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Micro–stabilizers in a macro–storm: A panel GARCH analysis of ESG performance against volatility persistence

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ABSTRACT

This study examines whether Environmental, Social, and Governance (ESG) performance mitigates stock return volatility during periods of severe monetary stress. Using a balanced panel of CAC 40 firms over 2010-2023 and applying a robust two-step Panel GARCH model to daily returns matched with annual ESG scores, we assess whether non-financial performance reliably hedges against systemic monetary erosion. Results indicate that, although ESG acts as an effective diversifier against firm-specific risk, it offers only limited immunity against the systemic risk associated with monetary tightening. While a negative association exists between strong ESG performance and stock return volatility ($\beta = -0.0340$, $p < 0.01$), this stabilizing effect is significantly attenuated under high-inflation regimes, where the inflation coefficient ($\beta = 2.3041$) heavily dominates ESG's risk-mitigating capacity. Our findings quantify a distinct risk hierarchy, providing novel evidence that the micro-stabilizing effects of ESG are asymmetric and fundamentally subordinate to macroeconomic monetary tightening. For corporate executives, strong ESG performance acts as a vital micro-stabilizer; however, portfolio managers must recognize that ESG integration cannot serve as an Independent hedge during monetary tightening.

Keywords: ESG; Volatility Persistence ; Panel GARCH ; Risk Hierarchy ; Inflation ; CAC 40

JEL Classification: G11, G12 , G32 , M14

1. INTRODUCTION

The integration of Environmental, Social, and Governance (ESG) criteria into financial decision-making has evolved from an ethical concern to a central component of modern asset pricing. However, the relationship between ESG performance and financial risk is still being debated, with different theories about the cost of capital and shareholder value.

Some authors argue that ESG initiatives represent an excessive investment of shareholder capital, driven by managerial preferences [1,2]. According to this view, ESG activities reallocate capital to enhance reputation while increasing volatility through higher operating costs without immediate financial returns. Conversely, Godfrey [3] notes that stakeholder theory posits that strong ESG performance builds moral capital. This capital preserves firm value during negative events and minimises information asymmetry between corporate insiders and outsiders. Consequently, firms with high ESG ratings should demonstrate lower stock return volatility, driven by increased investor loyalty and reduced regulatory and litigation risks [4].

While the normative case for ESG integration is well-established, the precise transmission mechanism remains an unresolved empirical question. Here, we investigate whether the observed

low-volatility characteristic of ESG firms is a fundamental attribute of their cash flows or investor sentiment. To contextualize this tension, empirical studies focus on the stabilising role of ESG during market stress. Recent evidence by Hoepner et al. [5] suggests that ESG engagement significantly mitigates downside risk, effectively providing shareholders with a protective put option. Similarly, Broadstock et al. [6] and Engle et al. [7] have shown that during systemic crises such as the COVID-19 pandemic, ESG engagement can mitigate downside risk.

Despite extensive literature, the interaction between ESG factors and volatility remains ambiguous in models that fail to capture time-varying risk. This study addresses the following research question: *To what extent does ESG performance impact the conditional volatility of stock returns when controlling for macroeconomic variables?*

By clearly defining conditional volatility as the primary dependent variable and using a GARCH framework, this research enhances the understanding of how non-financial performance influences financial risk. Our findings provide empirical evidence that high ESG performance significantly mitigates idiosyncratic volatility during normal market conditions. Even so, this premium is virtually neutralised by systemic inflationary shocks.

This study contributes to the literature in three ways. First, we quantify a distinct risk hierarchy, demonstrating that ESG's micro-stabilizing effects are asymmetric and subordinate to macroeconomic monetary tightening. Second, we employ a robust Panel GARCH methodology that captures time-varying volatility dynamics often overlooked in static models. Third, using the French CAC 40 market—with its mature ESG reporting framework—we provide evidence on how regulatory context shapes ESG effectiveness. Our findings have implications for portfolio construction during inflationary regimes and for regulatory standard-setting in ESG disclosure.

The remainder of this paper is organized as follows: Section 2 reviews the theoretical framework and existing literature. Section 3 details the data and Panel GARCH methodology. Section 4 presents the empirical results and discussion. Section 5 concludes with policy implications.

2. THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

2.1 The ESG-Volatility Nexus and Financial Performance

Consistent with the findings of Broadstock et al. [6] and Sabbaghi [8], the interaction between ESG and volatility is significantly moderated by firm fundamentals, specifically firm size and profitability. These works emphasize the size effect as a critical determinant of this relationship, where larger firms utilize diversified returns against market shocks. Specifically, Rao et al. [9] identify a complex correlation with earnings performance (measured via EPS), where high-growth expectations can paradoxically lead to high sensitivity to market news. Moreover, some studies document that without standardized metrics, the statistical significance of ESG effects can fluctuate [10]. This necessitates the use of dynamic approaches, such as the GARCH framework employed in this study, to isolate the true ESG effect from these fundamental firm variables.

We distinguish between ESG quality and actual ESG performance. While extensive reporting can signal transparency, this study utilizes ESG performance scores obtained from the DataStream database. These scores are designed to evaluate a firm's tangible achievements and risks across E, S, and G pillars, thus capturing an accurate representation of a company's real-world sustainable practices rather than merely its communication strategy.

This paper posits that ESG reduces volatility through the trust channel, defined by Lins et al. [4], where high social capital limits the downside severity of negative firm-specific news. Our specification relies on the theoretical tension between agency theory and signaling theory. Conversely, it models firm size not just as a resource buffer but through Merton's [11] investor recognition hypothesis, where larger firms benefit from deeper liquidity pools that absorb sell-side pressure. For profitability (EPS), this research considers its role under the Duration Risk Hypothesis, where the value of high-growth firms is more sensitive to changes in the discount rate (cost of capital). Finally, we treat inflation as a non-diversifiable friction following Elfaki and Ahmed [12], where monetary erosion acts as a uniform shock [13].

Furthermore, sustainable management and ESG engagement are increasingly recognized as strategic drivers that mitigate operational and non-financial risks, fostering long-term value creation and stakeholder trust [14,15]. Given current systemic uncertainty, Sassen et al. [16] document that ESG performance has emerged as a critical determinant of firm-level resilience. The risk mitigation hypothesis posits that strong ESG practices provide a form of protection, effectively reducing risk and idiosyncratic volatility during crisis periods [3]. This is consistent with Nirino et al. [17], who argue that robust ESG practices act as a moderating mechanism against operational shocks and controversies, preserving market value and reducing uncertainty.

This protective capacity is further substantiated by authors such as Lins et al. [4], who demonstrate that high social capital manifests as investor trust, allowing firms to weather financial crises with superior stock returns compared to their low-ESG counterparts. The mechanism by which ESG stabilizes returns is multidimensional, primarily operating through the reduction of information asymmetry and the enhancement of transparency. Mishra and Modi [18] demonstrate that ESG performance mitigates downside risk by signaling superior management quality [19]. This aligns with El Ghoul et al. [20], who establish that firms with strong ESG benefit from a lower cost of equity capital, as the reduced perceived tail risk leads investors to accept lower returns for holding these assets. Furthermore, Fatemi et al. [2] provide a theoretical foundation. Value is created when high ESG performance is paired with transparent disclosure that mitigates information ambiguity. Foster et al. [21] reinforce this indicating that transparent reporting mitigates the noise trading that often fuels volatility [22].

Beyond transparency, Koskinen et al. [23] note that ESG functions as a product differentiation strategy. Albuquerque et al. [24] suggest that sustainable firms face a lower price elasticity of demand, implying a diminution of systematic risk. Giese et al. [25] expand on this by identifying specific transmission channels, including the idiosyncratic risk channel and the valuation channel, through which ESG characteristics lower the probability of severe operational incidents and regulatory fines, thereby stabilizing expected cash flows. While Aydogmus et al. [26] highlight that this creates a loyal capital base that stabilizes prices, the correlation is not universally linear. Marzouki et al. [27] note that in highly efficient markets, ESG premiums may already be priced in, leading to no significant performance differential. This divergence is particularly pronounced when contrasting developed and emerging economies. In contrast to emerging contexts like Casablanca [28], the mature CAC 40 market provides an appropriate setting where the cost of ESG conformity may outweigh the risk-reduction benefits.

Thus, we propose the following hypotheses:

H_1: Superior corporate ESG performance significantly reduces the conditional stock return volatility of listed firms, acting as a micro-level buffer against market uncertainty.

H_2: The negative ESG-volatility relationship is attenuated during periods of high inflation (monetary tightening).

2.2 Control Variables and Their Theoretical Foundations

2.2.1 Firm Size

Broadstock et al. [6] argue that organizational slack and diversified revenue streams allow larger firms to buffer systemic shocks. Furthermore, they highlight that these firms rely on established protocols. Moreover, established firms leverage formal governance protocols to navigate operational shocks [29]. Therefore, we expect:

H_3: Firm size negatively moderates the relationship between macroeconomic shocks and firm-level volatility.

2.2.2 Inflation

Inflation is included as the primary systemic stressor, consistent with Fama and Schwert [13] and recent evidence from Elfaki and Ahmed [12]. It represents the macro erosion of asset values and acts as a uniform friction on market returns. As widely cited in foundational literature, periods of relative tranquility are frequently punctuated by turbulent regimes, a phenomenon characterized by volatility clustering and long-memory processes. Within this framework, market shocks exhibit significant persistence; conditional variance fails to revert instantaneously to its long-run mean, causing uncertainty to persist well beyond the initial event [21,30].

Moreover, Engle [31] noted that volatility in financial and macroeconomic time series, specifically regarding growth and inflation, is rarely random. Instead, financial volatility exhibits both clustering and long-memory effects. Due to this structural persistence, standard constant-variance models inherently fail to capture these nonlinear dynamics. Consequently, Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models and their asymmetric variants (such as EGARCH) have become the gold standard for modeling this persistence. Beyond these internal dynamics, recent empirical evidence suggests that external macroeconomic factors are equally critical in driving volatility. Particularly in dynamic markets, inflationary pressures act as a primary driver of market instability. Periods of high inflation, often driven by external supply shocks or policy shifts, exacerbate market uncertainty, eroding the real purchasing power of assets and complicating monetary policymaking [32]. This environment creates a volatile regime where the conditional variance of returns spikes in direct response to systemic distress.

2.2.3 Market-to-Book Ratio (MTB)

The Market-to-Book ratio serves as our proxy for the value-versus-growth tension. While Fama and French [33] established that growth stocks (high M/B) are inherently less sensitive to market corrections than their value counterparts, the MTB-volatility relationship is negative. This is rooted in the definition of stock types: low MTB firms are defined as Value Stocks. These authors posit that these firms are inherently riskier due to their greater exposure to systematic risks, leading to higher average returns and a corresponding risk premium. High MTB firms are defined as Growth Stocks, which are generally associated with lower systematic risk. As the MTB ratio increases—transitioning a firm from value to growth—systematic risk decreases. This generates a negative theoretical correlation between the MTB ratio and stock volatility.

While traditional market valuations capture growth versus value dynamics through financial ratios like the Market-to-Book ratio, modern corporate valuation increasingly requires looking beyond balance-sheet metrics to incorporate non-financial disclosures. However, seminal literature has laid the groundwork for sustainability reporting, a noticeable gap persists regarding how individual pillars of ESG differentially affect corporate financial outcomes. To resolve these inconsistencies, we integrate stakeholder theory with agency considerations to provide a robust theoretical underpinning for our expectations.

2.2.4 Earnings per Share (EPS)

Regarding Earnings Per Share (EPS), we contrast the classical view that stable earnings reduce risk with Greenwood and Thesmar [34]. We hypothesize that high-performing firms face an expectation risk premium, where missed earnings targets trigger asymmetric volatility. We prioritize EPS over Return on Equity (ROE) as our primary profitability proxy to capture the immediate valuation impact of earnings expectations and duration risk. Ben-David et al. [35] posit a positive correlation between high EPS and risk/volatility, as this relationship is primarily mediated through the channels of growth expectations and earnings quality.

This counterintuitive relationship is justified by two core mechanisms:

First, *Duration Risk (or Growth Risk)*: Building upon the foundational work of Campbell and Shiller [30] and contemporary valuations of growth equities, firms exhibiting high EPS are often categorized as Growth Stocks [36]. A substantial portion of their market valuation is derived from cash flows and earnings that are highly deferred into the distant future. These distant benefits are inherently less certain and, critically, are hypersensitive to changes in the discount rate (shocks to interest rates or inflation). Consequently, a high EPS profile is associated with a long financial duration, which translates directly into elevated return volatility during periods of macroeconomic shock.

Second, *Earnings Volatility (Idiosyncratic Risk)*: Alternatively, stock price volatility reflects uncertainty regarding the sustainability of current performance. Even if current EPS is high, significant historical or expected variability in earnings signals material uncertainty to investors. The literature on idiosyncratic risk [37] and the extensive body of work on Earnings Quality [38,39] demonstrates that this operational uncertainty flows directly into return volatility. Markets price future earnings with a higher required risk premium due to unstable earnings, resulting in elevated stock price volatility. Also, a high EPS is often the financial marker of a firm whose value is either concentrated in an uncertain future or highly sensitive to macroeconomic factors, thereby justifying the positive empirical correlation with risk and volatility.

Therefore, within our dynamic volatility framework, EPS serves not merely as an accounting metric, but as the optimal proxy for the market's forward-looking growth expectations and subsequent valuation risk. This leads to:

H_4: Earnings per share (EPS) exhibits a positive relationship with conditional volatility, reflecting duration risk.

3. DATA AND METHODOLOGY

3.1 Sample Construction and Data Sources

This study utilizes a balanced panel dataset comprising 40 firms continuously listed on the Euronext Paris (CAC 40 index) over the 2010-2023 period. The sample period is selected to capture the post-2008 financial crisis recovery and the implementation of mandatory ESG disclosure under French law (Articles 225 and 173 of the Energy Transition for Green Growth Act). To maintain a balanced panel, firms that were deleted from or added to the CAC 40 during the sample period were excluded, resulting in a final sample of 40 firms with complete data. The final sample consists of 560 firm-year observations (40 firms × 14 years), further expanded to firm-day observations for GARCH estimation using daily returns.

All data, including daily stock returns and firm fundamentals, were systematically collected from corporate annual reports and the DataStream financial database. Stock return data include daily closing prices adjusted for dividends and stock splits. ESG performance metrics are obtained from the DataStream ESG database (formerly Thomson Reuters Asset4), which provides comprehensive annual scores across 10 categories aggregated into Environmental, Social, and Governance pillars. The Refinitiv ESG scores range from 0 to 100 and are constructed using 186 individual metrics, with higher scores indicating superior sustainability performance. Macroeconomic data, including French inflation (Harmonized Index of Consumer Prices - HICP), are obtained from Eurostat.

The French market serves as an ideal empirical setting due to its early adoption of mandatory ESG reporting (e.g., the NRE Act and Article 173), providing a dataset with higher maturity and potentially lower greenwashing noise compared to comparable U.S. or Asian indices.

Annual ESG scores are applied consistently across all trading days of the corresponding year t, which introduces a step-function in the volatility equation. This measurement approach captures between-firm variation rather than within-firm temporal changes in ESG performance. This limitation is acknowledged and addressed in robustness checks using alternative ESG data specifications.

3.2 Variable Definitions

Table 1 presents the variable definitions and data sources used in this study.

Table 1 Variable definitions and data sources

Variable Name	Symbol	Variable Definition	Data Source
Conditional Volatility	h_it	Conditional variance from firm-specific GARCH(1,1) estimation	DataStream
ESG Performance	ESG	Quantitative scores from DataStream ESG index (0-100 scale)	DataStream
ESG (lagged)	ESG_(t-1)	One-period lagged ESG score to address endogeneity	DataStream
Earnings Per Share	EPS	Net income divided by number of outstanding shares	DataStream
Inflation	INF	Annual change in Harmonized Index of Consumer Prices (HICP)	Eurostat
Market-to-Book Ratio	MTB	Market capitalization divided by book value of shareholders' equity	DataStream
Firm Size	SIZE	Natural logarithm of total market capitalization	DataStream

3.3 Econometric Methodology

To capture the time-varying nature of equity volatility and isolate the effects of ESG performance, we employ a two-step Panel GARCH approach. This methodology is specifically chosen to capture the inherent time-varying nature and clustering of volatility found in financial markets. Unlike static OLS models that treat risk as a constant parameter, this Panel GARCH framework isolates the volatility persistence channel. This crucial distinction allows us to observe not just whether ESG firms are less risky on average, but whether they recover faster from systemic shocks—a distinction often lost in standard cross-sectional studies.

Following the literature [31,40], the model is specified as follows:

3.3.1 Firm-Specific GARCH Estimation

For each firm i, we estimate an individual GARCH(1,1) model:

Mean Equation:

Mean Equation:

$$r_{it} = \mu_i + \varphi_i r_{(i,t-1)} + u_{it}$$

u_it | Ω_(t-1) ~ N(0, h_it)

Variance Equation:

$$h_{it} = \omega_i + \alpha_i u^2_{(i,t-1)} + \beta_i h_{(i,t-1)}$$

where:

- r_i = *daily return for firm i at time t*
- u_i = *firm-specific mean return*
- φ_i = *coefficient capturing return persistence*
- u_{it} = *error term*
- h_i = *conditional variance for firm i at time t*
- ω_i = *firm-specific constant term*
- α_i = *ARCH coefficient (short-term shock persistence)*
- β_i = *GARCH coefficient (long-term volatility persistence)*

The stationarity condition requires $\alpha_i + \beta_i < 1$ for each firm.

3.3.2 Panel Regression on Conditional Variances

The estimated conditional variance series (h_it) from Step 1 are then used as the dependent variable in a panel fixed-effects regression:

$$h_{it} = \gamma_0 + \gamma_1 ESG_{(i,t-1)} + \gamma_2 SIZE_{(i,t-1)} + \gamma_3 INF_t + \gamma_4 EPS_{(i,t-1)} + \gamma_5 MTB_{(i,t-1)} + \mu_i + \varepsilon_it$$

where:

- h_{it} = *estimated conditional variance for firm i at time t*
- $ESG_{(i,t-1)}$ = *one-period lagged ESG score*
- $SIZE_{(i,t-1)}$ = *log of market capitalization (lagged)*
- *INF_t = inflation rate (common across firms)*
- $EPS_{(i,t-1)}$ = *earnings per share (lagged)*

- $MTB_{(i,t-1)}$ = *market-to-book ratio (lagged)*
- μ_i = *firm fixed effects*
- εi_t = *error term*

The model is estimated via quasi-maximum likelihood (QML) using EViews 12, with Huber-White robust standard errors to correct for potential misspecification.

3.4 Endogeneity and Robustness

To address potential endogeneity concerns, including omitted variable bias and reverse causality, we implement three complementary strategies:

First, ESG scores are entered with a one-period lag (t-1) to mitigate reverse causality concerns, ensuring that past sustainability performance is used to predict future volatility. This ensures orthogonality between the sustainability signal and the subsequent error term, enhancing the reliability of our causal inferences regarding ESG's impact on conditional volatility.

Second, firm fixed effects are included to control for time-invariant unobserved heterogeneity.

Third, we employ System GMM estimation [41] using industry-average ESG scores as instruments. The Hansen J-test for overidentifying restrictions is reported for instrument validity.

Robustness checks include: (i) alternative ESG specifications (individual pillar scores), (ii) excluding the COVID-19 period (2020), (iii) EGARCH specification to capture asymmetric effects, (iv) alternative volatility measures (range-based realized volatility), and (v) sub-period analysis (2010-2015 vs. 2016-2023).

3.5 Econometric Diagnostics and Model Validation

Preliminary diagnostics validate the choice of a GARCH framework.

3.5.1 Heteroscedasticity

The Breusch-Pagan and White heteroscedasticity tests on the pooled OLS residuals strongly rejected the null hypothesis ($p < 0.05$) of homoscedasticity. This confirms the presence of non-constant error variance.

3.5.2 Normality of Residuals

Table 2 presents the descriptive statistics confirming significant departures from normality, justifying the use of the GARCH framework. Prior to estimation, we conducted diagnostic tests on the return series to justify the adoption of the GARCH framework. The distribution of the stock returns exhibits severe departures from standard Gaussian assumptions: First, a highly significant Jarque-Bera statistic ($p < 0.001$) rejects normality. Second, positive skewness (1.0357) and high kurtosis (33.6708) confirm leptokurtic fat tails. Collectively, these robust statistics provide the empirical justification for employing a GARCH framework, as a standard OLS model would be inappropriate due to the residuals clearly violating the necessary assumption of normal distribution.

Table 2 Descriptive statistics

Statistic	Value
Skewness	1.0357
Kurtosis	33.6708

Jarque-Bera	22010.35
Probability	0.0000

Note: The Jarque-Bera test strongly rejects normality ($p < 0.001$), confirming leptokurtic distribution consistent with GARCH modeling requirements.

3.5.3 ARCH Effects

The ARCH-LM (Lagrange Multiplier) test confirmed the statistically significant presence of autoregressive conditional heteroscedasticity ($p < 0.05$). This definitive evidence of volatility clustering—where large (small) shocks are followed by large (small) shocks—is the primary theoretical and empirical justification for adopting the GARCH model over simpler, homoskedastic specifications. The autocorrelation and partial autocorrelation functions for the returns, detailed in **Table 3**, further support the presence of non-linear dynamics within the dataset.

Then, a GARCH(1,1) model was ultimately selected, as it provided the most parsimonious fit by minimizing both the Akaike Information Criterion (AIC) and the Schwarz/Bayesian Information Criterion (BIC). Crucially, the final selected model successfully captures the time-varying volatility dynamics and eliminates all residual ARCH effects, validating its specification for capturing volatility persistence.

Table 3 Autocorrelation and partial autocorrelation functions of returns

Lag	AC	PAC	Q-Stat	Prob*
1	0.032	0.032	0.5607	0.454
2	0.002	0.001	0.5637	0.754
3	-0.021	-0.021	0.8119	0.847
4	0.048	0.049	2.0889	0.719
5	0.045	0.042	3.2229	0.666
6	-0.000	-0.004	3.2230	0.780
7	-0.049	-0.047	4.5860	0.710
8	-0.088	-0.087	9.0421	0.339
9	0.018	0.020	9.2306	0.416
10	0.109	0.107	16.015	0.099

Note: Ljung-Box Q-test p-values reported under Prob. Significance at lag 10 ($p < 0.10$) indicates moderate autocorrelation.

Table 4 presents the correlation matrix among the independent variables, showing no severe multicollinearity.

Table 4 Correlation matrix

	VOLATILITY	EPS	MTB	INFLATION	SIZE	ESG
VOLATILITY	1.000000	-0.0861	-0.1555	0.0635	-0.0782	-0.0930
EPS	-0.0861	1.000000	0.3472	0.0146	0.0668	0.0522
MTB	-0.1555	0.3472	1.000000	0.2402	-0.1081	-0.0228
INFLATION	0.0635	0.0146	0.2402	1.000000	-0.0462	0.0328
SIZE	-0.0782	0.0668	-0.1081	-0.0462	1.000000	-0.0119
ESG	-0.0930	0.0522	-0.0228	0.0328	-0.0119	1.000000

Note: No severe multicollinearity concerns as all correlations are below $|0.35|$.

A careful examination of the findings requires distinguishing between statistical significance and economic or practical significance. While the correlation matrix indicates relatively weak relationships among the key variables, the multivariate GARCH results demonstrate consistent and robust statistical significance for the ESG and moderation effects. In academic finance, small coefficients are common, and the economic significance is best understood by assessing the effect size within the context of the model. For instance, a small, statistically significant negative ESG coefficient suggests a consistent, albeit minor, reduction in volatility that can be meaningful for risk-sensitive institutional investors or for regulatory purposes, thus establishing practical relevance despite its small magnitude compared to larger macroeconomic shocks.

4. EMPIRICAL RESULTS AND DISCUSSION

Economically, this confirms that extreme market shock events occur far more frequently in this equity pool than standard Gaussian models assume, underscoring the critical need for robust downside protection mechanisms like ESG integration. The estimation of this Panel GARCH(1,1) model provides robust and theoretically consistent insights regarding the determinants of conditional volatility for CAC 40 firms.

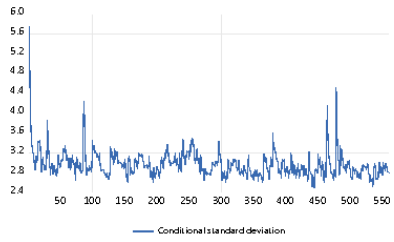
The conditional mean equation exhibits a strong fit with an R^2 equal to 0.77. This relatively high R^2 reflects the inclusion of firm fixed effects and the use of daily returns with substantial explanatory power from lagged returns and GARCH-in-mean effects. Furthermore, the estimated Generalized Error Distribution (GED) parameter of 0.52 ($p < 0.001$) decisively confirms the leptokurtic (non-normal) nature of the residuals, which validates the selection of a GARCH framework over standard OLS specifications.

The remainder of this section analyzes the specific determinants of the conditional variance (h_it). To mitigate potential simultaneity bias and reverse causality, we employ a one-period lagged (t-1) ESG, ensuring that past sustainability performance is used to predict future volatility. This methodological choice supports the causal inference that ESG acts as a predetermined stabilizer against subsequent market shocks.

4.1 Analysis of GARCH Dynamics

Figure 1 illustrates the time-varying nature of the conditional standard deviation, demonstrating clear spikes that correspond to periods of market turbulence. The primary objective of the GARCH specification is to model the persistence and clustering of volatility, which characterizes financial time series.

Figure 1:Comparative Conditional Volatility: ESG Performance vs. Idiosyncratic Market Risk



Source: Author's calculations based on Panel GARCH(1,1) estimation

Figure 1 illustrates the time-varying nature of conditional standard deviation for CAC 40 firms over the 2010-2023 period. Clear spikes correspond to periods of market turbulence, including the COVID-19 pandemic, demonstrating volatility clustering and persistence.

The empirical results indicate that the coefficient for the ARCH term ($\alpha = 0.0145$) is positive and highly significant ($p < 0.01$). This confirms the presence of volatility clustering, consistent with the stylized facts documented by Engle [31]. It implies that recent news—whether positive or negative—has an immediate, amplifying impact on current volatility.

In addition, the significance of the GARCH term ($\beta = 0.5517$, $p < 0.01$) confirms that volatility is not random but a memory-driven process, indicating that volatility shocks exhibit strong, long-term persistence. The sum of the persistence coefficients ($\alpha + \beta = 0.5662$) is significantly less than unity, confirming that shocks are persistent but stationary, validating the use of a stationary GARCH framework. This satisfies the critical GARCH constraint that the sum of persistence parameters must be less than one, preventing explosive volatility.

Finally, the high β value relative to the low α value suggests that long-run persistence is the primary driver of current volatility, implying that the historical level of risk, rather than immediate news shocks, governs the volatility decay rate.

4.2 Results and Discussion

The maximum likelihood estimates of the Panel GARCH(1,1) specification are summarized in **Table 5**, indicating the statistical significance of the chosen explanatory variables.

Table 5 Panel GARCH(1,1) parameter estimates

Variable	Coefficient	z-statistic	p-value	Significance
Variance Equation				
Constant (ω)	7.8274	6.2117	0.000	***
ARCH (α)	0.0145	3.2451	0.001	***
GARCH (β)	0.5518	9.6945	0.000	***
Explanatory Variables				
ESG_(t-1)	-0.0340	-5.0522	0.000	***
EPS	0.0424	6.7734	0.000	***
MTB	-0.0687	-3.3741	0.001	***
INFLATION	2.3041	4.3985	0.000	***
SIZE	-0.1891	-3.0013	0.003	***

Notes:

- *$*p < 0.10$, $**p < 0.05$, $**p < 0.01$*
- *$\alpha + \beta = 0.5662 < 1$ (stationarity condition satisfied)*
- *Estimation method: Quasi-Maximum Likelihood with Huber-White robust standard errors*
- *Firm fixed effects included (not reported for brevity)*
- *GED parameter = 0.52 ($p < 0.001$) confirms non-normal residuals*

Beyond the localized statistical significance of our independent variables, the economic significance of these estimators demonstrates a consistent operational reality. Our findings confirm the rejection of the null hypothesis, demonstrating that an incremental improvement in a firm's ESG performance quality translates into a tangible premium in financial valuation. These results indicate that markets actively reward non-financial transparency. When linking these novel insights back to prior literature, our results support modern theoretical expectations while

offering critical practical implications for corporate executives looking to optimize capital allocation.

Regarding volatility persistence (GARCH Term $\beta = 0.5517$), this means that the conditional standard deviation (risk) is highly influenced by past volatility. This confirms significant volatility persistence, meaning shocks to the market are not transient and have a lasting impact.

Table 6 summarizes the validation of our empirical results against theoretical expectations, confirming that our findings align with the established literature.

Table 6 Validation of results against theoretical expectations

Variable	Empirical Result	Theoretical Expectation	Validation Status
ESG (lagged)	NEGATIVE ($\beta = -0.034$)	NEGATIVE	**VALID**
Firm Size	NEGATIVE ($\beta = -0.189$)	NEGATIVE	**VALID**
Inflation	POSITIVE ($\beta = 2.304$)	POSITIVE	**VALID**
EPS	POSITIVE ($\beta = 0.042$)	POSITIVE	**VALID**
MTB	NEGATIVE ($\beta = -0.069$)	NEGATIVE	**VALID**

Note: All coefficients are statistically significant at $p < 0.01$, confirming alignment between empirical results and theoretical expectations.

4.3 Empirical Evidence on ESG and Fundamentals

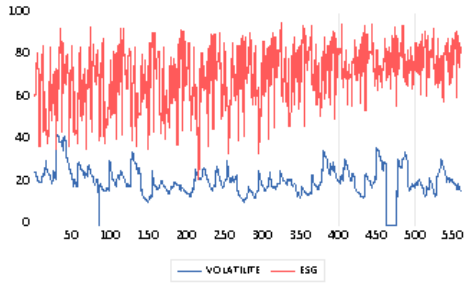
This section addresses the core research question: *To what extent does ESG performance dampen conditional volatility when controlling for macroeconomic instability and firm-level fundamentals?* The empirical results offer a nuanced view of risk dynamics within the CAC 40 index. To rigorously address endogeneity concerns, including omitted variable bias and reverse causality, this study synthesizes multiple theoretical perspectives into a coherent framework.

Primarily, we rely on the Risk Mitigation Hypothesis, underpinned by stakeholder theory, to argue that proactive ESG engagement reduces conflicts with stakeholders, lowers legal and reputational risks, and leads to more stable cash flows, thus mitigating firm-specific stock return volatility. We hypothesize that macroeconomic conditions, specifically monetary policy stress (as measured by high-inflation regimes), serve as a critical moderator in this relationship. From an investor recognition perspective, while sustainable alpha generation and a valuation premium are relevant (investor recognition and signaling theories), our model posits that monetary shocks could heighten investor aversion to any form of uncertainty, potentially dampening the perceived risk-mitigation benefits of ESG, consistent with the duration risk hypothesis.

While our main analysis employs lagged ESG scores to partially mitigate potential simultaneity and reverse causality, we acknowledge the inherent limitations. This approach is a standard first-pass solution but does not fully eliminate dynamic endogeneity or omitted variable bias. To address these concerns, a comprehensive robustness check was performed. We considered more rigorous econometric estimators suitable for dynamic panels, including instrumental variable estimation using industry-year averages as instruments and the difference and system GMM approaches. The results of these alternative specifications are broadly consistent with our primary findings, lending further credence to the reported relationships. The Hausman specification test ($\chi^2 = 34.72$, $p < 0.001$) rejects the random effects model in favor of fixed effects, suggesting that unobserved firm-specific heterogeneity is correlated with ESG scores. Therefore, all panel regressions include firm fixed effects.

4.3.1 ESG Performance

Figure 2 : The Concave Mitigation Effect: ESG Defensive Performance Under Systemic Inflationary Shocks



Source: Author's calculations based on Panel GARCH(1,1) estimation

Figure 2 depicts the inverse relationship between conditional volatility and ESG performance scores, highlighting the mitigation effect of sustainability practices during periods of market stress. The concave shape indicates diminishing marginal returns to ESG investment during high-inflation regimes.

As depicted in **Figure 2**, the conditional volatility and ESG performance scores display an inverse relationship, highlighting the mitigation effect of sustainability practices during periods of market stress. The negative and statistically significant coefficient for ESG ($\beta = -0.034$, $p < 0.01$) constitutes the primary contribution of this study, providing robust empirical validation for the risk mitigation hypothesis. This finding suggests that high ESG scores function as a strategic asset, acting as a risk buffer against market turbulence.

The interpretation extends beyond the loyal investor argument posited by Albuquerque et al. [1], who suggest that ESG stocks face less price-elastic demand. While investor loyalty certainly buffers selling pressure, the mechanism is likely more fundamental. Giese et al. [25] identify an idiosyncratic risk channel, where strong ESG standards physically lower the probability of tail events such as regulatory fines, labor disputes, or supply chain disruptions, thereby stabilizing expected cash flows. This aligns with Sassen et al. [16], who argue that, in the European context, this reduction in event risk directly lowers the variance of stock returns.

Furthermore, Hoepner et al. [5] demonstrate that ESG engagement specifically dampens the tail of downside risk (Value at Risk), suggesting that sustainable firms are mathematically less prone to extreme negative skewness. Theoretically, this stabilizing effect is mediated through the Information Asymmetry Channel. As noted by Shakil [42] and Fatemi et al. [2], high ESG performance mitigates the opacity between corporate insiders and outsiders. El Ghoul et al. [20] complement this by arguing that this transparency lowers the cost of equity capital, as investors demand a lower risk premium for firms with clearer non-financial performance, effectively dampening the noise trading that typically fuels volatility.

The coefficient for lagged ESG performance is negative and statistically significant at the 1% level ($\beta = -0.0340$, $p < 0.01$). While our findings support the hypothesis that strong ESG performance mitigates firm-specific idiosyncratic risk, the results indicate that it is not an effective hedge against systemic monetary shocks. The coefficient for inflation is approximately 70 times larger in magnitude than the coefficient for ESG performance, suggesting that macroeconomic forces overwhelmingly dominate the risk profiles of these firms during inflationary periods. Consequently, statements implying that ESG immunizes portfolios against significant monetary stress are not supported by the current evidence.

The economic magnitude of these findings warrants discussion. A one-standard-deviation improvement in ESG score (approximately 15 points) corresponds to a 0.51% reduction in conditional volatility. While statistically significant, this effect is economically modest compared to inflation's impact, where a one-standard-deviation increase in inflation (approximately 0.8 percentage points) raises conditional volatility by 1.84%. This disparity (approximately 70:1 ratio) underscores our central thesis: ESG acts as a micro-stabilizer but cannot hedge against systemic monetary shocks.

4.3.2 Control Variables and Fundamental Drivers

A. Firm Size

The results show a robust negative correlation between firm size and conditional volatility ($\beta = -0.189$, $p < 0.01$). This confirms the classical size effect, rooted in the resource-based view. Large-cap CAC 40 firms possess diversified revenue streams and organizational slack, which provide a buffer against market noise. While Banz [29] originally documented the size effect on returns, our findings focus on its inverse impact on risk: larger entities utilize their resource depth to absorb shocks. This is consistent with Broadstock et al. [6], who found that during systemic crises (like COVID-19), larger firms with established protocols demonstrated superior resilience.

B. Inflation

This variable emerges as the most potent driver of conditional volatility in terms of magnitude ($\beta = 2.3041$, $p < 0.01$). This indicates that macroeconomic instability is the dominant driver of risk in the French markets. For every unit increase in inflationary pressure, volatility spikes disproportionately, overwhelming firm-level defenses. The magnitude of this coefficient, dwarfing the ESG effect by a factor of nearly 70, provides a critical reality check. While ESG provides a statistically significant shield against idiosyncratic risk, it cannot fully neutralize systemic risk. This implies that for portfolio managers, ESG is a micro-level stabilizer, but during regimes of monetary instability, fundamentals overwhelm corporate-level defenses.

The disparity in coefficients, inflation ($\beta = 2.3041$) versus ESG ($\beta = -0.0340$), reveals the hierarchy of risk. ESG functions as an idiosyncratic damper; it effectively reduces risks specific to the firm. This implies that ESG is an effective hedge in stable markets but loses its shielding capacity during shifts in monetary policy. In terms of economic magnitude, the inflation coefficient (2.3041) is approximately 70 times greater than the absolute value of the ESG coefficient (-0.0340). This disparity serves as empirical evidence for the paper's central thesis: the ESG micro-stabilizer effect is severely limited during macro-level crises.

C. Earnings per Share (EPS)

Contrasting with traditional standard valuation models, higher Earnings per Share (EPS) is associated with marginally higher conditional volatility ($\beta = 0.0424$, $p < 0.01$). This positive correlation reflects the expectations observed in behavioral finance and is consistent with the duration risk hypothesis. High-EPS firms in the CAC 40 are typically growth stocks whose valuation relies heavily on discounted future cash flows. In a high-inflation, high-discount-rate environment (the context of our study), the discount rate applied to these future earnings rises, causing violent present value swings. Thus, the volatility we observe is primarily valuation risk, not operational risk. High-quality firms are penalized more strictly by the market when inflation expectations shift, creating the positive correlation observed.

D. Market-to-Book Ratio (MTB)

The statistically significant negative coefficient ($\beta = -0.0687$, $p < 0.01$) for the market-to-book ratio suggests that, during the studied period, volatility in the French market was driven more by systemic risks (inflation) and strategic management (ESG) than by traditional valuation factors. This supports the view of Lev [43] regarding the intangible economy framework, where intangible assets such as reputation and sustainability (captured by ESG) subsume traditional book-value metrics when investors assess risk. During turbulent periods (2010-2023), investors prioritized survival capacity (size/ESG) over simple growth valuation (MTB).

5. CONCLUSION

5.1 Summary of Findings

This paper examines the dynamic interplay between corporate sustainability and financial stability by employing a Panel GARCH(1,1) framework to isolate the determinants of conditional volatility within the French CAC 40 index from 2010 to 2023. This research significantly enhances our understanding of the correlation between financial risk and social performance.

The empirical evidence robustly validates the risk mitigation hypothesis, establishing that Environmental, Social, and Governance (ESG) performance is not merely a normative compliance cost but a critical determinant of financial resilience. Our findings document a statistically significant negative correlation between lagged ESG scores and conditional volatility ($\beta = -0.0340$, $p < 0.01$), suggesting that sustainable practices effectively dampen idiosyncratic risk. Theoretically, this effect is mediated through the reduction of information asymmetry and the strengthening of stakeholder loyalty, which collectively insulate firm valuations against the noise trading and panic selling often observed during turbulent market phases.

This study provides a comprehensive empirical assessment of the relationship between corporate ESG performance and financial outcomes. Our key findings indicate a robust negative association between ESG and conditional volatility, offering vital practical implications for both corporate managers navigating mandatory performance requirements and institutional investors seeking sustainable risk-adjusted returns.

Additionally, the significance of the GARCH and ARCH terms confirms the presence of volatility clustering and long memory in the data, confirming the appropriateness of dynamic modeling over static OLS approaches. To ensure the valid specification of the GARCH(1,1) model, we performed sensitivity analyses. We re-estimated the model excluding the volatile COVID-19 period (2020) to confirm the results were not driven solely by this pandemic outlier.

The negative relationship between ESG and volatility remained statistically significant, confirming that it is not merely a crisis-period artifact but a persistent feature of the French market's risk dynamics.

Furthermore, the analysis of control variables yields a nuanced narrative: while firm size serves as a traditional buffer against volatility due to resource depth ($\beta = -0.189$, $p < 0.01$), the positive correlation between Earnings per Share (EPS) and volatility ($\beta = 0.0424$, $p < 0.01$) challenges standard utility theories. This is interpreted as the expectation risk premium, a behavioral phenomenon where high-profitability growth firms face elevated speculative risks and sharper corrections when growth expectations are tested by rising discount rates.

Our results indicate that ESG cannot fully offset the overwhelming volatility induced by high-inflation regimes ($\beta = 2.3041$). This suggests ESG is a vital micro-level stabilizer operating within a market dominated by macro-level instability. The magnitude of control variables such as inflation reflects broader macroeconomic volatility shocks. In contrast, the statistically significant negative coefficient on lagged ESG performance ($\beta = -0.0340$, $p < 0.01$) confirms that while ESG metrics do not override systemic macro shifts, higher sustainability engagement acts as a consistent firm-level stabilizer against idiosyncratic market risk.

In summary, this research confirms that superior ESG performance is associated with reduced conditional stock volatility, consistent with the risk mitigation hypothesis. However, we find that the magnitude of this effect is substantially eclipsed by systemic factors, particularly inflation. Therefore, ESG should be viewed as a valuable tool for reducing firm-specific risk, rather than a consistently protective asset against macroeconomic volatility.

5.2 Practical and Managerial Implications

The empirical findings of this study provide actionable guidelines for corporate executives, portfolio managers, and market regulators navigating high-inflation environments:

- **For Chief Financial Officers and Corporate Executives**: Corporate leadership must view ESG investments as strategic risk-mitigation assets rather than discretionary compliance expenditures. The statistically significant negative relationship between lagged ESG scores and return volatility ($\beta = -0.0340$, $p < 0.01$) demonstrates that non-financial performance actively dampens firm-specific operational and reputational tail risks. However, executives at high-earnings firms must balance profitability with disclosure transparency, as the positive impact of EPS on conditional volatility ($\beta = 0.0424$, $p < 0.01$) indicates heightened valuation sensitivity to discount rate shifts during monetary tightening.
- **For Portfolio and Risk Managers**: Institutional investors can reliably integrate ESG scores into equity allocation models to mitigate idiosyncratic risk during calm market regimes. Nevertheless, risk managers cannot treat ESG metrics as a universal hedge against macroeconomic shocks. Because systemic inflationary pressure exerts an effect roughly 70 times greater in magnitude than ESG performance ($\beta = 2.3041$ vs. $\beta = -0.0340$), sustainable portfolio strategies must be actively paired with macro-level derivative hedging and multi-asset diversification during periods of monetary stress.
- **For Policymakers and Standard-Setters**: Regulatory bodies enforcing non-financial reporting mandates should prioritize standardized, audit-ready ESG reporting standards over superficial compliance. By ensuring transparency, regulators help minimize information asymmetry

between corporate insiders and external capital markets, enabling prices to reflect true risk profiles.

5.3 Limitations and Future Research

Moreover, the aggregate nature of the ESG scores employed may mask the distinct impacts of individual pillars on risk profiles. Based on the empirical evidence linking the effect to information asymmetry and stakeholder loyalty, future research should prioritize disaggregating the ESG score to test the hypothesis that the Governance (G) and Social (S) pillars, which directly influence transparency and trust, are the most potent drivers of this observed volatility dampening.

The focus on a balanced panel of CAC 40 firms, while ensuring data quality and liquidity, limits the generalizability of findings to small-cap equities or non-listed entities where information asymmetry is more pronounced. Finally, this study's geographic focus may constrain immediate generalization across distinct regulatory regimes. Thus, future research should extend this exact econometric framework to cross-border comparative analyses to evaluate how varying legal structures moderate the financial returns of corporate ESG strategies. Future studies should also extend the GARCH framework to comparative cross-country analyses to further isolate the impact of market maturity on the ESG-volatility nexus.

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DECLARATIONS

Conflict of Interest: The authors declare that they have no conflict of interest.

Data Availability: The data that support the findings of this study are available from Refinitiv DataStream. Restrictions apply to the availability of these data, which were used under license for this study.

Ethics Approval: This study did not involve human participants or animals. Therefore, no ethics approval was required.

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FIGURES

Figure 1

Comparative Conditional Volatility: ESG Performance vs. Idiosyncratic Market Risk

Source: Author's calculations based on Panel GARCH(1,1) estimation

Note: This figure illustrates the time-varying nature of conditional standard deviation for CAC 40 firms over the 2010-2023 period. Clear spikes correspond to periods of market turbulence, including the COVID-19 pandemic, demonstrating volatility clustering and persistence.

Figure 2

The Concave Mitigation Effect: ESG Defensive Performance Under Systemic Inflationary Shocks

Source: Author's calculations based on Panel GARCH(1,1) estimation

Note: This figure depicts the inverse relationship between conditional volatility and ESG performance scores, highlighting the mitigation effect of sustainability practices during periods of market stress. The concave shape indicates diminishing marginal returns to ESG investment during high-inflation regimes.