Overall = 0.0445                                         max =         9

                                                F(14, 30)          =      8.45
corr(u_i, Xb) = -0.8482                         Prob > F           =    0.0000

                                (Std. err. adjusted for 31 clusters in firm_id)
```

SCRratio	Coefficient	Robust std. err.	t	P>|t|	[95% conf.	interval]
ESGScore	-.0003715	.0018997	-0.20	0.846	-.0042513	.0035083
size	-.1777773	.0642704	-2.77	0.010	-.3090348	-.0465197
ROA	1.032141	1.16387	0.89	0.382	-1.3448	3.409081
yearsrates	.0047704	.0410848	0.12	0.908	-.0791359	.0886766
GDP	.0063567	.0074875	0.85	0.403	-.0089349	.0216483
CPI	-.0117856	.0103144	-1.14	0.262	-.0328503	.0092791
Year						
2017	.1081054	.0379504	2.85	0.008	.0306003	.1856106
2018	.1441444	.050306	2.87	0.008	.0414057	.2468831
2019	.1578546	.0792616	1.99	0.056	-.0040192	.3197284
2020	.1591396	.1009701	1.58	0.125	-.047069	.3653481
2021	.2124017	.107887	1.97	0.058	-.0079329	.4327363
2022	.3456587	.1186381	2.91	0.007	.1033673	.5879501
2023	.3015295	.1237457	2.44	0.021	.048807	.554252
2024	.3199246	.1256062	2.55	0.016	.0634024	.5764467
_cons	3.900916	.7510325	5.19	0.000	2.367103	5.434729
sigma_u	.525566					
sigma_e	.19219109					
rho	.88204827	(fraction of variance due to u_i)				

Appendix V

```
. xtreg SCRratio Env size ROA yearsrates GDP CPI i.Year, fe vce(cluster firm_id)

Fixed-effects (within) regression               Number of obs      =       269
Group variable: firm_id                         Number of groups   =        31

R-squared:                                      Obs per group:
     Within  = 0.2440                                         min =         2
     Between = 0.1540                                         avg =       8.7
     Overall = 0.0443                                         max =         9

                                                F(14, 30)          =      5.97
corr(u_i, Xb) = -0.8490                         Prob > F           =    0.0000

                                (Std. err. adjusted for 31 clusters in firm_id)
------------------------------------------------------------------------------
             |               Robust
   SCRratio |      Coef.   Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
         Env |  -.0008322   .0015744    -0.53   0.601    -.0040475    .0023832
        size |  -.1729654   .0600728    -2.88   0.007    -.2956503   -.0502804
         ROA |   1.008856   1.197946     0.84   0.406    -1.437675    3.455388
  yearsrates |   .0074789   .0381627     0.20   0.846    -.0704597    .0854175
         GDP |    .007452   .0067557     1.10   0.279    -.0063449     .021249
         CPI |  -.0118935   .0102033    -1.17   0.253    -.0327315    .0089445
             |
        Year |
        2017 |   .1077658   .0367545     2.93   0.006     .0327031    .1828284
        2018 |    .143068   .0468833     3.05   0.005     .0473195    .2388165
        2019 |    .159387   .0765597     2.08   0.046     .0030312    .3157429
        2020 |   .1629789   .0874657     1.86   0.072    -.0156499    .3416077
        2021 |   .2056344   .0952723     2.16   0.039     .0110625    .4002063
        2022 |   .3401739   .1085912     3.13   0.004     .1184011    .5619468
        2023 |   .2975178   .1178786     2.52   0.017     .0567777     .538258
        2024 |   .3127432   .1162886     2.69   0.012     .0752503    .5502362
             |
       _cons |   3.877426   .7135761     5.43   0.000     2.420109    5.334743
-------------+----------------------------------------------------------------
     sigma_u |  .52739262
     sigma_e |  .19201941
         rho |  .88295313   (fraction of variance due to u_i)
------------------------------------------------------------------------------

.
```

Appendix VI

```
. xtreg SCRratio Soc size ROA yearsrates GDP CPI i.Year, fe vce(cluster firm_id)

Fixed-effects (within) regression               Number of obs      =       269
Group variable: firm_id                         Number of groups   =        31

R-squared:                                      Obs per group:
     Within  = 0.2432                                         min =         2
     Between = 0.1550                                         avg =       8.7
     Overall = 0.0451                                         max =         9

                                                F(14, 30)          =      7.45
corr(u_i, Xb) = -0.8504                         Prob > F           =    0.0000

                                  (Std. err. adjusted for 31 clusters in firm_id)
```

SCRratio	Coefficient	Robust std. err.	t	P>|t|	[95% conf.	interval]
Soc	-.0006798	.0019119	-0.36	0.725	-.0045844	.0032248
size	-.1771261	.0634547	-2.79	0.009	-.306718	-.0475342
ROA	1.092921	1.163308	0.94	0.355	-1.282871	3.468713
yearsrates	.0028704	.0407704	0.07	0.944	-.0803938	.0861347
GDP	.0062342	.0073313	0.85	0.402	-.0087383	.0212067
CPI	-.0111751	.0101	-1.11	0.277	-.0318019	.0094518
Year						
2017	.1071262	.0363218	2.95	0.006	.0329471	.1813053
2018	.143172	.047386	3.02	0.005	.0463969	.239947
2019	.1557442	.0739214	2.11	0.044	.0047767	.3067118
2020	.1561179	.0879156	1.78	0.086	-.0234298	.3356655
2021	.2105443	.1015636	2.07	0.047	.0031238	.4179648
2022	.343956	.1137421	3.02	0.005	.1116637	.5762483
2023	.3024474	.1226872	2.47	0.020	.0518867	.553008
2024	.3228878	.1247712	2.59	0.015	.0680711	.5777046
_cons	3.913746	.7702655	5.08	0.000	2.340654	5.486838
sigma_u	.52896715					
sigma_e	.19212792					
rho	.8834516	(fraction of variance due to u_i)				

Appendix VII

```
. xtreg SCRratio Gov size ROA yearsrates GDP CPI i.Year, fe vce(cluster firm_id)

Fixed-effects (within) regression               Number of obs      =       269
Group variable: firm_id                         Number of groups   =        31

R-squared:                                      Obs per group:
     Within  = 0.2426                                         min =         2
     Between = 0.1544                                         avg =       8.7
     Overall = 0.0436                                         max =         9

                                                F(14, 30)          =      6.29
corr(u_i, Xb) = -0.8436                         Prob > F           =    0.0000

                                 (Std. err. adjusted for 31 clusters in firm_id)
------------------------------------------------------------------------------
             |               Robust
   SCRratio |      Coef.   Std. err.      t    P>|t|     [95% conf. interval]
-------------+----------------------------------------------------------------
         Gov |    .000145   .0014606     0.10   0.922    -.0028379     .003128
        size |   -.176693   .0621867    -2.84   0.008    -.3036953    -.0496907
         ROA |    1.08437   1.042369     1.04   0.307    -1.044431     3.21317
  yearsrates |   .0027033   .0430578     0.06   0.950    -.0852324      .090639
         GDP |   .0061126   .0076249     0.80   0.429    -.0094596     .0216848
         CPI |  -.0115122   .0102763    -1.12   0.271    -.0324992     .0094748
             |
        Year |
        2017 |    .106619   .0370058     2.88   0.007     .031043     .1821949
        2018 |   .1408326   .0461359     3.05   0.005     .0466106    .2350545
        2019 |    .152641   .0732861     2.08   0.046     .0029708    .3023112
        2020 |   .1500202   .0985859     1.52   0.139     -.051319    .3513594
        2021 |   .2043279   .1003979     2.04   0.051    -.0007119    .4093677
        2022 |   .3396859   .1135894     2.99   0.006     .1077055    .5716663
        2023 |   .2975124   .1182382     2.52   0.017     .0560378     .538987
        2024 |   .3163658   .1198874     2.64   0.013      .071523    .5612086
             |
       _cons |   3.860237   .6757794     5.71   0.000     2.480111    5.240362
-------------+----------------------------------------------------------------
     sigma_u |  .51905465
     sigma_e |  .19220111
         rho |  .87941837   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Appendix VIII

```
. xtreg solvency_volatility ESGScore size ROA yearsrates GDP CPI i.Year, fe vce(cluste
> r firm_id)

Fixed-effects (within) regression               Number of obs     =        210
Group variable: firm_id                         Number of groups  =         31

R-squared:                                      Obs per group:
     Within  = 0.0530                                         min =          2
     Between = 0.0010                                         avg =        6.8
     Overall = 0.0271                                         max =          7

                                                F(12, 30)         =       2.02
corr(u_i, Xb) = -0.0728                         Prob > F          =     0.0588

                                (Std. err. adjusted for 31 clusters in firm_id)
```

solvency_v~y	Coefficient	Robust std. err.	t	P>|t|	[95% conf.	interval]
ESGScore	-.0004796	.0011647	-0.41	0.683	-.0028583	.0018991
size	-.0003096	.0603694	-0.01	0.996	-.1236003	.1229811
ROA	-.1919258	.4007701	-0.48	0.635	-1.010408	.6265561
yearsrates	-.0020784	.0175898	-0.12	0.907	-.0380015	.0338448
GDP	.0036749	.0035792	1.03	0.313	-.0036348	.0109847
CPI	-.0109003	.0076084	-1.43	0.162	-.0264388	.0046381
Year						
2019	-.0126914	.0163119	-0.78	0.443	-.0460047	.0206218
2020	.0038623	.0341122	0.11	0.911	-.065804	.0735287
2021	-.0285691	.0309628	-0.92	0.364	-.0918036	.0346654
2022	.0733376	.0569638	1.29	0.208	-.0429981	.1896732
2023	.0451303	.0494644	0.91	0.369	-.0558894	.14615
2024	-.0100999	.0463968	-0.22	0.829	-.1048549	.0846551
_cons	.188413	.659085	0.29	0.777	-1.157618	1.534444
sigma_u	.06528125					
sigma_e	.08244024					
rho	.38538872	(fraction of variance due to u_i)				

Appendix IX

```
. xtreg SCRratio ESGScore Stress ESG_Stress size ROA yearsrates GDP CPI i.Year, fe vce
> (cluster firm_id)
note: 2022.Year omitted because of collinearity.

Fixed-effects (within) regression               Number of obs      =       269
Group variable: firm_id                         Number of groups   =        31

R-squared:                                      Obs per group:
     Within  = 0.2436                                         min =         2
     Between = 0.1546                                         avg =       8.7
     Overall = 0.0442                                         max =         9

                                                F(15, 30)          =      7.94
corr(u_i, Xb) = -0.8470                         Prob > F           =    0.0000

                                (Std. err. adjusted for 31 clusters in firm_id)
```

SCRratio	Coefficient	Robust std. err.	t	P>|t|	[95% conf.	interval]
ESGScore	-.0004842	.0020261	-0.24	0.813	-.0046221	.0036537
Stress	.2854378	.1642661	1.74	0.093	-.0500383	.6209139
ESG_Stress	.0009318	.0018201	0.51	0.612	-.0027853	.0046489
size	-.1772277	.0645158	-2.75	0.010	-.3089866	-.0454687
ROA	1.067738	1.16402	0.92	0.366	-1.309508	3.444983
yearsrates	.0039152	.0413899	0.09	0.925	-.0806143	.0884447
GDP	.0059358	.0074162	0.80	0.430	-.0092101	.0210816
CPI	-.0120558	.0102156	-1.18	0.247	-.0329189	.0088072
Year						
2017	.109071	.0389666	2.80	0.009	.0294906	.1886513
2018	.1454009	.0512577	2.84	0.008	.0407188	.2500831
2019	.1584107	.0799343	1.98	0.057	-.004837	.3216583
2020	-.1916304	.1460826	-1.31	0.200	-.4899709	.1067101
2021	.2157463	.1091763	1.98	0.057	-.0072214	.438714
2022	0	(omitted)				
2023	.3054842	.1240306	2.46	0.020	.0521798	.5587885
2024	.3231455	.1273715	2.54	0.017	.0630181	.5832728
_cons	3.902251	.7545432	5.17	0.000	2.361268	5.443234
sigma_u	.52405701					
sigma_e	.19250768					
rho	.88110424	(fraction of variance due to u_i)				

Appendix X

	Author/s	Objective	Type of paper	Country	Sample	Methodology	Main results
1	Albuquerque, Koskinen, Yang & Zhang (2020)	To test theories of environmental and social policies by exploiting the exogenous COVID-19 market crash as a shock to identify the causal link from ESG to financial performance.	Empirical	USA	US-listed stocks during	Regression analysis, event study	Stocks with higher ES ratings had significantly higher returns, lower return volatility, and higher operating profit margins during the Q1-2020 crash. ES firms with higher advertising expenditure earned higher returns, and stocks held by more ES-oriented investors had lower volatility, highlighting the role of customer and investor loyalty in the resilience of ES stocks.
2	Alokla, Tzouvanas & Albitar (2025)	To investigate the impact of climate change risks on the credit (default) risk of insurance firms using cross-country evidence.	Empirical	Global	150 insurance firms across 31 countries	regression on Z-score, F-score, and Altman's Z-score	There is a significant negative relationship between climate change risks and insurers' credit risk Z-scores), implying that higher climate risks increase the likelihood of insurer default. The findings underscore the urgency of proactive climate-risk management, enhanced risk-assessment methodologies, and adaptation strategies in the insurance sector.
3	Barney (1991)	To develop the resource-based view (RBV) of the firm, explaining how firm resources generate sustained competitive advantage.	Conceptual	Global	—	Conceptual framework development	Sustained competitive advantage derives from firm resources that are valuable, rare, imperfectly imitable, and non-substitutable (the VRIN attributes). The framework links internal resource heterogeneity and immobility to lasting performance differences, providing a foundational theory for strategic management and later ESG/sustainability-as-resource arguments.
4	Berg, Fabisik & Sautner (2020)	To examine how ESG ratings change over time, documenting that rating providers retroactively revise historical ESG scores and assessing the consequences for research and investing.	Empirical	Global	Refinitiv ESG rating data across multiple rewrites	Empirical analysis of ESG rating revisions across data vintages	Historical ESG ratings are subject to widespread retroactive revisions, so the "past" of ESG scores is unstable and unpredictable. These rewrites alter the relationship between ESG and outcomes such as stock returns, raising concerns about the reliability and replicability of ESG-based research and investment strategies.
5	Berg, Kölbel &	To investigate the divergence of ESG ratings across major rating	Empirical	Global	ESG ratings from KLD,	Mapping of methodologies and decomposition of	ESG ratings diverge substantially (correlations of 0.38–0.71). Divergence stems mainly from measurement (56%), then scope

	Rigobon (2022)	agencies and to decompose the sources of that divergence.			Sustainalytics, Moody's ESG, S&P Global, Refinitiv, MSCI	divergence	(38%) and weight (6%). A "rater effect" is detected, where a rater's overall view of a firm influences its category-level measurements, calling for greater scrutiny of how ESG data are generated.
6	Bouattour, Kalai & Helali (2024)	To analyse the non-linear effect of ESG performance on banking stability in the digital era for European banks.	Empirical	EU	European banks operating in 15 European countries	Panel Smooth Transition	The relationship between ESG performance and bank stability is non-linear, with three ESG regimes. Higher ESG scores are associated with a lower risk of bank failure (stakeholder theory), while banks with weak ESG scores fail to avoid the fragility caused by technological-infrastructure investments. Banks should adopt a digital strategy grounded in improving sustainability.
7	Brasch & Eckert (2025)	To empirically investigate the development of the ESG score and its pillar scores, and data availability, by region, firm size, and business sector within the insurance industry.	Empirical	Global	LSEG (Refinitiv) data on insurers (2010–2022)	Descriptive statistics and correlation analysis	Region, firm size, and insurers' core business lead to different developments in ESG scores and data availability, with no clear evolution pattern. The study finds significant, strong interrelationships within the ESG score and its data availability, providing a foundation for better interpreting and applying ESG metrics in insurance.
8	Bressan (2023)	To analyse how ESG scores affect the financial conditions, stability, and market valuation of Property & Casualty insurance companies.	Empirical	Global	Global P&C insurers	Panel regression analysis	More sustainable insurers show higher operating leverage yet appear financially stable (lower combined ratios, higher z-scores), while market-to-book ratios decrease in ESG scores. In the US subsample, stocks of sustainable insurers earn highly positive excess returns, indicating a strong link between sustainability practices and insurers' ability to do business and create value.
9	Brogi, Cappiello,	To identify the determinants of insurance companies' ESG	Empirical	USA	107 listed US insurance	Fractional regression model linking ESG scores to size,	Larger, more profitable, and more solvent insurance companies show the highest level of ESG awareness. The model sheds light

	Lagasio & Santoboni (2022)	awareness by exploring the interaction between financial ratios and ESG scores.			companies	profitability, and solvency	on how ESG practices unfold in the insurance industry and on which financial characteristics most drive specific ESG policies.
10	Chaiyawat & Guayjarernpanishk (2025)	To develop an integrated risk-modelling framework assessing capital adequacy and optimizing portfolio performance for life and non-life insurers, and to evaluate the role of green bonds.	Empirical	Thailand	Daily data 2014–2024 for Thai life and non-life insurer portfolios	ARMA–GJR–GARCH with skewed Student-t innovations, extreme value theory, and dynamic R-vine copulas; VaR and Sharpe-ratio analysis	Green bonds significantly improve risk-adjusted returns and can reduce capital requirements, particularly for life insurers with long-term sustainability mandates. The findings support integrating ESG considerations into supervisory investment guidelines to enhance insurers' financial resilience.
11	Chiaramonte, Dreassi, Paltrinieri & Piserà (2020)	To provide the first empirical evidence of the relationship between ESG and stability in the insurance sector.	Empirical	USA	94 American listed insurers	Regression analysis with robustness checks	ESG scores enhance insurers' stability, and the relationship is driven by the environmental and especially social dimensions, while governance plays an insignificant role. The association is stronger for life insurers, suggesting their long-term business model fosters CSR benefits.
12	Citterio & King (2023)	To analyse the predictive power of ESG indicators for forecasting bank financial distress.	Empirical	USA & EU	362 commercial banks	Default-prediction models, machine-learning, and ensemble approaches	Adding ESG indicators improves the model's ability to correctly identify distress and strongly reduces the likelihood of misclassifying distressed/defaulted banks as healthy. The findings support incorporating ESG factors—alongside traditional predictors—into bank default-prediction toolkits used by supervisors.
13	Curcio, Gianfrancesco, Onorato & Vioto (2024)	To investigate whether and how the systemic risk of European banks and insurers is sensitive to the ESG performance of non-financial companies.	Empirical	EU	European banks and insurers	Market-based approach	Better ESG performance of non-financial companies reduces the systemic risk of banks and insurers more than brown/market peers, while higher riskiness raises it. Banks are systemically more vulnerable to green firms' riskiness; insurers are more exposed to the oil & gas industry. The E, S, and G channels affect systemic risk differently.
14	Engelhard	To investigate the association	Empirical	EU	1,452 firms	Multivariate regression /	High-ESG European firms are associated with higher abnormal

	t, Ekkenga & Posch (2021)	between ESG ratings and stock performance during the COVID-19 crisis, and how it varies with country-level trust and regulation.			from 16 European countries (Refinitiv ESG ratings)	event-study over the COVID-19 “collapse period”	returns and lower stock volatility during the crisis, with the social score the predominant driver. ESG is value-enhancing in low-trust countries and in countries with poorer security regulation and lower disclosure standards.
15	Flannery & Rangan (2006)	To distinguish among competing capital-structure theories by testing whether firms have long-run leverage targets and how quickly they adjust toward them.	Empirical	USA	Large panel of US listed firms	panel estimation	Firms do have target capital structures, and the typical firm closes about one-third of the gap between its actual and target debt ratios each year, supporting a (modified) trade-off view over pure pecking-order or market-timing explanations.
16	Freeman (2010)	To set out the central insight of stakeholder theory—the "jointness" of stakeholder interests—and argue against managing by trading off one stakeholder group against another.	Conceptual	Global	—	Theoretical synthesis	Argues that business is a set of interconnected stakeholder relationships in which no stakeholder stands alone in value creation. Rather than trading off stakeholder interests, managers should find the "sweet spot" of jointly satisfying customers, suppliers, employees, financiers, and communities, providing a foundational framework widely applied in ESG/CSR research.
17	Galletta, Mazzù & Naciti (2022)	To map the intellectual development, author characteristics, and research trends of ESG performance in the banking industry.	Conceptual	Global	271 publications	Bibliometric and cluster analysis	The analysis traces the evolution of ESG-in-banking research, identifying top authors, institutions, highly cited works, co-authorship networks, and influential journals, and outlines emerging research lines for deeper study, providing a structured map of the field’s current status and future directions.
18	Giráldez-Puig, Moreno, Perez-Calero &	To investigate the relationship between ESG controversies and insolvency risk in the insurance sector, and the moderating effect of ESG practices.	Empirical	Global	120 stock insurance firms	System-GMM estimations	ESG controversies positively influence insurers’ insolvency risk, while ESG practices mitigate these effects. The Governance (G) component plays the key role in counteracting the impact of ESG controversies on insolvency risk.

	Guerrero Villegas (2025)						
19	Grochola & Schlütter (2025)	To examine how insurers use discretionary scope in calculating Solvency II capital requirements (risk model choice, long-term guarantees measures) and how these choices affect reported solvency ratios.	Empirical	EU/ EEA	49 stock insurers	Risk-profile analysis and empirical regression	Long-term guarantees measures substantially raise reported solvency ratios and are chosen mainly by less solvent insurers and those with high interest-rate and sovereign-credit-risk sensitivity. Internal models are used more often by large insurers, especially for market risks for which they already hold adequate immunization strategies.
20	Hanika (2025)	To analyse how public risk disclosure under Solvency II affects life insurers' risk-taking behaviour.	Empirical	Germany	58 German life insurer	Panel empirical analysis combined with a shareholder-value-maximization model	Publicly reported solvency ratios affect premium growth and surrender rates, and insurers tend to improve ratios after a decline. To maintain higher ratios and mitigate adverse policyholder reactions, insurers act less riskily (hold more reserves, sell less-risky portfolios). Public risk disclosure can strengthen market discipline, but its level and design must be carefully calibrated.
21	Hart (1995)	To develop a natural-resource-based view of the firm—a theory of competitive advantage grounded in the firm's relationship to the natural environment.	Conceptual	Global (conceptual)	—	conceptual framework development with propositions	Proposes that competitive advantage can be rooted in three interconnected environmental strategies—pollution prevention, product stewardship, and sustainable development—each with distinct resource requirements. The natural environment, long ignored by management theory, becomes a key source of sustained competitive advantage.
22	Hipólito, Borges, Tavares, Vale, Azevedo &	To assess the determinants of European insurance companies' ESG performance and the connections between these determinants and each of the three ESG pillars.	Empirical	EU	30 largest European insurers	European panel data analysis	Older, larger, more profitable, and less leveraged insurers—with smaller but more gender-diverse boards, a sustainability committee, and a standalone sustainability report—tend to show higher ESG performance. Higher-ESG insurers are also located in countries with higher GDP growth, extending Brogi et al. (2022) from the US to the European setting.

	Oliveira (2025)						
23	Karaman, Mahmood, Uyar & Kuzey (2025)	To test the association between country-level environmental degradation and firm-level ESG performance, and whether ESG engagement contributes to financial stability in the energy sector.	Empirical	Global	4,537 firm-year observations	2SLS regression	Environmental degradation (ecological footprint) is negatively associated with energy firms' ESG and environmental performance, supporting institutional theory. An inverted U-shaped relationship is found between ESG performance and financial stability, implying limits to the stabilizing benefits of ESG and offering implications for environmental regulation.
24	Kouwenberg (2017)	To derive the optimal strategic asset allocation and risk budgeting for European insurers under the Solvency II market-risk framework.	Empirical	EU	A representative European life insurance company	Analytical derivation of marginal contribution to the SCR and optimal asset allocation under the SII standard formula	Derives expressions for an investment's marginal contribution to the Solvency Capital Requirement and the optimal asset allocation that maximizes expected return on own funds subject to the SCR market-risk limit. The framework clarifies the return–marginal-risk trade-off and shows how risk budgeting can be applied under Solvency II.
25	Lee & Koh (2024)	To examine the association between ESG performance and firm risk in US financial firms.	Empirical	USA	453 US publicly traded financial firms; 2014–2020	Panel regression	Higher composite ESG performance is significantly negatively associated with total, idiosyncratic, and systematic risk. The S and G pillars relate negatively to both systematic and idiosyncratic risk, while E is associated only with systematic risk. ESG also weakens the extent to which leverage contributes to firm risk, evidencing risk-management benefits of ESG.
26	Lins, Servaes & Tamayo (2017)	To examine whether social capital and trust, built through CSR, affect firm performance during the 2008–2009 financial crisis.	Empirical	USA	US listed firms during the 2008–2009 financial crisis	Regression analysis	During the crisis, high-CSR (high social capital) firms earned stock returns four to seven percentage points higher than low-CSR firms, and showed higher profitability, growth, and sales per employee while raising more debt. Trust between a firm and its stakeholders/investors pays off when overall trust in markets suffers a negative shock.
27	Meral,	To examine the influence of ESG	Empirical	Global	22 life and 59	Panel data analysis o	Higher ESG scores are significantly associated with higher return

	Ersoy & Dogan (2026)	factors on the performance of global insurance companies.			non-life insurance firms		on assets, more efficient management of expense and loss ratios, and increased investment returns. The findings underline the importance of incorporating ESG factors into insurance decision-making to enhance sectoral resilience and corporate performance.
28	Miani, Mantovani & Palmieri (2026)	To examine whether ESG performance is associated with lower default risk in European insurers, and whether this differs between life and non-life business models.	Empirical	EU	Unbalanced panel of 152 insurers from 22 European countries;	Panel quantile regressions	Higher ESG performance is associated with lower short- and long-term default probabilities, with larger, more robust effects for non-life insurers and firms in the upper quantiles of default risk. For life insurers the association is weaker, with capital strength and asset-liability management as primary drivers and ESG operating as a complementary factor.
29	Monti, Pattitoni, Petracci & Randl (2022)	To investigate the relationship between corporate social responsibility (CSR) and equity risk using a large international sample.	Empirical	Global	Listed firms from 52 countries;	Panel regression analysis	Higher CSR scores are related to lower total, systematic, and idiosyncratic risk. The risk-reducing effect is more pronounced in weaker institutional environments—civil-law countries and those with low security regulation or disclosure—and in high-impact/high-profile industries and non-cross-listed firms. The effect strengthened during the financial crisis and held in the COVID-19 period.
30	Moreno, Parrado-Martínez & Trujillo-Ponce (2022)	To compare six Z-score approaches and determine which best measures the financial soundness of insurance firms.	Empirical	Spain	183 Spanish insurance firms	OLS regression, and system-GMM dynamic panel estimator	The best Z-score formula combines current ROA and capitalization with the standard deviation of returns over the full sample period. The Z-score can serve as a simple, effective early-warning indicator for microprudential supervision, complementing the more complex Solvency II regime.
31	Müller & Reuse (2023)	To examine the equivalence between the UK's post-Brexit regime ("Solvency UK") and EU Solvency II, and the potential	Conceptual	UK / EU	Academic sources plus government, regulator,	Literature review	The two UK reforms make Solvency UK diverge from Solvency II in parts, which could harm a future equivalence decision. The paper builds a forward-looking equivalence-mapping framework that closes the research gap and reduces uncertainty in the

		impact of the UK Solvency II Review and the Financial Services and Markets Bill.			and consultancy publications		insurance industry.
32	Otero González, Durán Santomil & Hoyt (2023)	To analyse whether the degree of Enterprise Risk Management (ERM) implementation affects insurers' performance under the Solvency II framework.	Empirical	Spain	44 insurance entities; composite ERM index of 76 variables	Composite ERM index construction and regression analysis	Higher degree and quality of ERM implementation is associated with better ROE and ROA. Risk governance makes performance higher and more stable; results also suggest Solvency II models penalize small companies, though management improvements can offset implementation costs.
33	Poufinas & Siopi (2024)	To examine how investment portfolio structure affects insurers' solvency, measured by the Solvency Capital Requirement ratio.	Empirical	EU	88 EU-based insurance groups	Linear regression	Firm-specific factors (unit-/index-linked liabilities, firm size, property/collective-undertaking/bond/equity investments, government-to-corporate bond ratio) and country-specific factors (life/non-life market concentration, bond-market development, banking concentration, non-performing loans) significantly affect solvency ratios. Machine learning outperforms linear regression.
34	Schwartze & Dobler (2026)	To provide initial evidence, grounded in socio-political theory, on the determinants of insurers' narrative risk disclosure in SFCRs.	Empirical	Germany	1,510 solo SFCRs by 302 German listed and non-listed insurers	Content analysis and regression	Risk-disclosure volume is positively associated with insurer size and life-insurer status, and negatively associated with the solvency ratio and public-law legal form. Socio-political theories explain the variation, indicating that public (social and political) pressure drives narrative risk disclosure to the broad public.
35	Seretis, Aleksanyan & Tsalavoutas (2026)	To investigate whether and how mandatory Solvency II implementation changed analyst forecast properties.	Empirical	EU/EEA	EEA insurers	Quantitative empirical analysis of forecast error and dispersion	Disclosure of general solvency information, risk profile, and voluntary economic-solvency narrative information reduces analyst forecast errors and dispersion; solvency coverage and embedded value have similar effects. However, disclosure of valuation-for-solvency and capital-management information worsens forecast properties.
36	Sheehan,	To propose a "Solvency II	Empirical	EU	2	Scenario simulation	The swap reduces the SCR by about 6% and raises the SCR

	Humberg, Shannon, Fortmann & Materne (2023)	portfolio swap" as a new diversification solution helping small, specialised non-life insurers mitigate their diversification disadvantage.			hypothetical insurance companies		coverage ratio by up to 17%. It offers small and specialised insurers an alternative risk-transfer and diversification method beyond M&A, potentially improving competition in the EU insurance market.
37	Siopi, Poufinas, Chen & Agiropoulos (2023)	To predict the solvency of insurers within a set of European insurers.	Empirical	EU	29 EU insurance groups;	Regularized linear regression and machine learning	Reinvestment rate, cash and equivalents, long-term investment, and losses-benefits-and-adjustments expenses have the greatest predictive impact on insurer solvency. The paper identifies key determinants that help insurers maintain strong SCR ratios.
38	Sood & Özen (2024)	To identify the benefits of ESG in the insurance sector for achieving sustainability through a systematic review of the literature.	Conceptual	Global	literatures on ESG in insurance	Systematic literature review	Integrating ESG and sustainable insurance represents a potential new revenue stream for the sector. ESG factors affect all insurer operations—most notably investment activity, risk management, product management, and the valuation of assets and liabilities—yet very few PRISMA/SLR studies exist, highlighting a clear research gap.
39	van der Heide (2023)	To examine the role of regulatory change (Solvency II implementation) in the financialization of insurance and how insurers re-articulate past practices in the language of financial risk management.	Empirical	EU	Documents and 44 oral interviews	Qualitative document analysis and interviews	Solvency II requires insurers to justify their actions using concepts from modern finance theory, shifting solvency evaluation toward a financialized logic. To avoid the immediate failure of traditional business models, insurers had to re-articulate past practices in the language of financial risk management.