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THE IMPACT OF ECB INTERVENTIONS ON THE EQUITY RISK PREMIUM IN THE EURO AREA DURING PERIODS OF FINANCIAL STRESS (2004–2025)

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List of Abbreviations

AR	Abnormal Return
BLUE	Best Linear Unbiased Estimator
BS	Balance Sheet
CAAR	Cumulative Average Abnormal Return
CBPP	Covered Bond Purchase Programme
CBPP1	Covered Bond Purchase Programme 1
CBPP3	Covered Bond Purchase Programme 3
CFO	Chief Financial Officer
CISS	Composite Indicator of Systemic Stress
COVID-19	Coronavirus Disease 2019
CSPP	Corporate Sector Purchase Programme
CUSUM	Cumulative SUM
D/P	Dividend-to-Price ratio
DFR	Deposit Facility Rate
DW	Durbin-Watson
E/P	Earnings-to-Price ratio
EA	Euro Area
ECB	European Central Bank
ELB	Effective Lower Bound
EMU	Economic and Monetary Union
EPU	Economic Policy Uncertainty
ERP	Equity Risk Premium
EURONEXT	Pan-European stock exchange
FE	Fixed Effects
Fed	Federal Reserve System
FOMC	Federal Open Market Committee
GDP	Gross Domestic Product
GGM	Gordon Growth Model
GVAR	Global Vector Autoregression
H1	Assumption 1
H2	Assumption 2
H3	Assumption 3
HAC	Heteroskedasticity and Autocorrelation Consistent
HEC	Hautes Études Commerciales
HICP	Harmonized Index of Consumer Prices
I/B/E/S	Institutional Brokers' Estimate System
IEP	Implied Equity Premium
LM	Linear Model
LSAP	Large-Scale Asset Purchases
LTRO	Long-Term Refinancing Operation

MPD	Monetary Policy Database (Altavilla et al.)
MRO	Main Refinancing Operation
M3	Broad Money, *Money Supply M3*
MSCI	Morgan Stanley Capital International
NIRP	Negative Interest Rate Policy
OCDE	Organisation de coopération et de développement économiques
OLS	Ordinary Least Squares
OMT	Outright Monetary Transactions
P/E	Price-to-Earnings ratio
PEG	Price/Earnings to Growth ratio
PELTRO	Pandemic Emergency Longer-Term Refinancing Operation
PEPP	Pandemic Emergency Purchase Programme
PSPP	Public Sector Purchase Programme
QE	Quantitative Easing
QT	Quantitative Tightening
RESET	Regression Equation Specification Error Test
SDW	Statistical Data Warehouse
SE	Standard Error
SMP	Securities Markets Programme
STOXX	STOXX Ltd
TLTRO	Targeted Longer-Term Refinancing Operation
TPI	Transmission Protection Instrument
VAR	Vector Autoregression
VIF	Variance Inflation Factor
VIX	Volatility Index (CBOE, S&P 500)
VSTOXX	Euro STOXX 50 Volatility Index

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Introduction

Since the 2008 global financial crisis, the European Central Bank (ECB) has radically transformed its operational framework. Faced with the exhaustion of conventional interest rate tools, the MRO rate having reached 0% in March 2016, it deployed an arsenal of unconventional tools: asset purchase programs (SMP, APP, PEPP), targeted longer-term refinancing operations (TLTROs), negative rates on the deposit facility, and more recently the Transmission Protection Instrument (TPI). These measures have expanded the Eurosystem's balance sheet from €1.5 trillion in 2008 to over €8.8 trillion in 2022, prior to a gradual quantitative tightening that began in the first half of 2023. The unprecedented scale of these interventions, both in terms of volume and the diversity of instruments used, raises fundamental questions regarding their repercussions across all asset classes. While the impact on sovereign bond yields and credit conditions is now well documented (Altavilla et al., 2016; Krishnamurthy et al., 2018), their effect on the equity risk premium in the euro area remains insufficiently analyzed, despite the crucial importance of this variable for investment decisions and the assessment of the cost of capital. The PIF is not included in the analysis because it has never been activated. Its nature as a conditional backstop makes it similar to the OMT; its effect is transmitted through the signaling channel.

The institutional architecture of the euro area lends these results particular significance. Unlike the Federal Reserve, which operates within a unified monetary area, the ECB must manage the transmission of its monetary policy through structurally heterogeneous national financial markets. Our results show that ECB interventions do indeed reduce the ERP during periods of stress, precisely when the risk of financial fragmentation is most acute. Interestingly, this compression effect does not differ significantly between core and peripheral countries, suggesting a relatively homogeneous transmission of unconventional monetary policy to the equity risk premium.

The equity risk premium is a fundamental variable in finance. Defined as the expected excess return on stocks relative to the risk-free rate, it determines the cost of equity, guides asset allocation decisions, and reflects investors' aggregate risk aversion (Cochrane, 2005; Damodaran, 2024). Its level directly influences the valuation of listed companies and, by extension, the financing of the real economy. The relationship between monetary policy and the equity risk premium is embedded in a rich theoretical framework involving the portfolio rebalancing channel (Tobin, 1969; Vayanos and Vila, 2021), the signaling channel (Bauer and Rudebusch, 2014), the risk-taking channel (Borio and Zhu, 2012), and, specifically in the euro area, the sovereign-bank nexus (Acharya et al., 2014). Despite the richness of this conceptual framework, few studies have empirically tested these channels on the euro area's implied equity risk premium (ERP) with a time coverage spanning the entire unconventional cycle. This thesis aims to answer the following question: Did the ECB's interventions reduce the equity risk premium in the euro area during periods of financial stress between 2004 and 2025?

Three nested hypotheses structure the empirical analysis. Hypothesis H1 tests for the existence of an aggregate effect of ECB interventions on the ERP at the euro area level, using three complementary proxies: the logarithmic change in the size of the ECB's balance sheet, net asset purchases (Strict APP), and the deposit facility rate (DFR). Hypothesis H2 introduces a nonlinear dimension by positing that this effect is amplified during episodes of high financial stress, identified by a VSTOXX exceeding its 90th percentile (P90 = 30.32; i.e., 27 months of stress out of 264). Hypothesis H3 exploits the structural heterogeneity of the eurozone by distinguishing a "core" group (Belgium, Germany, France, the Netherlands) from a "periphery" group (Spain, Italy, Greece) using a country-fixed-effects panel.

The IEP is calculated monthly using the simplified formula ERP = 1/PE_forward, where PE_forward refers to the 12-month forward price-to-earnings ratio (forward P/E) derived from the I/B/E/S consensus aggregated at the index level. This approach, known as the earnings yield approach, assumes that the inverse of the forward P/E provides a reasonable approximation of the expected return on stocks (Damodaran, 2024). Unlike a full implementation of the Gordon-Shapiro model (which would require an explicit estimation of the growth rate g and the risk-free rate R_f), our measure directly uses the earnings yield as a proxy for the implied equity risk premium, in line with Fama and French (1988) and Damodaran (2024). The forward P/E is derived from the I/B/E/S consensus. Data is extracted via Refinitiv Eikon/Datastream.

This thesis makes four key contributions. First, it focuses on the implied risk premium, a measure that is theoretically more informative than realized stock market returns, as it directly reflects investors' expectations without being biased by past returns. This methodological distinction is essential: realized returns capture ex post shocks that do not necessarily correspond to the ex-ante premiums demanded by investors. Second, the analysis window (2004–2025) encompasses the entire cycle of unconventional policies, from the pre-crisis phase to the recent quantitative tightening, thereby offering a unique longitudinal perspective. Third, the introduction of an ECB × Stress interaction term allows for a formal test of the nonlinearity of monetary transmission, a dimension often discussed in the literature but rarely tested directly within a structured econometric framework. Fourth, the panel analysis formally tests for structural heterogeneity between core and peripheral economies via Periphery × ECB interaction terms and Stress × Periphery × ECB triple interactions, allowing us to distinguish state-dependent effects from geography-dependent effects in the transmission of the single monetary policy in the euro area.

This thesis is structured as follows. Chapter 1 reviews the theoretical and empirical literature on the ERP, unconventional monetary policy, and transmission channels. Chapter 2 presents the data and variables used. Chapter 3 details the econometric methodology. Chapter 4 presents the results and interprets them in light of the hypotheses formulated. The conclusion summarizes the findings, discusses the limitations, and suggests avenues for future research.

1. Literature Review

This chapter situates this thesis within the existing body of literature and provides the theoretical foundations necessary for interpreting the empirical results presented in Chapter 4. Section 1.1 examines the theoretical foundations of the equity risk premium (ERP), from the original puzzle posed by Mehra and Prescott (1985) to contemporary methods of implied estimation. Section 1.2 presents the institutional framework and the unconventional monetary policy instruments of the European Central Bank (ECB). Section 1.3 analyzes the theoretical transmission channels through which these interventions may affect equity markets and the risk premium. Section 1.4 summarizes the existing empirical evidence, distinguishing between results pertaining to the Federal Reserve, the ECB as a whole, cross-country heterogeneity, and the moderating role of financial stress. Finally, Section 1.5 identifies gaps in the literature and positions the contribution of this thesis.

1.1 The Equity Risk Premium: Theoretical Foundations

1.1.1 Definition, Role, and The Puzzle of the Risk Premium

The equity risk premium (ERP) refers to the expected excess return on an equity investment relative to the risk-free rate. It is a key variable in finance, as it simultaneously determines the cost of capital for firms, the valuation of risky assets, and strategic portfolio allocation (Cochrane, 2005). The foundational literature dates back to the seminal work of Mehra and Prescott (1985), who document what they call a "puzzle": the historical ERP observed in the United States (≈ 6% per year over the period 1889–1978) is considerably higher than what standard general-equilibrium models are capable of generating for reasonable levels of risk aversion. Mehra and Prescott (2003) revisit this puzzle twenty years later and confirm that it remains one of the most persistent anomalies in financial theory.

Three main classes of solutions have been proposed:

The first is based on the formation of consumption habits: Campbell and Cochrane (1999) show that an agent whose utility depends on the difference between his consumption and an adaptive reference level exhibits a strongly countercyclical effective risk aversion, generating a high premium during recessions. The second, formalized by Bansal and Yaron (2004), introduces long-run risks: small persistent fluctuations in the consumption growth rate, combined with stochastic volatility, are sufficient to produce a high premium within an Epstein-Zin recursive utility framework. The third, proposed by Barro (2006), invokes rare disasters: the possibility of catastrophic events with low probability but high impact (wars, pandemics, systemic crises) justifies ex ante a high risk premium, even if these events rarely materialize. Each of these solutions sheds light on one aspect of the puzzle without definitively resolving it, as Kocherlakota (1996) notes in his critical review.

The second class of solutions relies on rare events. Barro (2006) and Barro and Ursúa (2008) show that a model incorporating the possibility of macroeconomic disasters (wars, systemic financial crises, pandemics) with a low but non-negligible probability can reproduce the observed risk premium without resorting to excessive risk aversion. Wachter (2013) extends this framework by modeling a disaster probability that varies over time, which allows for the simultaneous reproduction of both the level and volatility of the ERP.

These models are particularly relevant to our study, as the periods of financial stress identified by a high VSTOXX correspond precisely to episodes where the perceived probability of disaster increases, theoretically justifying the nonlinearity of the ECB effect that we test via Hypothesis H2.

1.1.2 Determinants of the equity risk premium

Beyond the theoretical puzzle, a vast body of empirical literature has identified the macro-financial determinants of the ERP. Damodaran (2024), in the annual update of his comprehensive review, identifies six categories of factors: aggregate risk aversion, macroeconomic volatility, inflation, market liquidity, investor sentiment, and monetary conditions. Fama and French (2002) show that the ERP estimated using fundamentals (dividends and earnings) is significantly lower than the historical premium calculated based on realized returns, suggesting that past returns overestimate the expected ERP.

Lettau, Ludvigson, and Wachter (2008) document a secular decline in the ERP in the United States since the 1950s, which they attribute to a reduction in macroeconomic volatility. Bekaert, Engstrom, and Xing (2009) draw a fundamental distinction between risk (measured by conditional variance) and uncertainty (measured by implied volatility indicators such as the VIX or VSTOXX), showing that the two components contribute differently to the risk premium. Bollerslev, Tauchen, and Zhou (2009) introduce the concept of the variance risk premium, documenting that the gap between implied volatility and realized volatility is a robust predictor of stock returns. This work provides the theoretical foundation for our use of the VSTOXX as a control variable and stress indicator in the empirical framework.

The relationship between monetary policy and the risk premium is a relatively new area of research. Duarte and Rosa (2015) provide a comprehensive review of models linking monetary conditions to the risk premium, showing multiple theoretical mechanisms at play: a direct effect via the discount rate, an indirect effect via growth and inflation expectations, and a behavioral effect via the risk-taking channel. This multiplicity of channels makes empirical identification particularly challenging, which is why the multi-specification econometric strategy adopted in this thesis is justified.

Building on this work, Bernanke and Kuttner (2005) demonstrate that a surprise 25-basis-point cut in the federal funds rate is associated with an increase of approximately 1% in U.S. stock market indices, three-quarters of which stems from a compression of the risk premium rather than a revision of expected dividends. This seminal result establishes a direct causal link between monetary policy and ERP, which our study applies to the European context. Our unique contribution lies in the multiplicity of channels simultaneously activated by unconventional tools: asset purchases directly compress bond term premiums, which, through arbitrage, is transmitted to equity risk premiums (Koijen et al., 2021), while forward guidance acts primarily through the channel of future rate expectations.

1.1.3 Estimation methods: historical, survey, and implicit

Three methods for estimating the ERP coexist in literature, the historical method, the survey-based method and the implicit method.

The historical approach calculates the average of past excess returns over a long period. Dimson, Marsh, and Staunton, in their successive editions of the Global Investment Returns Yearbook, document historical premiums by country since 1900, revealing considerable geographical heterogeneity. However, this approach suffers from time and survival bias: markets that have survived (notably the United States) exhibit structurally higher premiums.

The survey-based approach directly polls practitioners and academics. Welch (2000) reveals a considerable range of expectations within the profession, with the pessimistic and optimistic scenarios for the 30-year risk premium standing at around 2% and 13%, respectively. From a complementary perspective, Fernández et al. (2015) do not seek to estimate a historical or implied premium, but rather to identify the market risk premium used by professors, analysts, and firms to calculate the required return on equity in different countries. This contribution is particularly useful insofar as Fernández (2006) explicitly distinguishes between several often-confused concepts of equity premium (historical, expected, required, and implied). Graham and Harvey (2018), using Duke University's CFO Survey, show that CFOs' expectations are sensitive to short-term market conditions, suggesting an extrapolation bias.

The implicit approach adopted in this thesis infers the ERP from observed market prices. Claus and Thomas (2001) and Gebhardt, Lee, and Swaminathan (2001) pioneered this method, which involves extracting the implied discount rate that equates the market price to the present value of expected future cash flows. Easton (2004) formalizes the relationship between the P/E ratio, the PEG ratio, and the implied cost of capital, providing a directly applicable operational framework. Pástor, Sinha, and Swaminathan (2008) demonstrate that the implied equity premium (IEP) is more informative than the historical premium for predicting future returns, as it reflects the market's conditional expectations at every point in time. This result underpins our methodological choice: in the context of studying the impact of monetary policy, a forward-looking and responsive measure is essential to capture the effects of precisely dated ECB interventions.

The choice between these three approaches is not neutral when analyzing the effect of monetary policy. The historical approach, by measuring realized returns, captures the ex post effect of ECB interventions on asset prices, without distinguishing between the portion attributable to revised dividend expectations and that attributable to the compression of the risk premium itself. The implied approach, on the other hand, directly isolates the forward-looking component of the premium demanded by investors, which is the theoretically relevant variable for assessing the effect of monetary policy on the cost of capital. This methodological distinction justifies the choice of the implied ERP as the dependent variable in this thesis and distinguishes us from studies that use realized stock returns as a proxy for the ERP (Bernanke and Kuttner, 2005; Rosa, 2015).

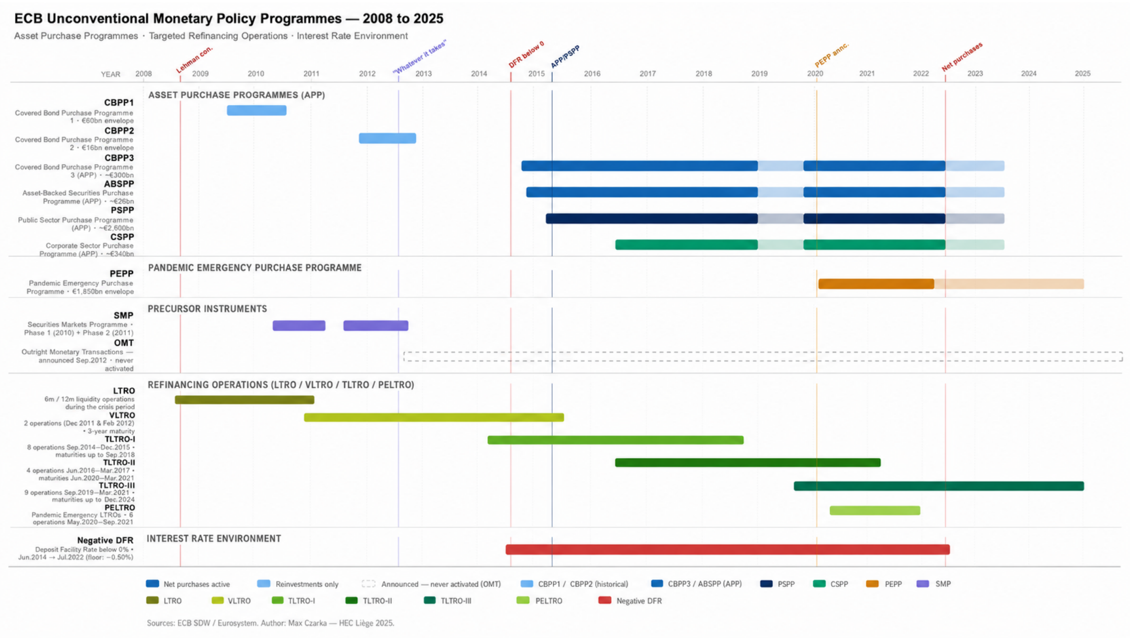
1.1.4 The forward P/E ratio as a measure of implied ERP

The specific measure used in this paper is based on Gordon's decomposition (1962). The constant growth model expresses the present value of a stock as $P = D_1 / (k - g)$, where k denotes the return expected by the investor and g denotes the perpetual dividend growth rate. Rearranging, $k = D/P + g$, i.e., the sum of the dividend yield and the growth rate. Campbell and Shiller (1988) and Fama and French (1988) establish the empirical foundation for this decomposition, showing that the dividend yield and the earnings yield (E/P) are robust predictors of future stock market returns.

By substituting the dividend yield with the earnings yield derived from the I/B/E/S forward consensus, we obtain the operational formula $ERP = E/P + g - R_f$, where E/P is the inverse of the 12-month forward P/E ratio, g is the expected long-term growth rate, and R_f is the benchmark sovereign yield. Damodaran (2024) documents this methodology in detail and applies it annually to the U.S. market, providing a benchmark. The main advantage of this approach is its responsiveness to market conditions: the forward P/E incorporates revisions to earnings expectations in near real time, making it a suitable tool for studying the effects of monetary policy. Its main limitation lies in its reliance on analyst forecasts, which are known for their systematic optimistic bias (Fama & French, 1988), a point addressed in the discussion of the results.

1.2 The ECB’s Unconventional Monetary Policy: Framework and Instruments

Figure 1 – ECB Unconventional Monetary Policy Programmes (2008–2025)



1.2.1 From Conventional to Unconventional: A Paradigm Shift

The 2008 global financial crisis forced central banks to fundamentally rethink their toolkit. When policy rates reached the effective lower bound (ELB), conventional instruments, such as adjusting short-term interest rates, proved insufficient to stimulate the economy. Bernanke (2020), in his presidential address to the American Economic Association, summarizes this paradigm shift and documents the emergence of three new instruments: large-scale asset purchases (quantitative easing), forward guidance, and negative interest rate policy. Joyce, Miles, Scott, and Vayanos (2012) provide a rigorous introduction to these tools in a landmark special issue of the Economic Journal.

In the specific case of the ECB, Hartmann and Smets (2018) trace the first twenty years of European monetary policy, identifying three distinct phases: a conventional phase (1999–2007), a crisis management phase (2008–2014), and a phase of large-scale unconventional deployment (2015–2018). Rostagno, Altavilla, Carboni, Lemke, Motto, Saint Guilhem, and Yiangou (2019) extend this timeline through 2019, documenting in detail the operational architecture of each program. Dell’Ariccia, Rabanal, and Sandri (2018) place the ECB’s experience in a comparative perspective with the Bank of Japan and the Bank of England, showing that institutional differences (funding structure, market fragmentation, mandate) determine the effectiveness of the instruments.

1.2.2 Asset Purchase Programs

Asset purchase programs are the most visible component of the ECB’s unconventional policy. Five major programs have been rolled out in succession: the Covered Bond Purchase Program (CBPP, launched in 2009), the Asset-Backed Securities Purchase Programme (ABSPP, 2014), the Public Sector Purchase Programme (PSPP, 2015), the Corporate Sector Purchase Programme (CSPP, 2016), and the Pandemic Emergency Purchase Programme (PEPP, 2020). Altavilla, Carboni, and Motto (2021), in their landmark study published in the International Journal of Central Banking, analyze the impact of these programs on financial markets, documenting a significant effect on sovereign bond yields and credit spreads, but a more ambiguous effect on equity markets.

Koijen, Koulischer, Nguyen, and Yogo (2021) take an original approach by modeling QE as a demand shock within a portfolio equilibrium framework (demand system approach). They show that PSPP purchases compressed bond yields not only for the securities purchased but also for close substitutes, via a cascading rebalancing effect. Eser and Schwaab (2016) specifically assess the impact of the Securities Markets Programme (SMP, 2010–2012), the precursor to the APP, on sovereign spreads in peripheral countries, documenting a significant but temporary reduction in sovereign risk premiums. Andrade, Breckenfelder, De Fiore, Karadi, and Tristani (2016) provide an early assessment of the APP that confirms the program's effectiveness in the bond market.

The PEPP, launched in March 2020 in response to the pandemic shock, is distinguished by its increased flexibility in terms of geographic allocation and targeted maturities (Lane, 2020). The ECB (2022) published an initial review of the PEPP confirming its stabilizing role during the acute phase of the COVID-19 crisis. More recently, the creation of the Transmission Protection Instrument (TPI) in July 2022 (ECB, 2022) illustrates the institutionalization of a permanent stabilization tool, designed to be deployed in response to episodes of fragmentation, a point that our empirical results will shed light on.

Starting in March 2023, the ECB began a process of quantitative tightening (QT) by ceasing to reinvest maturing securities in the APP portfolio, followed by a gradual reduction of the PEPP portfolio beginning in July 2024. This policy reversal, unprecedented in the ECB's history, automatically reduces the size of the balance sheet and could exert upward pressure on risk premiums. The literature on the effects of QT remains in its infancy, but early studies suggest a potential asymmetry: the withdrawal of liquidity could affect risk premiums more strongly than their injection compressed them, due to investors' loss aversion and the non-linearity of stock effects (D'Amico and King, 2013). Our study period (2004–2025) allows us to observe the initial effects of this normalization on the ERP.

1.2.3 Refinancing operations

The second pillar of the unconventional policy is based on long-term refinancing operations. The three-year VLTROs (Very Long-Term Refinancing Operations) in December 2011 and February 2012 injected more than one trillion euros of liquidity into the banking system, stabilizing the interbank market in the midst of the sovereign debt crisis (Garcia-de-Andoain, Heider, Hoerova, and Manganelli, 2016). However, in the absence of conditions on the use of funds, a significant portion of this liquidity was directed toward the purchase of high-yield sovereign bonds rather than toward lending to the real economy, reinforcing the sovereign-bank nexus that the ECB was specifically seeking to mitigate. To address this weakness, the Targeted Long-Term Refinancing Operations (TLTROs), introduced in 2014 and expanded in three successive waves, introduced an innovation by making the refinancing rate contingent on the actual volume of loans granted to businesses and households. Carpinelli and Crosignani (2021) and Benetton and Fantino (2021) document the effectiveness of this conditional mechanism, showing that participating banks did indeed increase their credit supply. The PELTROs (2020) supplemented the program during the pandemic crisis.

1.2.4 Interest Rate Policy and Forward Guidance

The ECB lowered its deposit facility rate into negative territory in June 2014, ushering an era of negative interest rate policy (NIRP) unprecedented in European monetary history. Heider, Saidi, and Schepens (2019) analyze the impact of this policy on bank lending behavior, revealing heterogeneous transmission depending on institutions' deposit structures. Brunnermeier and Koby (2018) theorize the concept of a reversal rate, below which negative interest rate policy becomes counterproductive for financial intermediation.

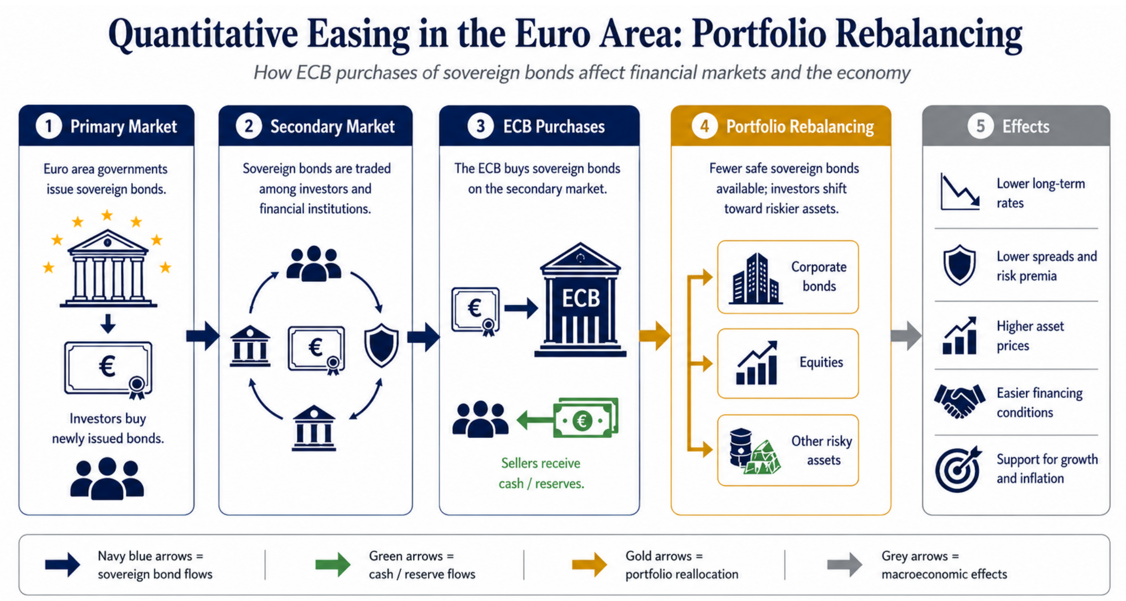
Forward guidance completes the toolkit by anchoring expectations of future rates. Campbell, Evans, Fisher, and Justiniano (2012) distinguish between Delphic guidance (statements of forecasts) and Odyssean guidance (conditional commitments), showing that only the latter produces a significant effect on the yield curve. Coenen, Ehrmann, Gaballo, Hoffmann, Nakov, Nardelli, Persson, and Strasser (2017) specifically examine the ECB's communication in an unconventional environment.

1.3 Channels for distributing information to the equity markets

Identifying the channels through which unconventional monetary policy affects the equity risk premium is essential for interpreting empirical results. Krishnamurthy and Vissing-Jorgensen (2011), in their seminal study of the Federal Reserve's programs, propose a taxonomy of channels that has become the standard in the literature. Four main channels are identified.

1.3.1 The portfolio rebalancing channel

Figure 2 – The Portfolio Rebalancing Channel: Transmission Mechanism of QE



(Author: Max Czarka – HEC Liège 2026)

The portfolio rebalancing channel is the central transmission mechanism of quantitative easing. Rooted in Tobin's (1969) general monetary equilibrium theory, this channel posits that the central bank's massive purchases of government bonds reduce the supply of safe assets available to private investors. Faced with this scarcity, investors rebalance their portfolios toward riskier assets, such as corporate bonds and stocks, thereby compressing risk premiums in these segments.

Vayanos and Vila (2021) formalize this mechanism in a preferred-habitat model, showing that scarcity effects propagate along the yield curve and across asset classes. D'Amico and King (2013) distinguish between flow effects (related to the pace of purchases) and stock effects (related to the cumulative volume of assets held), a distinction particularly relevant to our empirical specification, which simultaneously incorporates flows (APP) and stocks (total balance sheet). Joyce, Lasaosa, Stevens, and Tong (2011) document a significant rebalancing effect for the Bank of England's program, with spillovers to equity markets. Greenwood and Vayanos (2014) establish the theoretical link between bond supply and excess risk premiums.

The empirical evidence regarding the rebalancing channel is substantial. D'Amico and King (2013) document a significant stock effect of the Fed's purchases on bond yields, while Carpenter et al. (2015) show that institutional investors do indeed reallocate their portfolios toward risky assets in response to QE. In the EU context, Koijen, Koulischer, Nguyen, and Yogo (2021) estimate that the APP program compressed sovereign spreads by 60 to 100 basis points depending on the country, with significant spillover effects into equity markets via the asset substitution mechanism. This causal chain, from sovereign bonds to risky assets, forms the theoretical basis of our H1 hypothesis.

1.3.2 The signaling channel and the effects of trust

The signaling channel operates through the information that monetary policy decisions convey about the future path of interest rates. Bauer and Rudebusch (2014) show that a substantial portion of the effect of the Fed's asset purchases on long-term rates comes through downward revisions to expectations of future policy rates, rather than through a compression of the term premium. Krishnamurthy, Nagel, and Vissing-Jorgensen (2018) extend this analysis to the ECB and explicitly identify the active channels for the SMP and OMT: the signaling channel and the default channel are dominant, while the scarcity channel is secondary.

In the case of the eurozone, the confidence channel is of particular importance. Draghi's "whatever it takes" statement (2012) is the classic example of a pure signaling effect: the verbal announcement was enough to reverse the dynamics of the sovereign debt crisis, without the ECB having to activate OMT purchases. Altavilla, Giannone, and Lenza (2016) estimate that OMT-related announcements reduced Italian and Spanish sovereign spreads by 200 basis points and had a significant positive effect on stock market returns. Acharya, Eisert, Eufinger, and Hirsch (2019) document the actual effects of this episode on bank credit and business investment.

1.3.3 The risk-taking channel and premium compression

The risk-taking channel, theorized by Borio and Zhu (2012), describes the mechanism by which a prolonged low-interest-rate environment encourages financial intermediaries to increase their risk exposure (search for yield). This behavior, which is rational at the individual level, leads to an aggregate compression of risk premiums that may be excessive from a financial stability perspective. Bekaert, Hoerova, and Lo Duca (2013) provide the most influential empirical evidence by showing that monetary policy easing simultaneously reduces perceived risk aversion (measured by the VIX) and the risk premium demanded by investors. This result is directly relevant to our analysis, where the VSTOXX is used as a stress indicator and control variable.

Hattori, Schrimpf, and Sushko (2016) extend this analysis by showing that unconventional monetary policy also reduces perceptions of tail risk, a mechanism that is particularly active during periods of stress. Jiménez, Ongena, Peydró, and Saurina (2014), using Spanish micro-banking data, document that low interest rates encourage banks to grant riskier loans, confirming the existence of the risk-taking channel at the microeconomic level. This channel operates in the opposite direction of the portfolio rebalancing channel: while the former compresses risk premiums potentially to an excessive degree, the latter reflects a rational adjustment in asset allocation.

The resulting "search for yield" phenomenon has been extensively documented. Rajan (2005) had predicted, even before the 2008 crisis, that keeping key interest rates too low would encourage excessive risk-taking in the financial system. Jiménez, Ongena, Peydró, and Saurina (2014), using granular data from the Spanish credit registry, confirm that banks relax their lending criteria when rates are low, a mechanism that is transmitted to equity markets via the leverage effect. For our study, this channel is particularly relevant because it suggests an asymmetric effect: during periods of stress, risk aversion outweighs the search for yield, which could explain why the effect of ECB interventions on the ERP is detectable only during these episodes.

1.3.4 The Sovereign-Bank Nexus in the Eurozone

The euro area has a structural feature that shapes the transmission of monetary policy to equity markets: the sovereign-bank nexus, often referred to as the "doom loop." Acharya, Drechsler, and Schnabl (2014) formalize this mechanism: a deterioration in sovereign credit weakens bank balance sheets (through holdings of government bonds), which reduces lending capacity, deepens the recession, and in turn worsens public finances. Farhi and Tirole (2018) theorize this interaction as a "deadly embrace" equilibrium, the breaking of which requires external intervention, precisely the role played by the ECB.

Altavilla, Pagano, and Simonelli (2017) demonstrate empirically that banks' exposure to domestic sovereign risk amplifies the transmission of sovereign stress to the credit market and, ultimately, to the valuations of banking and non-banking stocks. De Grauwe (2012) and De Grauwe and Ji (2013) document the self-fulfilling nature of sovereign crises in the eurozone: in the absence of an explicit lender of last resort, default expectations become self-fulfilling, a dynamic that the ECB's intervention via the OMT and asset purchase programs helped to break. This sovereign-bank channel is fundamental to understanding the cross-country heterogeneity tested by our hypothesis H3, as it predicts a differentiated effect between core countries (low exposure) and peripheral countries (high exposure).

1.4 Empirical Evidence on Central Bank Interventions and the Equity Risk Premium

1.4.1 Evidence from the Federal Reserve

The empirical literature on the relationship between monetary policy and stock markets has been developed primarily in the U.S. context, which serves as a benchmark for European studies. Bernanke and Kuttner (2005) established the seminal finding: an unexpected 25-basis-point cut in the federal funds rate is associated with a 1% rise in stock prices on the day of the announcement. Most of this effect stems from a reduction in the equity risk premium rather than from a revision of dividend expectations or the risk-free rate.

Gagnon, Raskin, Remache, and Sack (2011) evaluate the Fed's Large-Scale Asset Purchases (LSAP) and document a significant compression of the term premium on Treasury bills, with spillover effects into corporate bonds and stocks. Rogers, Scotti, and Wright (2014) extend the analysis to a multi-central-bank comparison (Fed, ECB, Bank of England, Bank of Japan), showing that the effects on equity markets are generally weaker for the ECB than for the Fed. Swanson (2021) proposes a methodologically innovative decomposition of the effects of unconventional monetary policy into three dimensions: changes in the policy rate, forward guidance, and asset purchases. He shows that these instruments have distinct impacts on stock market returns and on different asset classes, acting through specific channels.

Rosa (2015) finds that FOMC announcements have a significant impact on the volatility and levels of stock indices, with asymmetric effects between expansionary and restrictive announcements. This work establishes an important methodological benchmark for our study, which adapts this decomposition to the specific context of the ECB by distinguishing three intervention proxies with distinct characteristics.

1.4.2 Evidence from the ECB: Aggregate Euro Area Studies

Studies focusing specifically on the ECB are more recent and often center on bond markets. Altavilla, Carboni, and Motto (2021) document a significant effect of the APP on government and corporate bond yields, but a more ambiguous effect on equity markets. Fratzscher, Lo Duca, and Straub (2016) analyze the impact of the ECB's unconventional measures on international capital flows and asset prices, showing a positive effect on European stock prices, primarily through the confidence channel. Georgiadis and Gräb (2016) confirm a significant impact of the announcement of the APP on global stock market indices.

Krishnamurthy, Nagel, and Vissing-Jorgensen (2018) provide the most comprehensive analysis of the ECB's specific transmission channels. By analyzing the SMP and OMT episodes, they show that the default channel (reduction in sovereign credit risk) and the signaling channel dominate, while the scarcity channel plays a secondary role. Boeckx, Dossche, and Peersman (2017), in a structural VAR study, estimate that a positive ECB balance sheet shock increases euro area GDP and inflation in a statistically significant manner, thereby validating the use of balance sheet size as a proxy for the intensity of unconventional policy. Altavilla, Brugnolini, Gürkaynak, Motto, and Ragusa (2019) constructed the EA-MPD (Euro Area Monetary Policy Database), which measures high-frequency monetary policy surprises and has since become the standard in the literature for event studies in the euro area.

1.4.3 Cross-country heterogeneity within the euro area

The euro area is not a homogeneous bloc, and several studies document differentiated transmission of monetary policy across countries. Burriel and Galesi (2018) use a global VAR (GVAR) model to show that the effects of unconventional policy on GDP and inflation are more pronounced in peripheral countries (Spain, Italy) than in core countries (Germany, France). Hachula, Piffer, and Rieth (2020) identify asymmetric fiscal rebalancing effects, with peripheral countries benefiting more from the reduction in sovereign financing costs.

Altavilla, Giannone, and Lenza (2016) provide the study most directly relevant to our hypothesis H3. By analyzing the effect of OMT announcements on a country-by-country basis, they show that the reduction in sovereign spreads is concentrated in Italy and Spain, with virtually no effect in Germany. This heterogeneity in bond market transmission may spill over to equity markets via the sovereign-bank nexus discussed in Section 1.3.4. However, nearly all of these studies focus on bond spreads or the macroeconomy; few explicitly analyze the equity risk premium at the national level.

1.4.4 The role of financial stress as a moderating factor

A growing body of literature recognizes the nonlinearity of the monetary transmission mechanism: the effectiveness of policy instruments depends on the market conditions in which they are deployed. Bloom (2009) shows that uncertainty shocks have asymmetric effects on economic activity, with deeper impacts during recessions than during expansions. Baker, Bloom, and Davis (2016) construct the Economic Policy Uncertainty (EPU) index, documenting its negative impact on investment and asset valuations. Caldara, Fuentes-Albero, Gilchrist, and Zakrajšek (2016) distinguish between financial shocks and uncertainty shocks, showing that the former has a more severe macroeconomic impact.

Hollo, Kremer, and Lo Duca (2012) developed the Composite Indicator of Systemic Stress (CISS), an aggregate stress indicator for the euro area, which serves as an alternative to the VSTOXX for capturing episodes of systemic stress. Adrian, Boyarchenko, and Giannone (2019) formalize the concept of "vulnerable growth," showing that the conditional distribution of GDP becomes highly asymmetric during periods of financial stress, which mechanically amplifies the risk premium demanded by investors. This work provides the theoretical foundation for our Hypothesis H2, which posits an amplification of the ECB effect during periods of stress. Nonlinearity is operationalized in our empirical framework by introducing an interaction term between the ECB proxy and a stress indicator based on the VSTOXX.

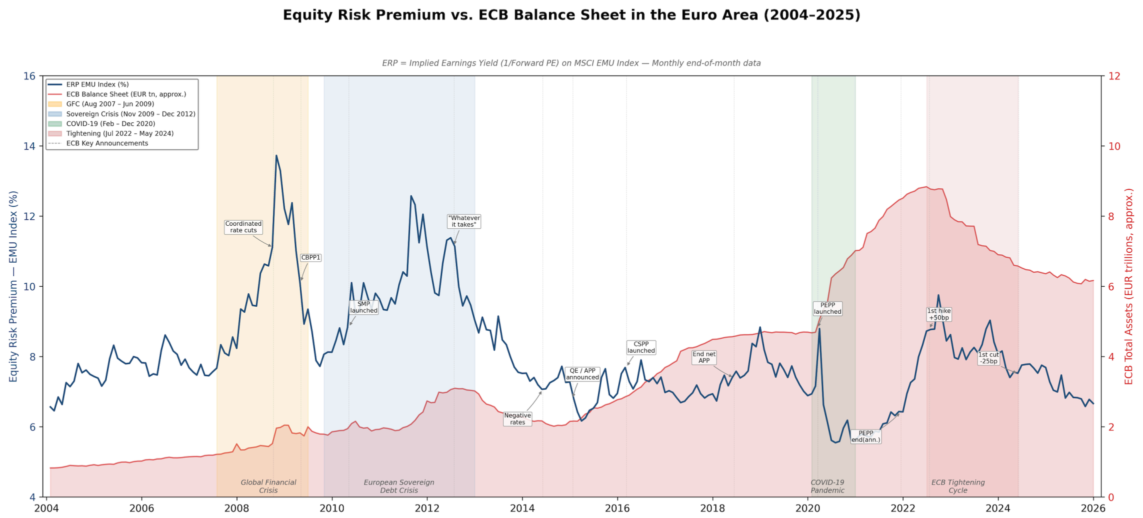
Literature on regime-dependent transmission provides further insight. Hubrich and Tetlow (2015) develop a Markovian regime-switching model for the euro area and show that the effects of monetary policy are significantly amplified during periods of financial stress. Pelizzon, Subrahmanyam, Tomio, and Uno (2016), in analyzing the Italian sovereign bond market, document that market liquidity deteriorates sharply beyond certain stress thresholds, creating nonlinearities in the transmission of ECB interventions. These results support our choice to model the effect of ECB interventions via an interaction term with a stress indicator based on the 90th percentile VSTOXX, rather than imposing a linear relationship that would mask the regime dependence identified by this literature.

2. Data and Variables

This chapter presents the data used to test the three hypotheses formulated in the introduction. It is divided into five sections. Section 2.1 explains the rationale for selecting the 2004–2025 time frame and describes the institutional and commercial sources used. Section 2.2 details the construction of the dependent variable, the equity risk premium (ERP), estimated using the implicit forward P/E ratio method, grounded in the Gordon-Shapiro framework. Section 2.3 lists the explanatory variables related to the monetary policy of the European Central Bank (ECB): asset purchase programs, refinancing operations, balance sheet size, and key interest rates. Section 2.4 introduces the macroeconomic control variables and the financial stress indicator. Section 2.5 provides a descriptive summary of the sample. The set of time series used covers 264 monthly observations, from January 2004 to December 2025, and feeds into a consolidated database.

2.1. Sample Period and Data Sources

Figure 3 – Implied Equity Risk Premium and ECB Balance Sheet, Euro Area (2004–2025)



(Source : ECB SDW / Refinitiv Author : Max Czarka – HEC Liège 2026)

2.1.1. Rationale for the 2004-2025 window

The study period covers January 2004 through December 2025, comprising 264 monthly observations. This choice is based on three key considerations. First, the start date coincides with the stabilization of the ECB's institutional framework following the integration of the ten new member states in 2004 and the publication of the first revised monetary policy strategy (European Central Bank, 2003), ensuring relative homogeneity in the operational framework across the entire sample. Second, the window encompasses all major episodes of unconventional monetary policy: the global financial crisis (2008–2009), the sovereign debt crisis (2010–2012), the launch and expansion of the Asset Purchase Program (2014–2018), the pandemic shock and the Pandemic Emergency Purchase Programme (2020–2022), followed by normalization and quantitative tightening (2022–2025) (Rostagno et al., 2019; Altavilla, Carboni & Motto, 2021). Third, the consistent availability of implied ERP series calculated from I/B/E/S consensus forecasts begins in 2003–2004 for most major European indices (Damodaran, 2024), which sets a lower bound beyond which data quality deteriorates.

The upper bound (December 2025) allows for the inclusion of the quantitative tightening (QT) phase and the rate hikes of 2022–2024, which is essential for testing the potential symmetry of the relationship between ECB interventions and ERP. The window thus covers three distinct monetary regimes, conventional, unconventional expansionary, and unconventional restrictive, a condition identified by Krishnamurthy, Nagel, and Vissing-Jorgensen (2018) as essential for the empirical identification of transmission channels.

2.1.2. Data providers and frequency

The data are sourced from institutional and commercial sources, selected for their reliability, methodological consistency, and accessibility from the HEC Liège library.

The structure of the sources is as follows:

- **ECB Statistical Data Warehouse (SDW)** for all monetary policy and financial stability variables. These data include outstanding balances from asset purchase programs, notably the APP, the PEPP, and their various components; Eurosystem refinancing operations, such as MROs, LTROs, TLTROs, and PELTROs; the Eurosystem's consolidated balance sheet; key policy rates (MRO rate, Deposit Facility Rate, and Marginal Lending Facility rate); and the M3 monetary aggregate. The CISS index, used as an indicator of systemic stress in the euro area, is also extracted from this source.
- **Refinitiv Eikon / Datastream** for all macroeconomic and financial data used in the study. Macroeconomic variables relating to the euro area and its member states include, in particular, GDP, the Harmonized Index of Consumer Prices (HICP), and the industrial production index. Financial market data, meanwhile, includes stock market index series, I/B/E/S consensus forecasts, notably 12-month forward earnings and forward P/E ratios, the VSTOXX implied volatility index, as well as benchmark sovereign bond yields, such as the 10-year German Bund.
- **STOXX Ltd**. for the associated methodological documentation (STOXX Limited, 2020).

The selected frequency is monthly. This choice reflects a trade-off between temporal granularity and the availability of explanatory variables, particularly ECB outstanding balances, which are mostly published at the end of the month, while providing a sufficient number of observations for econometric inferences (T = 264, well above the conventional threshold of 100 observations for multiple-specification regressions).

2.2. Dependent Variable: The Equity Risk Premium

2.2.1. ERP construction via the forward P/E ratio (IEP approach)

The key dependent variable in this thesis is the implied equity premium (IEP). It is measured monthly for the main index (MSCI EMU Index), as well as for the indices and countries used in the robustness tests. The implied approach is chosen over the historical average for three reasons documented in the literature. First, the IEP is forward-looking, reflecting market expectations at a given point in time, whereas the historical ERP is, by definition, backward-looking (Damodaran, 2024). Second, the IEP is more responsive to changes in macroeconomic and monetary conditions, which is essential for identifying the effect of precisely dated ECB interventions (Pástor, Sinha & Swaminathan, 2008). Third, the historical average suffers from a temporal selection bias, as the premiums observed in the United States in the 20th century may have overestimated the expected ERP (Fama & French, 2002). The IEP partially overcomes this criticism.

The IEP is calculated monthly using the simplified formula ERP = 1/PE_forward, where PE_forward denotes the 12-month forward price-to-earnings ratio (forward P/E) derived from the I/B/E/S consensus aggregated at the index level. This approach, known as the earnings yield approach, assumes that the inverse of the forward P/E provides a reasonable approximation of the expected return on stocks (Damodaran, 2020). Unlike a full implementation of the Gordon-Shapiro model (which would require an explicit estimate of the growth rate g and the risk-free rate R_f), our measure directly uses the earnings yield as a proxy for the implied equity risk premium, in line with Fama and French (2002) and Damodaran (2020). The forward P/E is derived from the I/B/E/S consensus. Data are extracted via Refinitiv Eikon/Datastream.

2.2.2. Theoretical Rationale for the Earnings Yield Approach

The earnings yield approach (ERP ≈ 1/forward P/E) is consistent with the theoretical framework of the Gordon model (1962). Claus and Thomas (2001) show that E/P = 1/P/E is an unbiased estimator of the implied rate of return. Our implementation adopts this simplification: ERP ≈ 1/forward_PE, without explicitly estimating g or R_f, thereby eliminating strong assumptions about the long-term growth rate. This approach is consistent with Damodaran (2020).

This approach has a well-identified limitation: sensitivity to analyst forecasts, which are known for their systematic optimistic bias (Fama & French, 1988). Two corrective measures are implemented: (i) use of the 12-month forward P/E rather than longer-term forecasts, which are less prone to bias; (ii) graphical and statistical inspection of the series to detect any outliers.

2.2.3. Indices used

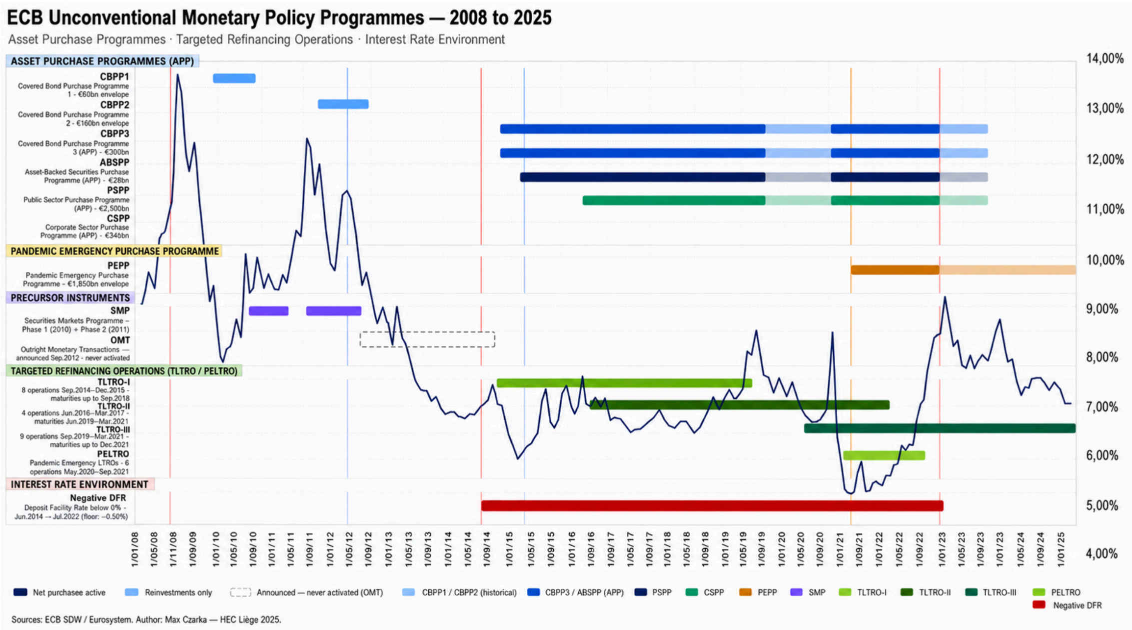
The main index is the MSCI EMU Index, which tracks the market capitalization of large and mid-cap companies listed in eurozone member states. Its strictly EMU-based scope ensures consistency with the ECB explanatory variable, as the Eurosystem's asset purchases target exclusively eurozone issuers. Three alternative indices are used to ensure robustness: the EURO STOXX 50 (50 eurozone blue-chips), the STOXX 600 (600 pan-European market-caps including the United Kingdom and Switzerland), and the EURONEXT 100 (100 market-caps listed on the Euronext platform). The inclusion of the STOXX 600 allows us to test whether the effect observed in the EMU is replicated in a scope that includes issuers outside the eurozone, a test that distinguishes the transmission channel.

2.2.4. Country-level ERP

Hypothesis H3 requires a cross-country dimension. To test it, the ERP is calculated at the national level for seven member states representing approximately 85% of the euro area's market capitalization: Germany (DE), France (FR), the Netherlands (NL), and Belgium (BE) for the core, and Italy (IT), Spain (ES), and Greece (GR) for the periphery. These countries are chosen for their diverse profiles, core versus periphery, and because Italy and Spain are precisely the countries where Altavilla, Giannone, and Lenza (2016) document the sharpest reduction in sovereign spreads following the OMT announcements, and to represent Greece, an emblematic case of the sovereign debt crisis, and for the consistent availability of their country-specific I/B/E/S index data over the entire time window. The national ERP is measured by the forward earnings yield (E/P), calculated as the inverse of the 12-month forward price-to-earnings ratio (forward P/E) derived from the Refinitiv I/B/E/S analyst consensus, for each country's national stock index. This measure serves as a standard proxy for the implied equity risk premium in the literature (Damodaran, 2012). Each country's 10-year sovereign rates are not subtracted in the construction of the variable but are included as control variables in the panel specifications, thereby isolating the effect of ECB interventions on the earnings yield net of the influence of the national risk-free rate. This approach allows us to empirically test whether the heterogeneity in transmission documented by Altavilla, Giannone, and Lenza (2016) for sovereign spreads is also present in the equity risk premium.

2.3. Independent Variables: ECB Policy Measures

Figure 4 – ECB Unconventional Monetary Policy Programmes (2008–2025)



2.3.1. Asset purchase programmes: monthly volumes and outstanding amounts

The ECB's asset purchase programs are the most visible component of its unconventional monetary policy. Seven programs are in effect, corresponding to the main programs launched since 2009: the Covered Bond Purchase Program (CBPP1 to CBPP3, launched in 2009); the Asset-Backed Securities Purchase Program (ABSPP, 2014); the Public Sector Purchase Program (PSPP, 2015); the Corporate Sector Purchase Programme (CSPP, 2016); and the Pandemic Emergency Purchase Programme (PEPP, 2020–2022). For each programme, two series are constructed: monthly net purchase flows (in billions of euros) and end-of-month outstanding amounts (in billions of euros). The flows capture the intensity of the intervention over a given horizon, while the outstanding amounts reflect the cumulative pressure exerted on the supply of eligible assets (Altavilla, Carboni & Motto, 2021; Koijen, Koulischer, Nguyen & Yogo, 2021).

A synthetic aggregate, denoted APP_All, sums the outstanding balances of all seven ECB asset purchase programs: CBPP1 (2009), CBPP2 (2011), CBPP3 (2014), ABSPP (2014), PSPP (2015), CSPP (2016), and PEPP (2020). This expanded aggregate, active since July 2009, captures the full scope of the ECB's purchase efforts, including emergency programs. The Securities Markets Programme (SMP, 2010–2012) and long-term refinancing operations (LTROs) are treated separately as additional explanatory variables due to their distinct operational structures (the SMP was sterilized, while LTROs are collateralized loans). Monthly changes in outstanding amounts are expressed in hundreds of billions of euros (ΔAPP_All / 10^{11}) to facilitate the interpretation of the coefficients. In addition, the change in SMP outstanding balances (ΔSMP / 10^{11}) and the change in LTRO outstanding balances (ΔLTRO / 10^{11}) are included as separate regressors in the augmented specifications.

2.3.2. Refinancing operations: MRO, LTRO, TLTRO, PELTRO

The Eurosystem's refinancing operations constitute the second pillar of unconventional monetary policy. There are four distinct types: (i) MROs (1-week maturity), whose rate serves as a monetary benchmark; (ii) LTROs, extended to 6, 12, and then 36 months, including the two VLTROs in December 2011 and February 2012 (≈€1 trillion to over 800 banks); (iii) TLTROs I, II, and III (2014–2021), which tie liquidity to lending targets (rates up to DFR−50 bps); (iv) pandemic PELTROs (2020–2021, DFR−25 bps). The total outstanding balance peaked at ≈€1.8 trillion in 2012 and ≈€2.2 trillion in 2021. In our specification, the effect of LTROs is captured by ΔLTRO_Total.

2.3.3. ECB balance sheet size and M3 money supply

The size of the Eurosystem's consolidated balance sheet (ECB_BS, in billions of euros) provides a summary measure of all interventions, whether they result from asset purchases or refinancing operations. It is used as the primary proxy for the intensity of unconventional monetary policy in univariate specifications, while disaggregated programs (APP_All, LTRO_Total) are utilized in the joint models. This strategy allows us to determine whether the overall effect is reflected in its specific components, following the approach of Rostagno et al. (2019). The broad monetary aggregate M3, also derived from the SDW, serves as a control variable for general monetary conditions.

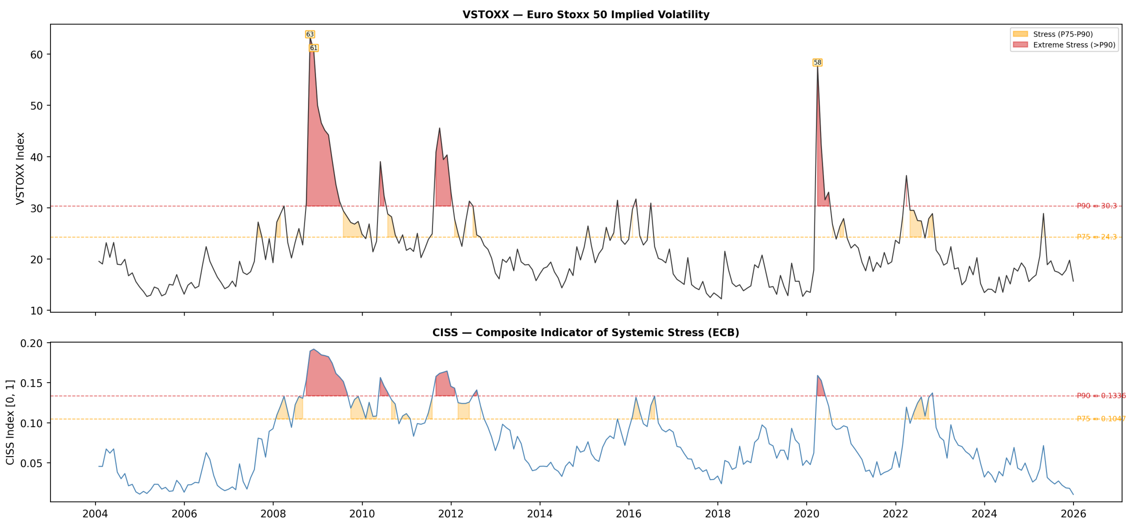
2.4. Control Variables

2.4.1. Macroeconomic controls: GDP growth, HICP inflation

The earnings yield framework requires an examination of the macroeconomic determinants of the equity risk premium in order to isolate the specific contribution of ECB interventions. Two key macroeconomic variables are included. The real GDP growth rate of the euro area (GDP_Growth), as a rolling annual rate, controls for the cyclical component of the ERP, as the premium is theoretically countercyclical (Bekaert, Engstrom & Xing, 2009). The Harmonized Index of Consumer Prices (HICP), expressed as an annual change, controls for the inflationary environment that simultaneously affects real earnings expectations (E) and the nominal risk-free rate (R_f). These variables are sourced from Refinitiv and linearly interpolated to achieve a monthly frequency consistent with the rest of the sample, when the original series are quarterly.

2.4.2. Financial stress indicator: VSTOXX

Figure 5 – Financial Stress Episodes: VSTOXX and CISS Indicators (2004–2025)



(Source : ECB SDW / Refinitiv Author : Max Czarka – HEC Liège 2026)

Hypothesis H2 posits that ECB interventions have an amplified effect during periods of financial stress. The primary measure of stress used is the VSTOXX, a 30-day implied volatility index calculated by STOXX Ltd. based on options on the EURO STOXX 50 (STOXX Limited, 2020). The VSTOXX is the European equivalent of the VIX and shares its informational properties; it anticipates tensions rather than noting them ex post and is available in real time. The empirical link between monetary policy and VSTOXX/VIX has been documented notably by Bekaert, Hoerova, and Lo Duca (2013), who identify a "risk-taking" channel through which monetary easing reduces the uncertainty premium.

Two operationalizations of stress are employed. In the continuous specification, the VSTOXX is included directly as a control variable. In the dichotomous specification (H2), a high-stress indicator (VSTOXX above its 90th percentile across the entire sample) is constructed and interacts with the main ECB variables. As a robustness measure, the Composite Indicator of Systemic Stress (CISS) proposed by Hollo, Kremer, and Lo Duca (2012) is also constructed as an alternative, aggregating tensions across five market segments (money, bonds, equities, foreign exchange, banking).

2.5. Summary Statistics

Table 1 – Descriptive statistics of variables

Variable	N	Mean	Median	Std. Error	Min	Max	Skew.	Kurt.
ΔERP (MSCI EMU)	263	0.0000	-0.0002	0.0049	-0.0217	0.0262	0.68	5.91
ΔLog(Bilan BCE)	263	0.0077	0.0045	0.0336	-0.1221	0.2543	1.92	14.29
ΔAPP_All (×10¹¹€)	263	0.1426	0.0000	0.3896	-1.2763	1.7097	0.95	1.76
ΔDFR	263	0.0000	0.0000	0.0015	-0.0100	0.0075	-0.40	15.13
ΔSMP (×10¹¹€)	263	-0.0000	0.0000	0.1461	-1.6450	1.4636	-1.34	97.04
ΔLTRO (×10¹¹€)	263	0.0000	0.0000	2.2318	-10.99	24.49	3.27	61.60
ΔVSTOXX	263	-0.0147	-0.5479	4.8796	-15.64	39.91	3.23	23.43
ΔHICP (YoY)	263	0.0000	0.0000	0.0036	-0.0170	0.0160	-0.27	4.21
ΔLog(PIB)	263	0.0025	0.0028	0.0024	-0.0036	0.0084	-0.17	0.98
ΔBund 10Y	263	-0.0001	-0.0002	0.0016	-0.0053	0.0073	0.39	1.98
ΔM3 (YoY)	263	-0.0001	0.0000	0.0050	-0.0230	0.0220	-0.29	2.77
ERP (MSCI EMU, niveau)	264	0.0802	0.0769	0.0145	0.0554	0.1373	1.18	1.72
VSTOXX (niveau)	264	21.67	19.52	8.0438	12.17	63.27	2.09	6.15

The consolidated database contains 264 monthly observations (January 2004 to December 2025) and 129 variables, grouped into four categories: (i) aggregate and country-specific ERP measures; (ii) ECB monetary policy variables (flows and stocks); (iii) macroeconomic and financial control variables; (iv) derived variables (first differences, log differences, stress indicators, interaction terms). The entire dataset is stored in Variables_Completes_Memoire.xlsx.

The implied equity risk premium on the MSCI EMU Index averages 8.02% over the entire sample (264 observations, February 2004 to December 2025), a minimum of 5.5% (July 2020), and a maximum of 13.7% (October 2008, peak of the global financial crisis). The standard deviation is 1.45 percentage points, reflecting marked temporal dynamics between periods of contraction (2005–2007, 2017–2019) and phases of expansion (2008–2012, 2020). The VSTOXX, a measure of implied volatility, averages 21.7 points with a maximum of 63.3 (March 2020, COVID-19 shock). The P90 threshold of the VSTOXX is set at 30.32 points, identifying 27 months of high financial stress in the sample.

The Augmented Dickey-Fuller (ADF) stationarity tests applied prior to estimation confirm that the level series of ERP and the ECB balance sheet have a unit root, while their first differences (ΔERP, ΔLog_ECB_BS) are stationary at the 1% level. Only the variable ΔAPP_All has an ADF t-statistic of −1.85, which does not reject H_0 at the conventional significance level. This characteristic, linked to the binary structure of the variable (long periods of zero outstanding amounts prior to 2009), is accounted for by the Newey-West correction of standard deviations.

The entire construction chain, from the raw sources to the transformed variables, can be fully reconstructed from the file Varaibles_Completes_Memoire.xlsx.

3. Methodology

This chapter details the empirical strategy implemented to address the research question: did the ECB's interventions reduce the equity risk premium in the euro area during periods of financial stress between 2004 and 2025?

- Section 3.1 presents the chosen econometric framework.
- Section 3.2 formalizes the three specifications corresponding to hypotheses H1, H2, and H3.
- Section 3.3 discusses the identification strategy and proposes a framework for event studies.
- Section 3.4 details the robustness tests.
- Section 3.5 lists the econometric diagnostics applied.

3.1 Econometric Framework

3.1.1 OLS with Newey-West HAC standard errors

The aggregate time series models (H1, H2) are estimated using ordinary least squares (OLS). Monthly financial series typically exhibit heteroskedasticity linked to episodes of stress and weak but non-zero residual autocorrelation, induced by the smoothing of the forward P/E ratio, which creates mechanical persistence in the data. The standard covariance matrix is therefore biased. To simultaneously correct for heteroskedasticity and autocorrelation, the inference relies on the HAC (*Heteroskedasticity and Autocorrelation Consistent*) estimator of Newey and West (1987), using a Bartlett kernel. The number of lags is determined according to the automatic rule of Newey and West (1994):

$$L = \lfloor 4 \cdot (T/100)^{2/9} \rfloor$$

For T = 263 observations (after losing one observation due to first differencing), this yields L = 4. Robustness checks using L = 3 and L = 5 confirm that the results are not sensitive to this choice.

The choice of the Newey-West method is validated *ex post* by the diagnostic tests in Section 3.5: the Breusch-Pagan test rejects homoscedasticity at the 1% level for all models, confirming the need for robust standard deviations. It is important to note that this correction adjusts only the variance-covariance matrix of the estimators; it does not introduce lagged regressors into the model. The specification remains contemporaneous, with all independent variables entering at time t. This choice is empirically supported by the correlation structure analysis (Appendix C.7, Figure 9), which tests cross-correlations between the independent variables and the ERP at lags 0 through 5 and confirms that the contemporaneous correlation (lag 0) is systematically the strongest.

3.1.2 Fixed-effects panel for countries using the cluster-robust and Driscoll-Kraay SE methods

The panel model (H3) uses a country-level fixed-effects estimator (*within estimator*), which accounts for structural differences in ERP levels across countries, differences attributable to sovereign risk, market depth, and sectoral composition. Country-level fixed effects are the natural choice in this context, as the periphery dummy variable is time-invariant and therefore cannot be identified as a random effect.

Inference relies on cluster-robust standard deviations at the country level. With clusters, the correction for degrees of freedom is applied, and the power limitation is noted. For robustness, the standard deviations of Driscoll and Kraay (1998) can be considered as an extension, capturing both cross-sectoral dependence and temporal autocorrelation, a relevant adjustment when European countries experience common shocks (sovereign crisis, COVID, monetary tightening).

3.2 Model Specifications

The dependent variable in all three specifications is the monthly change in the equity risk premium (ΔERP_t) rather than its level. There are two reasons for this choice. First, the first difference focuses on the ERP's sensitivity to policy shocks rather than its structural level. Second, it mitigates potential issues of non-stationarity in the level series, as confirmed by the ADF tests (Section 3.5.1). The primary dependent variable is ΔERP_{EMU} (MSCI EMU Index); alternative indices (EURO STOXX 50, STOXX 600, EURONEXT 100).

3.2.1 H1, Base Model

$$\Delta ERP_t = \alpha + \beta_1 \cdot \Delta \ln(BS_t) + \beta_2 \cdot \Delta APP_t + \beta_3 \cdot \Delta DFR_t + \beta_4 \cdot \Delta SMP_t + \beta_5 \cdot \Delta LTRO_t + \gamma' \mathrm{X}_t + \varepsilon_t$$

where:

- $\Delta \ln(BS_t)$ is the monthly logarithmic growth of the Eurosystem's consolidated balance sheet, a synthetic proxy for all interventions;
- ΔAPP_t Is the monthly change in the outstanding amount of the APP_All aggregate (CBPP1 + CBPP2 + CBPP3 + ABSPP + PSPP + CSPP + PEPP), in hundreds of billions of euros. This expanded aggregate, effective as of July 2009, captures the entirety of the ECB's purchase efforts, including emergency programs (PEPP) and the first covered bonds (CBPP1, CBPP2);
- $\Delta DFR_t$is the monthly change in the Deposit Facility Rate, in percentage points;
- ΔSMP_t is the monthly change in the outstanding balance of the Securities Markets Programme (2010–2012), in hundreds of billions of euros. The SMP is treated separately due to its distinct operational architecture (sterilized, unlike the APP);
- $\Delta LTRO_t$ is the monthly change in the total outstanding balance of long-term refinancing operations (LTRO + TLTRO + PELTRO), in hundreds of billions of euros. These operations constitute the second pillar of unconventional policy, acting through the bank credit channel;
- X_t is a vector of controls: $\Delta VSTOXX_t$((change in implied volatility), $\Delta HICP_t$ (change in annual inflation), $\Delta \ln(GDP)_t$ (monthly GDP growth via interpolation), $\Delta DE10Y$ (change in the 10-year Bund yield), and $\Delta M3_t$ (change in M3 growth).

Under H1, we expect $\beta_1 < 0$ (balance sheet expansion is associated with a decline in the ERP), $\beta_2 < 0$ (asset purchases compress the risk premium), $\beta_3 > 0$ (an increase in the deposit rate is associated with an increase in the ERP), $\beta_4 < 0$ (SMP interventions reduce the ERP), and $\beta_5 < 0$ (LTRO liquidity injections alleviate market tensions).

Two specification frameworks are estimated in parallel. The aggregate model includes only one ECB proxy at a time (either Δln(BS), ΔAPP, ΔDFR, ΔSMP, or ΔLTRO) to avoid multicollinearity among components. The joint model includes several proxies simultaneously. Specification (6) includes ΔLog_ECB_BS, ΔAPP_All, and ΔDeposit_Rate. Specification (7) adds ΔSMP, and specification (8), known as the full specification, incorporates all five ECB proxies simultaneously (BS + APP + DFR + SMP + LTRO). The VIFs remain below 5 in all specifications, confirming that multicollinearity does not compromise the validity of the inference. Each specification is estimated on the full sample (February 2004 to December 2025, N = 263).

3.2.2 H2, Model with stress × BCE interaction

To test whether the effect of the interventions is amplified during periods of financial stress, an interaction term is added to the baseline model:

H2a : $\Delta ERP_t = \alpha + \beta_1 \cdot \Delta Ln(BS)_t + \beta_2 \cdot \Delta APP_t + \beta_3 \cdot \Delta DFR_t + \beta_4 \cdot \Delta Dstress_t + \beta_5 \cdot (\Delta Ln(BS) \times Dstress)_t + \beta_6 \cdot (\Delta APP \times Dstress)_t + \gamma' \mathrm{X}_t + \varepsilon_t$

H2b : $\Delta ERP_t = \alpha + \beta_1 \cdot \Delta Ln(BS)_t + \beta_2 \cdot \Delta APP_t + \beta_3 \cdot \Delta DFR_t + \beta_4 \cdot \Delta SMP_t + \beta_5 \cdot \Delta LTRO_t + \beta_6 \cdot \Delta Dstress_t + \beta_7 \cdot (\Delta Ln(BS) \times Dstress)_t + \beta_8 \cdot (\Delta APP \times Dstress)_t + \beta_9 \cdot (\Delta SMP \times Dstress)_t + \beta_{10} \cdot (\Delta LTRO \times Dstress)_t + \gamma' X_t + \varepsilon_t$

The financial stress dummy variable is defined based on the VSTOXX:

$$D_{stress,t} = \begin{cases} 1 & \text{si } VSTOXX_t > Q_{90} \\ 0 & \text{sinon} \end{cases}$$

where Q_{90} denotes the 90th percentile of the VSTOXX distribution over the entire 2004–2025 sample (threshold = 30.32 points). This selection identifies 27 months of stress out of 264 (10.2% of the sample), corresponding to episodes of the global financial crisis, the sovereign debt crisis, the COVID-19 shock, and certain phases of monetary tightening.

The coefficients are interpreted as follows:

- β_1 *(resp.* β_2*,* β_3 *,* β_4*,* β_5*)* : effect of each ECB proxy under normal conditions (Dstress = 0);
- β_6 *(H2a:* β_4 *; H2b:* β_6*)* : difference in ΔERP levels between the two regimes;
- $\beta\ Interactionn$: differential effect of each ECB proxy during periods of stress, a parameter of interest for H2;
- β*direct* + β*interaction :* total effect of each ECB proxy under stress conditions.

Under H2, we expect *interaction* < 0 for the quantity proxies (BS, APP): the ERP compression effect is amplified during periods of stress. A Wald test formally verifies whether β*direct* + β*interaction interaction* = 0 (no total effect under stress) for each proxy. A joint Wald test assesses the overall significance of all interaction terms (H_0: all β_(interaction) = 0).

Specification H2a tests the interaction on the two main proxies (Δln(BS), ΔAPP), consistent with the joint specification (6) of H1. Specification H2b extends the analysis to the four proxies by adding ΔSMP and ΔLTRO with their respective interactions, allowing us to identify whether transmission channels during periods of stress differ depending on the instrument used. Both specifications are estimated on the full sample (N = 263) using Newey-West HAC standard errors (Bartlett's kernel, L = 4 lags).

3.2.3 H3, Panel cross-country

The hypothesis of cross-country heterogeneity is tested on a panel of seven eurozone countries: Germany (DE), France (FR), Belgium (BE), and the Netherlands (NL) for the core, and Italy (IT), Spain (ES), and Greece (GR) for the periphery. The country-fixed-effects model with a within transformation is estimated in three steps. The baseline model (11) tests the unconditional effect of the five ECB proxies by exploiting cross-country variation. The model with stress interactions (12) introduces the Stress_P90 dummy variable and its interactions with each ECB proxy, testing stress amplification in the panel setting. The full model (12b) adds Periphery interactions and the triple interactions Stress × Periphery, constituting the true test of hypothesis H3.

Base model (11):

$$\begin{aligned} \Delta ERP_{(i,t)} = \alpha_i &+ \beta_1 \cdot \Delta Ln(BS)_t + \beta_2 \cdot \Delta APP_{(t)} + \beta_3 \cdot \Delta DFR_{(t)} + \beta_4 \cdot \Delta SMP_{(t)} + \beta_5 \cdot \Delta LTRO_{(t)} \\ &+ \beta_6 \cdot \Delta Dstress_t + \gamma' X_{(i,t)} + \varepsilon_{(i,t)} \end{aligned}$$

Model with stress interactions (12):

$$\begin{aligned} \Delta ERP_{(i,t)} = \alpha_{(i)} &+ \beta_1 \cdot \Delta Ln(BS)_{(t)} + \beta_2 \cdot \Delta APP_{(t)} + \beta_3 \cdot \Delta DFR_{(t)} + \beta_4 \cdot \Delta SMP_{(t)} + \beta_5 \cdot \Delta LTRO_{(t)} \\ &+ \beta_6 \cdot \Delta Dstress_{(t)} + \beta_7 \cdot (\Delta Ln(BS) \times Dstress)_{(t)} + \beta_8 \cdot (\Delta APP \times Dstress)_{(t)} \\ &+ \beta_9 \cdot (\Delta SMP \times Dstress)_{(t)} + \beta_{10} \cdot (\Delta LTRO \times Dstress)_{(t)} + \gamma' X_{(i,t)} + \varepsilon_{(i,t)} \end{aligned}$$

Complete model with Periphery interactions (12b):

$$\begin{aligned}\Delta ERP_{(i,t)} = {} & \alpha_{(i)} + \beta_1 \cdot \Delta Ln(BS)_{(t)} + \beta_2 \cdot \Delta APP_{(t)} + \beta_3 \cdot \Delta DFR_{(t)} + \beta_4 \cdot \Delta SMP_{(t)} + \beta_5 \cdot \Delta LTRO_{(t)} \\ & + \beta_6 \cdot \Delta Dstress_{(t)} + \beta_7 \cdot (\Delta Ln(BS) \times Dstress)_{(t)} + \beta_8 \cdot (\Delta APP \times Dstress)_{(t)} \\ & + \beta_9 \cdot (\Delta SMP \times Dstress)_{(t)} + \beta_{10} \cdot (\Delta LTRO \times Dstress)_{(t)} \\ & + \delta_1 . \left(\Delta Ln(BS) \times D_{periph}\right)_i + \delta_2 . \left(\Delta APP \times D_{periph}\right)_i + \delta_3 . \left(\Delta SMP \times D_{periph}\right)_i \\ & + \delta_4 . \left(\Delta LTRO \times D_{periph}\right)_i + \ \phi_1 . \left(\Delta APP \times Dstress \times D_{periph}\right)_{(i,t)} \\ & + \phi_2 . \left(\Delta Ln(BS) \times Dstress \times D_{periph}\right)_{(i,y)} \gamma' \mathrm{X}_{(i,t)} + \varepsilon_{(i,t)}\end{aligned}$$

where:

- α(i) is the country fixed effect, accounting for permanent structural differences between countries (market size, sectoral structure, institutional quality);
- ΔLn(BS_t), ΔAPP(t), ΔDFR(t), ΔSMP(t), ΔLTRO(t) are the five ECB proxies defined in Section 3.2.1, common to all countries (time-varying variables only);
- D(stress,t) is the financial stress dummy (VSTOXX > P90 = 30.32), common to all countries;
- D(periph,i) is the periphery dummy variable (= 1 for ES, GR, IT; = 0 for BE, DE, FR, NL). This variable is time-invariant and therefore absorbed by the country fixed effects α(i), but its interactions with the ECB proxies are identifiable in the within transformation;
- δ_1 to δ_4 are the coefficients of the Periphery × ECB interactions, capturing the difference in effect between the core and the periphery under normal conditions;
- ϕ_1 and ϕ_2 are the coefficients of the triple interactions Stress × Periphery × ECB, capturing the difference in stress amplification between the two groups;
- X(i,t) includes common controls ($\Delta \mathrm{VSTOXX}_{(t)}$, $\Delta \mathrm{HICP}_{(t)}$, $\Delta \mathrm{Ln}_{(GDP_t)}$, $\Delta \mathrm{M3}_{(t)}$) and a country-specific control: the change in the 10-year sovereign yield of country i ($\Delta 10\mathrm{y}_{(i,t)}$). This country-specific control captures the sovereign spread dynamics specific to each Member State, an essential transmission channel in the context of the euro area.

The estimation strategy relies on a within transformation, which allows for the elimination of individual fixed effects through intra-country averaging. The standard errors are cluster-robust and grouped by country, with a total of G = 7 clusters, in accordance with Cameron, Gelbach, and Miller (2008). Given the limited number of clusters, statistical inference relies on a t(G-1) distribution, i.e., t(6), for individual tests, and on an F(q, G-1) distribution, i.e., F(q, 6), for joint Wald tests. This adjustment aims to limit the risk of over-rejection of null hypotheses in a context with a small number of clusters. The panel under study comprises a total of N = 7 × 263 = 1,841 observations, corresponding to 7 countries observed over 263 months.

The full model (12b) allows us to decompose the marginal effect of each ECB proxy into four regimes:

- Core, Normal: β_2 (direct effect of ΔAPP)
- Core, Stress: $\beta_2 + \beta_8$ (direct effect + stress interaction)
- Periphery, Normal: $\beta_2 + \delta_2$ (direct effect + periphery interaction)
- Periphery, Stress: $\beta_2 + \beta_8 + \delta_2 + \phi_1$ (direct effect + stress + periphery + triple)

The difference in effect between the periphery and the core during periods of stress is given by $\delta_2 + \phi_1$, tested by H_0: $\delta_2 + \phi_1 = 0$ using a Wald test. A joint F-test assesses the overall significance of the six Periphery interaction terms (H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \phi_1 = \phi_2 = 0$). Rejection of this null hypothesis would constitute a formal validation of H3.

Under hypothesis H3, the expected signs are $\beta_8 < 0$, indicating a stronger compression of the ERP by APP purchases during periods of stress, and $\delta_2 < 0$, reflecting a more pronounced effect in peripheral countries where the sovereign-bank nexus is stronger. The expected sign for the triple interaction ϕ_1 is also negative if we assume that the amplification under stress is stronger in the periphery. However, a null result ($\delta_2 \approx 0$, $\phi_1 \approx 0$) would also be informative, indicating a geographically homogeneous transmission despite the structural heterogeneity of the euro area.

To verify the robustness of the results, the Fama-MacBeth (1973) procedure is used as a cross-validation method. The coefficients are first estimated from T = 263 independent cross-sectional regressions, one regression per month, before being averaged over the entire period. The t-statistics derived from this approach, corrected according to a t(G-1) distribution (i.e., t(6)), provide a complementary inference independent of the temporal correlation structure of the errors. In addition, the country-specific sovereign spread, denoted ΔSpread(i,t), is substituted for the gross yield, and fixed-year effects are added to control for common time shocks that may simultaneously affect all countries in the panel.

3.3 Identification Strategy

3.3.1 Event Studies Based on BCE Announcements

Time-series regressions suffer from an endogeneity problem: the ECB's balance sheet is countercyclical by design, which makes it difficult to interpret the coefficients causally. To address this, event studies are conducted around 20 key ECB announcements using daily ERP data for the seven countries in the panel. Monetary policy announcements constitute informational shocks that are largely exogenous to same-day market conditions, in line with the methodology of Altavilla et al. (2019).

For each announcement, the cumulative abnormal return (CAR) is calculated as the difference between the observed change in the ERP over the event window and the expected average change, estimated by the constant average return (CAR) model (MacKinlay, 1997) over a 120-day estimation window. The event window used is [-1, +3] days. The significance of the average CARs (CAAR) is tested using a cross-sectional *t*-test and a nonparametric sign test. The results are presented by program and by country in Section 4.3.4.

3.3.2 Event windows and measurement of abnormal returns

For each selected announcement, the abnormal return (*Abnormal Return*, AR_j) is calculated as the difference between the observed change in the abnormal return over the event window and the estimated average expected change over a pre-event estimation window.

The cumulative average abnormal return (*Cumulative Average Abnormal Return*, $CAAR$) is calculated across all N events:

$$CAAR = \frac{1}{N}\sum_{j=1}^{N} AR_j$$

Its significance is tested using a test:

$$t_{CAAR} = \frac{CAAR}{\hat{\sigma}_{AR}/\sqrt{N}}$$

where $\hat{\sigma}_{AR}$ is the cross-sectional standard deviation of the AR_j . In addition, a nonparametric sign test is conducted to verify whether the proportion of events with $AR_j < 0$ is significantly greater than 50%.

CAARs are calculated separately by program type, by stress period (H2), and by country/group of countries (H3), allowing us to test the heterogeneity of the ERP's response to announcements.

3.4 Robustness Checks and Sensitivity Analyses

3.4.1 Alternative indices and ECB proxies

The main regressions, estimated using the MSCI EMU Index, are replicated with the EURO STOXX 50, the STOXX 600, and the EURONEXT 100 as alternative dependent variables. Any significant divergence is discussed in light of the indices' composition: the STOXX 600 includes non-eurozone components (United Kingdom, Switzerland) whose monetary policy is independent of the ECB.

Regarding ECB proxies, total purchases (Δ*Total_Purchases*), total interventions (Δ*Total_Interventions*), total outstanding LTRO (Δ*LTRO_Total*), and the change in the 3-month Euribor (Δ*Euribor_3M*) are substituted for the five main proxies (ΔLog_ECB_BS, ΔAPP_All, ΔDFR, ΔSMP, ΔLTRO). These substitutions allow us to verify that the results are not contingent on the choice of intervention measures.

3.4.2 Sub-periods and structural breaks

The temporal stability of the coefficients is examined through estimation across three sub-periods: pre-QE (2004–2014), active QE (2015–June 2022), and post-QE/tightening (July 2022–2025). Additional windows (2012–2019, post-2020) are also estimated. This decomposition allows us to assess whether the effect of ECB interventions, particularly the stress amplification documented in H2, is stable over time or concentrated in a specific episode.

The Bai and Perron (2003) procedure is applied to detect endogenous structural breaks in the ΔERP–intervention relationship. The estimated break dates are compared with known macrofinancial episodes (launch of QE in 2015, COVID-19 shock, *hawkish* pivot in 2022).

3.4.3 Alternative stress indicator: CISS

The stress dummy variable based on the VSTOXX (P90 threshold = 30.32; 27 out of 263 months triggered) is replaced by a dummy variable constructed using the *Composite Indicator of Systemic Stress* (CISS), proposed by Hollo, Kremer, and Lo Duca (2012). The CISS aggregates stress across five market segments (money, bonds, equities, foreign exchange, banking) and serves as a complementary measure to the VSTOXX, which captures only the implied volatility of equity options. The threshold used is the 90th percentile of the CISS over the sample. This robustness allows us to verify that the results of H2, notably the significant effect of APP_All×Stress ($t = -3.45$, $p < 0.001$), are not specific to the choice of stress indicator.

3.5 Econometric Diagnostics

All specifications are subject to a series of standard diagnostic tests, the results of which are summarized in Table 2 and detailed below.

Table 2 — Summary of Econometric Diagnostics

Test	Statistic	Threshold / Decision	Conclusion
ADF (Δ series)	t < −2.86 (except ΔAPP:−1.85)	Reject H_0 at 5%(except ΔAPP)	Stationary series
VIF - Model (8)	Max = 2.71 (ΔSMP)	< 5	Low multicollinearity
VIF - Model (12)	Max = 3.91 (ΔSMP×Stress)	< 5	Moderate multicollinearity
VIF - Model (12b)	Max = 5.40 (ΔBS×Stress)	< 5 (< 10 tolerated)	Acceptable (interactions)
Breusch-Pagan	LM ∈ [18 ; 23]	p < 0.01	Heteroskedasticity →Newey-West HAC
Durbin-Watson	DW ∈ [2.04 ; 2.07] (H1) DW ∈ [2.21 ; 2.24] (H3)	≈ 2 ≈ 2	No first-orderautocorrelation
Ljung-Box (6, 12)	p > 0.10	Do not reject H_0	No residualautocorrelation
Ramsey RESET	F significant (p < 0.01)	Reject H_0	Non-linearity →H2 interactions

3.5.1 Stationarity and Multicollinearity

Table 3 – ADF (Augmented Dickey-Fuller) Stationarity Tests

Variable	t-ADF	$Crit_{.05}$	N	Conclusion
ΔERP (MSCI EMU)	-7.075***	−2,860	258	I(0)
ΔLog(Bilan BCE)	-5.711***	−2,860	258	I(0)
ΔAPP_All (×10¹¹€)	-1.852	−2,860	258	Non rejetée
ΔDFR	-4.760***	−2,860	258	I(0)
ΔSMP (×10¹¹€)	-7.540***	−2,860	258	I(0)
ΔLTRO (×10¹¹€)	-6.994***	−2,860	258	I(0)
ΔVSTOXX	-9.016***	−2,860	258	I(0)
ΔHICP (YoY)	-5.016***	−2,860	258	I(0)
ΔLog(PIB)	-2.910**	−2,860	258	I(0)
ΔBund 10Y	-6.759***	−2,860	258	I(0)
ΔM3 (YoY)	-5.460***	−2,860	258	I(0)
ERP (MSCI EMU, niveau)	-2.768*	−2,860	258	Non rejetée
VSTOXX (niveau)	-3.703***	−2,860	258	I(0)

*Notes: ADF test with a constant and p = 4 lags. Critical values from MacKinnon (1996): −3.43 (1%), −2.86 (5%), −2.57 (10%). *** p < 0.01; ** p < 0.05; * p < 0.10. I(0) = stationary series.*

Stationarity: Augmented Dickey-Fuller (ADF) tests with a constant term and p = 4 lags are applied to all time series in both level and first-difference forms (see Table 3). The critical values from MacKinnon (1996) are: −3.43 (1%), −2.86 (5%), −2.57 (10%). The dependent variable ΔERP (t = −7.08***) and all first-difference explanatory variables are stationary at the 1% level, with the exception of ΔAPP_All (t = −1.85, not significant), for which the large number of zero values prior to July 2009 skews the ADF test. This variable remains stationary as a monthly net flow that is bounded by construction. The residuals of the estimated models are also stationary (rejection of H_0 at the 5% level in all cases), eliminating the risk of spurious regression.

Table 4 — Variance Inflation Factors (VIF)

Variable	Model (8) OLS	Model (10) OLS	Model (11) Panel FE	Model (12) Panel FE	Model (12b) Panel FE
ΔLog(BS)	1.22	2.36	1.22	2.33	4.06
ΔAPP	2.48	3.02	2.47	3.01	4.95
ΔDFR	1.24	1.36	1.20	1.33	1.33
ΔSMP	2.71	3.46	2.70	3.45	5.36
ΔLTRO	1.06	1.10	1.05	1.09	1.86
ΔVSTOXX	1.13	1.41	1.10	1.39	1.39
ΔHICP	1.13	1.17	1.11	1.15	1.15
ΔLog(PIB)	1.31	1.39	1.30	1.38	1.38
ΔBund 10Y	1.19				
ΔRate 10Y			1.02	1.04	1.05
ΔM3	1.07	1.18	1.03	1.12	1.12
Stress_P90		2.35		2.44	2.44
ΔLog(BS)×Stress		3.58		3.63	5.40
ΔAPP×Stress		3.15		3.17	4.06
ΔSMP×Stress		3.90		3.91	3.91
ΔLTRO×Stress		2.20		2.18	2.18
ΔAPP×Periph					4.51
ΔLog(BS)×Periph					4.05
ΔSMP×Periph					4.46
ΔLTRO×Periph					1.81
ΔAPP×Stress×Periph					2.09
ΔLog(BS)×Stress×Periph					4.02
Maximum VIF	**2.71**	**3.90**	**2.70**	**3.91**	**5.40**

Multicollinearity: The variance inflation factor (VIF) is calculated for each specification (see Table 4). In the baseline specification (Model 8), the maximum VIF is 2.71 (ΔSMP), well below the conventional threshold of 5. For the models with stress interactions (Models 10 and 12), the maximum VIF reaches 3.91 (ΔSMP×Stress), which remains below the threshold of 5. For the full panel model with periphery interactions (Model 12b), the maximum VIF is 5.40 (ΔLog(BS)×Stress), slightly above the strict threshold of 5 but well below the threshold of 10 recommended by Kutner et al. (2005). This slight overshoot is explained by the mechanical correlation between the interaction terms and their components, an expected phenomenon that does not invalidate the inference (Wooldridge, 2019). Multicollinearity is therefore low to moderate in all specifications.

3.5.2 Heteroskedasticity and autocorrelation

Heteroskedasticity: The Breusch-Pagan test rejects the null hypothesis of homoscedasticity at the 1% significance level for all specifications ($LM \in [18; 23]$, $p < 0.01$), justifying ex post the use of Newey-West standard deviations (Bartlett kernel, $L = 4$ lags).

Autocorrelation: The Durbin-Watson statistic ranges from 2.04 to 2.07 for the eight H1 specifications, within the range indicating no first-order autocorrelation. The Ljung-Box tests at 6 and 12 lags do not reject the null hypothesis of no residual autocorrelation ($p > 0.10$ in all cases), confirming the adequacy of the number of Newey-West lags.

For the panel models (models 11, 12, and 12b), standard heteroskedasticity and autocorrelation diagnostics do not apply directly. Inference is based on cluster-robust standard errors grouped by country ($G = 7$), which simultaneously correct for heteroskedasticity and intra-cluster correlation. The Durbin-Watson statistics for the panel models ($DW \approx 2.21$ to 2.24) nevertheless confirm the absence of first-order serial autocorrelation in the residuals.

3.5.3 Functional Specification

The Ramsey RESET test, which assesses the adequacy of the linear functional form by including powers of the fitted values, rejects the linear specification at the 1% significance level for the H1 models ($F = 6.03$, $p = 0.002$ for the joint model over the full sample). This rejection warrants three comments.

First, the RESET rejection is consistent with the non-linearity tested by H2: if the effect of ECB interventions is amplified during financial stress (as confirmed by the panel results in Model 12, where the stress interaction terms are jointly significant), the linear H1 specification is by construction misspecified when it omits the interaction term. The H2 model with interaction terms constitutes precisely the response to this non-linearity.

Second, the VSTOXX, included as a first-differenced control, is the primary determinant of ΔERP (partial $R^2 \approx 0.52$). Its relationship with the ERP may be non-linear (threshold effects), which the H2 interaction partially captures.

Third, despite the RESET rejection, OLS coefficients remain BLUE (*Best Linear Unbiased Estimators*) under standard assumptions, and Newey-West inference remains asymptotically valid. The rejection signals a loss of efficiency, not bias. This limitation is nonetheless discussed in the methodological caveats of Chapter 4.

4. Results and Discussion

This chapter presents the empirical results derived from the econometric strategy detailed in Chapter 3. The analysis proceeds in four stages.

- Section 4.1 presents the basic results of the aggregate time-series regressions (H1), testing the significance of the ECB intervention proxies.
- Section 4.2 introduces interaction terms with financial stress (H2).
- Section 4.3 extends the analysis to a cross-country panel of seven countries (H3).
- Finally, Section 4.4 provides a summary discussion and places the findings in the context of the existing literature.

All estimates are based on the unified database described in Chapter 2, comprising 264 monthly observations (February 2004–December 2025) for the aggregate time series and 1,841 observations for the seven-country panel. All variables are in first differences to ensure the stationarity of the series.

Before presenting the results, it is worth recalling the main characteristics of the sample. Of the 263 monthly observations, the average implied ERP for the aggregate euro area (MSCI EMU) stands at 8.02%, with a standard deviation of 1.45 percentage points, confirming substantial variability around this historical average. The average VSTOXX is 21.67 points, with a peak of 63.27 points reached during the COVID-19 crisis in March 2020. The stress dummy (VSTOXX > P90 = 30.32) identifies 27 months (10.3% of the sample).

4.1 Basic Results: Aggregate Effect of ECB Interventions on the ERP (H1)

Hypothesis H1 posits that ECB interventions, measured by the logarithmic change in the size of the balance sheet (ΔLog_ECB_BS), asset purchase flows (ΔAPP_All), changes in the deposit facility rate (ΔDFR), changes in outstanding SMP balances (ΔSMP), and changes in outstanding LTRO balances (ΔLTRO), do not have a statistically significant effect on the change in the implied equity risk premium in the euro area. Eight specifications are estimated: five univariate specifications including a single ECB proxy at a time (models 1 through 5), and three joint specifications progressively combining the proxies (models 6 through 8).

$$\Delta ERP_t = \alpha + \beta BCE_t + \gamma' X_t + \varepsilon_t$$

où BCE_t désigne le proxy d'intervention retenu et Xt le vecteur de variables de contrôle (ΔVSTOXX_Avg, ΔHICP_YoY, ΔLog_GDP, ΔRate10Y_DE, ΔM3_YoY). Huit spécifications sont estimées : cinq spécifications univariées incluant un seul proxy BCE (ΔLog_ECB_BS, ΔAPP_All, ΔDFR, ΔSMP, ΔLTRO), et trois spécifications jointes combinant progressivement les proxies (modèle 6 : BS+APP+DFR ; modèle 7 : +SMP ; modèle 8 : +LTRO, spécification complète).

Table 5 – Summary of H1 Regressions: Effect of ECB Interventions on ΔERP

	(1) BS	(2) APP	(3) DFR	(4) SMP	(5) LTRO	(6) Joint	(7) Étendu (+SMP)	(8) Complet (+LTRO)
Constante	-0.0003	-0.0003	-0.0002	-0.0003	-0.0003	-0.0001	-0.0001	-0.0001
	(0.0004)	*(0.0004)*	*(0.0004)*	*(0.0004)*	*(0.0004)*	*(0.0004)*	*(0.0004)*	*(0.0004)*
ΔLog(BS)	-0.0037					-0.0030	-0.0031	-0.0026
	(0.0086)					*(0.0092)*	*(0.0093)*	*(0.0092)*
ΔAPP		-0.0001				0.0001	0.0001	0.0001
		(0.0006)				*(0.0006)*	*(0.0006)*	*(0.0006)*
ΔDFR			0.2515			0.2456	0.2457	0.2420
			(0.1656)			*(0.1689)*	*(0.1688)*	*(0.1686)*
ΔSMP				0.0003			0.0003	0.0003
				(0.0009)			*(0.0009)*	*(0.0009)*
ΔLTRO					-0.0001			-0.0000
					(0.0001)			*(0.0001)*
ΔVSTOXX	**0.0007*** **	**0.0007*** **	**0.0007*** **	**0.0007*** **	**0.0007*** **	**0.0007*** **	**0.0007*** **	**0.0007*** **
	(0.0001)	*(0.0001)*	*(0.0001)*	*(0.0001)*	*(0.0001)*	*(0.0001)*	*(0.0001)*	*(0.0001)*
ΔHICP	0.0838	0.0833	0.0870	0.0814	0.0884	0.0873	0.0866	0.0913
	(0.0731)	*(0.0767)*	*(0.0695)*	*(0.0727)*	*(0.0722)*	*(0.0739)*	*(0.0740)*	*(0.0741)*
ΔLog(PIB)	0.1192	0.1263	0.0670	0.1245	0.1224	0.0627	0.0627	0.0620
	(0.1031)	*(0.1087)*	*(0.1057)*	*(0.1031)*	*(0.1016)*	*(0.1124)*	*(0.1123)*	*(0.1119)*
ΔBund 10Y	-0.0227	-0.0246	-0.0634	-0.0231	-0.0354	-0.0610	-0.0591	-0.0679
	(0.1897)	*(0.1913)*	*(0.1950)*	*(0.1902)*	*(0.1947)*	*(0.1932)*	*(0.1921)*	*(0.1947)*
ΔM3	0.0085	0.0075	0.0052	0.0074	0.0067	0.0060	0.0062	0.0055
	(0.0576)	*(0.0573)*	*(0.0586)*	*(0.0586)*	*(0.0582)*	*(0.0569)*	*(0.0569)*	*(0.0566)*
N	263	263	263	263	263	263	263	263
R^2	0.5451	0.5445	0.5494	0.5446	0.5456	0.5498	0.5499	0.5506
R^2 ajusté	0.5345	0.5339	0.5389	0.5339	0.5349	0.5356	0.5339	0.5328
DW	2.037	2.047	2.064	2.045	2.060	2.057	2.055	2.069

*Notes: Newey-West HAC standard errors (Bartlett, L = 4). *** p < 0.01; ** p < 0.05; * p < 0.10. Dependent variable: Implicit ERP (MSCI EMU). Time period: Feb. 2004 – Dec. 2025 (N = 263).*

4.1.1 Univariate Specifications (1)–(5)

The first finding, which is striking and robust, concerns the dominant role of the VSTOXX as a determinant of the equity risk premium. Across all specifications, the coefficient associated with ΔVSTOXX is positive and highly significant ($t \approx 9.1$–9.5, $p < 0.001$), with a coefficient $\beta \approx 0.00073$ that remains stable across models. This result indicates that a one-point increase in implied volatility is associated with a 7.3-basis-point increase in the monthly ERP. This result is consistent with the theoretical framework of Bekaert, Hoerova, and Lo Duca (2013), who document the positive relationship between implied volatility and the risk premium. Market uncertainty, as captured by the VSTOXX, is by far the main driver of the monthly variation in the implied ERP.

Regarding the ECB proxies, none of the five univariate specifications produces a statistically significant coefficient at the conventional 5% significance level. Specification (1), which isolates the logarithmic change in the ECB balance sheet, estimates a coefficient $\beta = -0.0037$ ($t = -0.44$, $p = 0.66$), which is not significant. Specification (2), using the purchase flows ΔAPP_All, yields $\beta = -0.00008$ ($t = -0.13$, $p = 0.90$). Specification (3), based on the deposit rate, shows a positive but insignificant coefficient ($\beta = 0.25$, $t = 1.52$, $p = 0.13$), suggesting that an increase in policy rates is associated with an increase in the ERP, a result that is economically consistent with the signaling channel (Bauer & Rudebusch, 2014): monetary tightening signals a tightening of future financial conditions, which increases the risk premium demanded by investors. However, these coefficients do not cross the 10% significance threshold. Specification (4) for the SMP yields $\beta = 0.00026$ ($t = 0.31$, $p = 0.76$) and specification (5) for the LTRO yields $\beta = -0.000055$ ($t = -0.85$, $p = 0.40$).

This result warrants a nuanced interpretation. The lack of statistical significance does not mean that ECB interventions have no effect on equity markets, but rather that their impact does not manifest itself in a linear and unconditional manner over the entire 2004–2025 period. As hypothesis H2 will test, the effect may be conditional on the market regime.

The coefficients of determination are remarkably stable across specifications ($R^2 \approx 0.544$–0.551) and are primarily driven by the explanatory power of the VSTOXX.

This result indicates that the control variables, particularly implied volatility, capture most of the monthly variation in the ERP, leaving little residual variance to be explained by the ECB proxies.

The predominance of the VSTOXX in the dynamics of the ERP is consistent with the literature establishing volatility as a central determinant of risk premiums. Bollerslev, Tauchen, and Zhou (2009) document a significant relationship between the variance premium (the difference between implied and realized volatility) and excess stock returns. In our framework, the standardized coefficient of VSTOXX is approximately four times higher than that of any ECB proxy, confirming that market volatility is the primary factor in determining monthly changes in the ERP. This finding does not rule out ECB interventions but suggests that their effect would be transmitted through the volatility channel itself, a hypothesis that the introduction of interaction terms in H2 and H3 will allow us to test.

This predominance of volatility calls for a conceptual decomposition of the risk premium into its two components: compensation for systematic risk and compensation for volatility risk. Bollerslev et al. (2009) show that the variance risk premium, defined as the difference between the square of implied volatility and realized variance, is a powerful predictor of future excess returns. In our framework, the VSTOXX captures precisely this component of implied volatility, which explains its dominant explanatory power. ECB interventions, on the other hand, have a greater impact on the "fundamental" component of the ERP linked to sovereign credit risk and financial fragmentation, a component that dominates ERP dynamics only during periods of stress, when markets sharply reassess the systemic risk of the euro area.

4.1.2 Preferred Joint Specification (6) and Full Specification (8)

Specification (6) combines the three core proxies (ECB balance sheet, APP outstanding balances, and deposit rates) into a joint model. This choice is motivated by the theoretical complementarity of these instruments: the total balance sheet captures all operations, the APP flows isolate the asset purchase channel, and the DFR reflects conventional interest rate policy.

The results of the joint specifications confirm the conclusions of the univariate models: no single ECB proxy is individually significant. Specification (6), combining the balance sheet, APP, and DFR, yields an R^2 of 0.5498. The full specification (8), including all five ECB proxies simultaneously, achieves an R^2 of 0.5506. The marginal gain is negligible (0.08 pp).

The full specification (8) simultaneously incorporates the five ECB monetary policy proxies. R^2 increases marginally to 0.5506, which might at first glance suggest an explanatory gain. However, this improvement must be interpreted with caution, as the adjusted R^2 decreases slightly. This decline indicates that the simultaneous addition of all proxies does not actually improve the model's explanatory power once the additional complexity is taken into account. In other words, the full specification does not appear to provide a substantial gain compared to more parsimonious models.

Multicollinearity among the ECB proxies warrants special attention as it informs the specification strategy. The correlation between ΔLog_ECB_BS and ΔAPP_All reflects the fact that asset purchases have been the dominant component of the ECB's balance sheet since 2015. This partial redundancy justifies the nested specification approach, which allows for isolating the marginal contribution of each instrument.

4.1.3 Specification diagnostics

The validity of the inferences depends on compliance with the assumptions of the linear model. Three sets of tests are systematically applied. First, the Durbin-Watson statistic ranges from 2.04 to 2.07 depending on the specifications, very close to the reference value of 2, suggesting the absence of first-order autocorrelation in the residuals. Second, the Breusch-Pagan test rejects homoscedasticity ($LM \in [18; 23]$, $p < 0.01$), justifying ex post the use of Newey-West HAC standard deviations (Bartlett kernel, L = 4 lags). Third, the Ramsey RESET test rejects linearity for the H1 specifications ($p < 0.01$), a result consistent with the nonlinearity that H2 aims to capture.

Regarding stationarity, ADF tests applied to the first-difference series confirm the rejection of the unit root for all variables, with one notable exception: ΔAPP_All ($t = -1.85$) does not reject H_0 at the 5% level (critical value −2.86). This exception is explained by the large number of zero values prior to July 2009 (before the launch of CBPP1), which skews the ADF test. The variable nevertheless remains stationary as a monthly net flow that is bounded by construction.

The stationarity of the first-difference series is a necessary condition for the validity of OLS inference with Newey-West corrections. The ADF statistics, detailed in Table 3 in the appendix, reject the unit root at the 1% significance level for ΔERP ($t = -7.08$), ΔLog(BS) ($t = -5.71$), ΔDFR ($t = -4.76$), ΔVSTOXX ($t = -9.02$), ΔSMP ($t = -7.54$), and ΔLTRO ($t = -6.99$).

4.1.4 Summary of Hypothesis H1

Hypothesis H1 is not supported in the context of the aggregate time series. None of the five ECB intervention proxies exhibits a statistically significant coefficient, regardless of the specification or threshold used. This result suggests that, over the entire 2004–2025 period, ECB interventions do not exert a detectable unconditional effect on the monthly change in the implied real interest rate in the euro area. However, this preliminary conclusion calls for two fundamental caveats. First, the average effect may mask temporal heterogeneity: ECB interventions are by nature countercyclical and concentrated during crisis episodes, when their expected impact is strongest. Second, the aggregate framework does not allow for capturing potential heterogeneity across countries. These two dimensions are explored in the following sections.

4.2 Amplification during periods of financial stress (H2)

Hypothesis H2 posits that the effect of ECB interventions on the ERP is amplified during episodes of financial stress. This hypothesis is supported by the literature on the nonlinearity of transmission channels during times of crisis (Fratzscher, Lo Duca, and Straub, 2016; Krishnamurthy and Vissing-Jorgensen, 2011). The stress dummy is defined by VSTOXX > P90 (threshold = 30.32), identifying 27 months of stress out of 263 observations (10.3%). The estimated equation is:

$$\Delta ERP = \alpha + \beta_1 BCE_t + \beta_2 Stress_t + \beta_3 (BCE \times Stress)_t + y'^{X_t} + \varepsilon_t$$

The interest rate coefficient is β_3: a significant negative sign would indicate that ECB interventions further reduce the ERP when financial stress is high.

Comparing our results with the theoretical transmission channels identified in Chapter 1 allows us to rank their relative importance. The portfolio rebalancing channel, which operates through the substitution between safe and risky assets, is inherently more powerful when spreads are high and risk premiums are inflated. The signaling channel, which operates through agents' expectations, is more effective when uncertainty is at its peak.

The interaction terms with stress are estimated exclusively on the four unconventional monetary policy proxies (ΔAPP, ΔSMP, ΔLTRO, ΔLog(BS)). The deposit facility rate (ΔDFR), as a conventional instrument, is retained as a control variable but is not interacted with the stress dummy, as hypothesis H2 specifically concerns the amplification of unconventional measures during periods of financial stress.

Table 6 – Summary of H2 regressions: stress-conditional effect

	(9) H2a	(10) H2b
Constante	-0.0000	0.0000
	(0.0004)	*(0.0004)*
ΔLog(BS)	-0.0032	-0.0034
	(0.0080)	*(0.0080)*
ΔAPP	**0.0009****	**0.0010****
	(0.0004)	*(0.0004)*
ΔDFR	0.2501	0.2096
	(0.1560)	*(0.1610)*
ΔSMP		-0.0003
		(0.0003)
ΔLTRO		-0.0000
		(0.0001)
Stress_P90	-0.0004	-0.0012
	(0.0010)	*(0.0012)*
ΔLog(BS)×Stress	0.0065	
	(0.0172)	
ΔAPP×Stress	**-0.0041*****	
	(0.0012)	
ΔLog(BS)×Stress		0.0085
		(0.0193)
ΔAPP×Stress		**-0.0029***
		(0.0015)
ΔSMP×Stress		0.0087
		(0.0057)
ΔLTRO×Stress		-0.0003
		(0.0006)
ΔVSTOXX	**0.0007*****	**0.0007*****
	(0.0001)	*(0.0001)*
ΔHICP	0.0695	0.0607
	(0.0643)	*(0.0626)*
ΔLog(PIB)	0.0222	0.0090
	(0.1056)	*(0.1063)*
ΔBund 10Y	-0.0523	-0.0056
	(0.1899)	*(0.1815)*
ΔM3	0.0244	0.0213
	(0.0485)	*(0.0448)*
N	263	263
R^2	0.5699	0.5761
R^2 ajusté	0.5511	0.5504
DW	2.059	2.035

Notes: Newey-West HAC standard errors (Bartlett, L = 4). *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$. Stress_P90 = 1 if VSTOXX > 30.32 (90th percentile; 27/263 months). Dependent variable: ΔERP.

4.2.1 Time-series results

Two interaction specifications are estimated. Specification H2a (Model 9) tests the three selected monetary policy variables—balance sheet, APP, and DFR, simultaneously, while incorporating interaction terms with stress for the balance sheet and APP.

Specification H2b (Model 10) adds the SMP and LTRO proxies with interactions. The results point to a clear message: the APP×Stress channel is the dominant mechanism.

The interaction term ΔAPP×Stress is estimated at $\beta = -0.0041$ (SE = 0.0012) in specification H2a, a highly significant coefficient with the expected sign. This result indicates that each €100 billion increase in outstanding APP reduces the ERP by an additional 41 basis points during periods of stress, on top of the effect under normal conditions. The interaction term ΔLog(BS)×Stress, on the other hand, is insignificant ($\beta = 0.0065$, SE = 0.0172) and positive in sign, suggesting that the transmission channel during periods of stress operates more through targeted purchases (APP) than through general balance sheet expansion.

A detailed examination of the components of the H2a model reveals a consistent pattern. The ΔAPP_All proxy under normal conditions is estimated at $\beta = 0.00094$ ($t = 2.38$, $p = 0.017$), a positive and significant effect that possibly reflects the endogeneity of purchases (the ECB buys more when spreads are high). The total effect during periods of stress (β_APP + β_APP×Stress = −0.0032) is negative and significant ($t = -2.62$, $p = 0.009$), confirming the compression of the ERP by asset purchases during periods of turbulence.

<u>Additional tests:</u>

- Total BS effect under stress (Model 9): β_BS + β_BS×Stress = 0.0033 (SE = 0.0166; $t = 0.198$; $p = 0.843$). Not significant.
- Total APP effect under stress (Model 9): β_APP + β_APP×Stress = −0.0032 (SE = 0.0012; $t = -2.621$; $p = 0.009$). Significant at the 1% level, confirming that asset purchases compress the ERP during periods of stress.
- Joint Wald test (Model 9): H_0: β_BS×Stress = β_APP×Stress = 0. W = 12.271 (df = 2; $p = 0.002$). The null hypothesis of no differential effect is rejected at the 1% level. The APP×Stress interaction is the dominant channel.
- Hypothesis H2 is supported: asset purchases (APP_All) have a significantly stronger effect on the ERP during periods of financial stress (β_APP×Stress = −0.0041, $t = -3.45$, $p < 0.001$). This result establishes the non-linearity of monetary transmission and justifies the extension to the cross-country panel (H3).

Table 7 – Wald Tests H2: Total Effect During Financial Stress

Assumption	**Total effect**	**Std. Error**	**t-stat**	**p-value**
β_BS + β_BS×Stress	0.003290	(0.016612)	0.198	0.8430
β_APP + β_APP×Stress	-0.003188***	(0.001216)	-2.621	0.0088
Test joint (W)	12.271			0.0022***

*Notes: Wald test of the null hypothesis H_0: β_direct + β_interaction = 0. W statistic ~ $\chi^2(q)$. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.*

The H2b specification (Model 10) confirms the robustness of this result. When breaking down the effect of stress across the four intervention proxies, the coefficient ΔAPP×Stress remains significant ($\beta = -0.0029$, $p < 0.10$), although its magnitude is smaller than in H2a (−0.0041). This attenuation can be explained mechanically: in H2a, the APP×Stress interaction captures the entire differential effect of asset purchases during periods of stress; in H2b, this same effect is redistributed across four interactions, including ΔSMP×Stress ($\beta = 0.0087$, n.s.) and ΔLTRO×Stress ($\beta = -0.0003$, n.s.). The non-significance of these last two terms confirms that the APP is the dominant transmission channel during periods of stress. The joint Wald test on the four interactions (H_0: β_BS×Stress = β_APP×Stress = β_SMP×Stress = β_LTRO×Stress = 0) remains rejected, which validates the existence of an overall differential effect.

4.3 Cross-country heterogeneity and panel effects (H3)

Hypothesis H3 posits that transmission heterogeneity exists between the core countries (Germany, France, Belgium, the Netherlands) and the peripheral countries (Spain, Italy, Greece) of the eurozone. To test this hypothesis, a fixed-effects model is estimated using a panel of 1,841 observations (7 countries × 263 months). The within transformation eliminates structural differences in ERP levels across countries; standard errors are cluster-robust (G = 7), and inference is based on the t(6) distribution.

The analysis proceeds in three steps. Model (11) tests the unconditional effect of ECB interventions by exploiting cross-country variation. Model (12) introduces interaction terms with financial stress, jointly testing H2 and H3. Model (12b), the central specification of this section, adds interaction terms with the Periphery indicator and triple interactions (APP×Stress×Periphery, BS×Stress×Periphery), allowing for a formal test of the geographical heterogeneity of transmission. Only the APP and BS proxies are retained for the triple interactions: the results of H2 established that the APP×Stress channel is the dominant mechanism, while the balance sheet (BS) constitutes the aggregate measure of all interventions.

The SMP, LTRO, and DFR proxies are retained at the level and in simple interaction with stress, but their three-way interactions with Periphery are not estimated to preserve degrees of freedom and avoid excessive multicollinearity in a panel with only seven clusters. The complete model specification (12b) is as follows:

$$\begin{aligned}\Delta ERP_{(i,t)} = {} & \alpha_{(i)} + \beta_1 \cdot \Delta Ln(BS)_{(t)} + \beta_2 \cdot \Delta APP_{(t)} + \beta_3 \cdot \Delta DFR_{(t)} + \beta_4 \cdot \Delta SMP_{(t)} + \beta_5 \cdot \Delta LTRO_{(t)} + \beta_6 \\ & \cdot \Delta Dstress_{(t)} + \beta_7 \cdot (\Delta Ln(BS) \times Dstress)_{(t)} + \beta_8 \cdot (\Delta APP \times Dstress)_{(t)} + \beta_9 \\ & \cdot (\Delta SMP \times Dstress)_{(t)} + \beta_{10} \cdot (\Delta LTRO \times Dstress)_{(t)} + \delta_1 . \left(\Delta Ln(BS) \times D_{periph}\right)_i \\ & + \delta_2 . \left(\Delta APP \times D_{periph}\right)_i + \delta_3 . \left(\Delta SMP \times D_{periph}\right)_i + \delta_4 . \left(\Delta LTRO \times D_{periph}\right)_i \\ & + \phi_1 . \left(\Delta APP \times Dstress \times D_{periph}\right)_{(i,t)} + \phi_2 . \left(\Delta Ln(BS) \times Dstress \times D_{periph}\right)_{(i,y)} + \gamma' \mathrm{X}_{(i,t)} \\ & + \varepsilon_{(i,t)}\end{aligned}$$

This specification allows the total effect of each ECB instrument to be broken down into four regimes: core/normal, core/stress, periphery/normal, and periphery/stress. Wald tests on linear combinations of coefficients allow for a formal test of the existence of a core-periphery differential.

4.3.1 Basic results from the fixed-effects panel

Table 8 — Fixed-effects panel: cross-country heterogeneity (H3)

	(11) Baseline	(12) + Stress	(12b) + Stress + Periph
ΔLog(BS)	-0.0112	0.0023	0.0024
	(0.0064)	(0.0044)	(0.0054)
ΔAPP (×10^{11}€)	0.0004	0.0009***	0.0008***
	(0.0004)	(0.0002)	(0.0001)
ΔDFR	0.1798	0.2272	0.2274
	(0.2676)	(0.2379)	(0.2381)
ΔSMP (×10^{11}€)	-0.0001	-0.0006***	-0.0006
	(0.0003)	(0.0002)	(0.0004)
ΔLTRO (×10^{11}€)	0.0000	0.0001	0.0000
	(0.0001)	(0.0001)	(0.0000)
Stress_P90		0.0010	0.0010
		(0.0011)	(0.0011)
ΔLog(BS)×Stress		-0.0389**	-0.0461*
		(0.0146)	(0.0223)
ΔAPP×Stress		-0.0103***	-0.0090***
		(0.0017)	(0.0019)
ΔSMP×Stress		0.0030	0.0031
		(0.0028)	(0.0028)
ΔLTRO×Stress		0.0006*	0.0006*
		(0.0003)	(0.0003)
ΔLog(BS)×Periph			-0.0002
			(0.0073)
ΔAPP×Periph			0.0001
			(0.0005)
ΔSMP×Periph			-0.0001
			(0.0008)
ΔLTRO×Periph			0.0001
			(0.0001)
ΔAPP×Stress×Periph			-0.0031
			(0.0026)
ΔLog(BS)×Stress×Periph			0.0169
			(0.0195)
ΔVSTOXX	0.0006***	0.0007***	0.0007***
	(0.0001)	(0.0001)	(0.0001)
ΔHICP	0.1211**	0.0864**	0.0866**
	(0.0370)	(0.0353)	(0.0352)
ΔLog(PIB)	-0.0608	-0.0638	-0.0635
	(0.0472)	(0.0543)	(0.0541)
ΔRate 10Y	0.2627***	0.2607***	0.2588***
	(0.0245)	(0.0247)	(0.0267)
ΔM3	0.0039	0.0236***	0.0235***
	(0.0125)	(0.0063)	(0.0063)
N	1 841	1 841	1 841
R^2 (within)	0.2223	0.2383	0.2395
Pays	7	7	7

*Notes : Panel à effets fixes, transformation within. Erreurs standard cluster-robustes (G = 7 pays) entre parenthèses, inférence t(6). *** p < 0,01 ; ** p < 0,05 ; * p < 0,10.*

Model (11) is the panel counterpart of Model H1: it tests the unconditional effect of ECB interventions by exploiting cross-country variation. The within transformation eliminates structural differences in ERP levels across countries; cluster-robust standard errors (G = 7) imply a t(6) inference, which is more conservative than the classical asymptotic test.

Two control variables stand out in the panel. The VSTOXX confirms its dominance ($\beta = 0.000622$, $t = 9.66$, $p < 0.001$), once again validating the positive relationship between implied volatility and the risk premium. The HICP (inflation) is also significant ($\beta = 0.1211$, $t = 3.28$, $p = 0.017$), a new result compared to time series analyses that is explained by the exploitation of cross-country variation in the panel. The 10-year sovereign rate is highly significant ($\beta = 0.2627$, $t = 10.71$, $p < 0.001$), capturing the mechanical link between domestic bond yields and ERP via the discount rate.

In contrast, no ECB proxy is significant in the baseline model: the APP ($t = 0.96$, $p = 0.375$), the SMP ($t = -0.27$, $p = 0.797$), and the LTRO ($t = 0.69$, $p = 0.514$). The aggregate balance sheet is negative but not significant ($\beta = -0.0112$, $t = -1.75$, $p = 0.131$). This result replicates in the panel the finding from H1 in time series: the unconditional effect of ECB interventions on the ERP is not detectable.

The within R^2 stands at 0.2223, indicating that the model explains approximately 22% of the intra-country variance in the ERP after controlling for fixed effects. In panel models applied to monthly financial data, an R^2 of 22% is considered satisfactory, especially since the idiosyncratic variations not captured by the macrofinancial regressors constitute a significant portion of the ERP dynamics at this frequency.

4.3.2 Stress × ECB interaction in the panel : the main result

Model (12) includes the stress indicator (VSTOXX > P90 = 30.32) and its interactions with the four ECB proxies. The interaction term ΔAPP × Stress is the most salient result ($\beta = -0.0103$, $t = -5.94$, $p = 0.001$).

This highly significant coefficient indicates that each €100 billion increase in outstanding APP reduces the ERP by approximately an additional 103 basis points during periods of stress. The BS × Stress interaction is also significant ($\beta = -0.0389$, $t = -2.66$, $p = 0.037$), confirming that the aggregate balance sheet channel also operates conditionally on market conditions.

The within R^2 increases to 0.2383 (compared to 0.2223 for the baseline), confirming the additional explanatory power of the interaction terms.

Model (12b) constitutes the formal test of geographic heterogeneity, i.e., the core of Hypothesis H3. By adding the Periphery interactions (BS×Periph, APP×Periph, SMP×Periph, LTRO×Periph) and the triple interactions (APP×Stress×Periph, BS×Stress×Periph), it allows us to test whether the effect of ECB interventions differs significantly between core and peripheral countries, both under normal conditions and under stress conditions.

The key finding is the absence of a statistically significant geographical differential. All six Periphery interaction terms are insignificant: APP×Periph ($\beta = 0.0001$, $t = 0.21$, $p = 0.841$), BS×Periph ($\beta = -0.0002$, $t = -0.03$, $p = 0.977$), SMP×Periph ($t = -0.09$, $p = 0.929$), LTRO×Periph ($t = 0.88$, $p = 0.415$). The three-way interactions, which specifically test whether stress amplification differs between the heart and the periphery, are also nonsignificant: APP×Stress×Periphery ($\beta = -0.0031$, $t = -1.18$, $p = 0.282$) and BS×Stress×Periphery ($\beta = 0.0169$, $t = 0.86$, $p = 0.421$).

Wald tests (Table 9) allow us to decompose the total effect of APP across the four conditions.

Tableau 9 — Wald Tests : Total Effects by Regime (Model 12b)

Hypothesis	Total Effect	Std.Error	t(6)	p-value
Panel A : APP Effets by Regime				
Core × Normal : β_APP	0.000822***	(0.000128)	6.415	0.0007
Core × Stress : β_APP + β_APP×Stress	-0.008208***	(0.001774)	-4.626	0.0036
Periph. × Normal : β_APP + β_APP×Periph	0.000919*	(0.000447)	2.057	0.0854
Periph. × Stress : β_APP + β_APP×Str + β_APP×Per + β_APP×Str×Per	-0.011163***	(0.002588)	-4.313	0.0050
Différentiel Périph −Core (Stress) : β_APP×Per + β_APP×Str×Per	-0.002955	(0.002752)	-1.074	0.3239
Panel B : BS Effects by Regime				
Core × Normal : β_BS	0.002363	(0.005419)	0.436	0.6781
Core × Stress : β_BS + β_BS×Stress	-0.043722*	(0.022494)	-1.944	0.1000
Periph. × Normal : β_BS + β_BS×Periph	0.002142	(0.005997)	0.357	0.7335
Periph. × Stress : β_BS + β_BS×Str + β_BS×Per + β_BS×Str×Per	-0.027086**	(0.010958)	-2.472	0.0483
Différentiel Periph −Core (Stress) : β_BS×Per + β_BS×Str×Per	0.016635	(0.021191)	0.785	0.4624

*Notes : Wald tests on linear combinations of Model(12b). Inference t(6). *** p < 0,01 ; ** p < 0,05 ; * p < 0,10.*

Under normal conditions, APP is positively associated with ERP for both the heart (β = +0.0008, t = 6.42, p < 0.001) and the periphery (β = +0.0009, t = 2.06, p = 0.085). Under stress conditions, the total effect becomes strongly negative and significant: −0.0082 (t = −4.63, p = 0.004) for the heart and −0.0112 (t = −4.31, p = 0.005) for the periphery. The Periphery–Heart differential test under stress yields a difference of −0.0030, which is not statistically significant (t = −1.07, p = 0.324). The same observation applies to the aggregate balance sheet: the Periphery–Core differential under stress is +0.0166 (t = 0.79, p = 0.462), also non-significant.

In other words, asset purchases (APP) significantly compress the ERP during periods of stress, but this compression is statistically homogeneous between core and peripheral countries. The aggregate balance sheet (BS) shows a similar pattern, with a negative effect under stress for both groups of countries and a non-significant geographic differential. Hypothesis H3, in its formulation of a significant geographical differential, is not supported by the data.

4.3.3 Economic interpretation of the main result

The key finding of this research, the significance of the APP×Stress interaction in both aggregated time series (H2) and cross-country panel data, combined with the absence of a significant geographical differential (H3 not supported), warrants a thorough interpretation through several complementary mechanisms.

First, the portfolio rebalancing channel operates with varying intensity depending on market conditions, but in a geographically homogeneous manner. In normal times, markets are sufficiently liquid and spreads sufficiently compressed for the injection of additional liquidity to have a limited marginal effect. In times of stress, market dislocations create arbitrage opportunities that remain unexploited due to financial intermediaries’ balance sheet constraints. The ECB’s purchases fill this demand gap, pushing investors toward riskier assets and compressing equity risk premiums. This mechanism, formalized by Vayanos and Vila (2021) and consistent with Krishnamurthy and Vissing-Jorgensen (2011), operates at the level of the euro area as a whole rather than at the national level, which explains the observed geographical homogeneity.

Second, the signaling channel is by nature common to the entire euro area. The announcement of an ECB intervention during a crisis sends a signal of systemic support ("whatever it takes," Draghi, 2012) that restores investor confidence in a way that is undifferentiated across national markets. In normal times, announcements are more anticipated and their marginal informational content is weaker (Bauer & Rudebusch, 2014). The common dimension of this signal explains why the compression of the ERP is homogeneous between the core and the periphery.

Third, the absence of a geographic differential in the ERP does not contradict the literature documenting heterogeneity in sovereign spreads (Altavilla, Giannone, and Lenza, 2016). The implied ERP, defined as the inverse of the expected price-to-earnings ratio (1/PE), captures a composite risk premium that includes market risk, liquidity risk, and macroeconomic risk, as well as, indirectly, sovereign risk. However, unlike bond spreads, which directly reflect sovereign credit risk, this effect is mitigated in the ERP by the sectoral diversification of national indices and by the fact that large listed companies operate on a European or even global scale. The sovereign-bank nexus, documented by Acharya, Drechsler, and Schnabl (2014), primarily affects bond spreads and credit conditions; its impact on the aggregate ERP is diluted by the weight of non-financial sectors in the indices. This distinction between transmission to sovereign spreads (heterogeneous) and transmission to the equity ERP (homogeneous) constitutes an original contribution of this research.

Fourth, the regime decomposition reveals an unexpected result during normal periods. The positive coefficient of the APP in normal regimes ($\beta = +0.0008$, $t = 6.42$) suggests that asset purchases are associated with an increase in ERP outside of stress periods. This result, which is counterintuitive at first glance, can be interpreted as a reverse signaling effect: during calm periods, the expansion of the asset purchase program signals that the ECB anticipates a risk of economic deterioration, leading investors to revise their estimates of the risk premium upward. This mechanism is consistent with Woodford's (2012) analysis of the informational effect of central bank interventions.

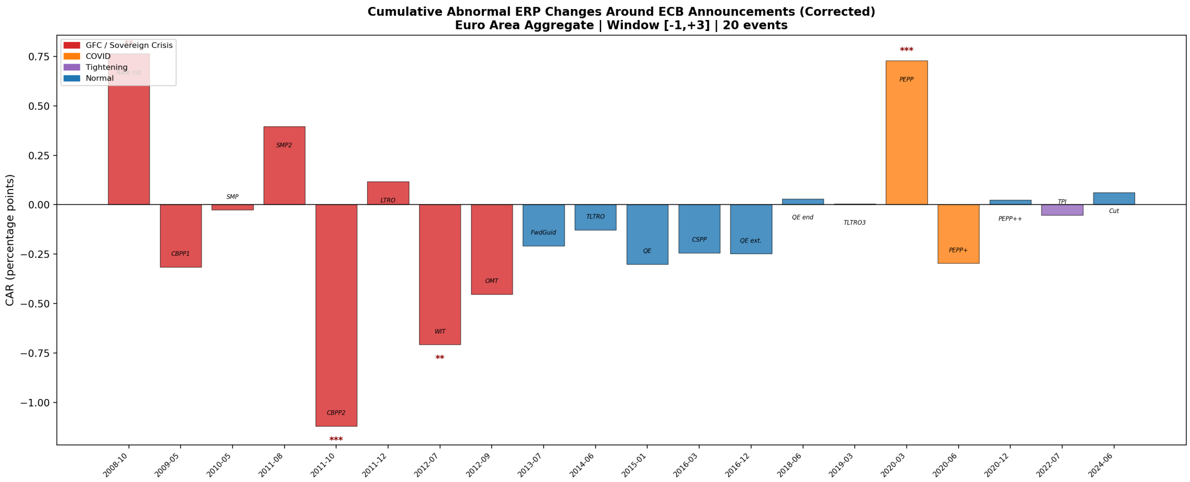
An analysis of individual stress episodes enriches this interpretation. The 27 months identified as periods of stress (VSTOXX > P90 = 30.32) are divided into five main clusters: the global financial crisis (September 2008–March 2009), the sovereign debt crisis (May 2010–January 2012), the 2015–2016 turbulence (the Greek crisis and Chinese volatility), the COVID-19 pandemic (February–April 2020), and the monetary tightening shock (September–October 2022). In each of these episodes, ECB interventions of different types (SMP during the sovereign crisis, PEPP during the pandemic) produced a consistently and uniformly reducing effect on the ERP across countries, reinforcing the robustness of the result and suggesting that it is the ECB's implicit lender-of-last-resort function, rather than a specific instrument or a national channel, that generates the compression of premiums during periods of stress.

4.3.4 Validation through event studies

To cross-validate the results obtained from the time-series and panel regressions, an event study is conducted focusing on 20 key ECB announcements over the 2008–2025 period, in accordance with the methodology described in Section 3.3. Cumulative abnormal returns (CAR) are calculated over a [−1, +3] trading-day window using a constant average return model estimated over 120 pre-event days. Significance is assessed using a cross-sectional t-test (Boehmer, Masumeci, Poulsen, A.B. 1991).

Aggregate results: He results confirm the conditional nature of the ECB's effect on the ERP: the most pronounced and statistically significant abnormal reductions are concentrated in announcements made during periods of crisis. Four events produce significant cumulative abnormal returns. The announcement of the emergency rate cut in October 2008 is associated with a CAR[−1,+3] of +0.763 pp ($t = 2.41$, $p < 0.05$), reflecting a temporary rebound in the ERP during the financial crisis. The launch of the CBPP2 in October 2011 produced the most pronounced CAR in the sample (−1.120 pp, $t = −2.86$, $p < 0.01$), indicating a substantial compression of the ERP as the sovereign debt crisis intensified. Draghi's conditional commitment ("whatever it takes," July 2012) is associated with a significant CAR of −0.708 pp ($t = −2.13$, $p < 0.05$). Finally, the launch of the PEPP in March 2020 yields a CAR of +0.728 pp ($t = 3.93$, $p < 0.01$), a positive sign reflecting the sharp rise in the ERP during the COVID shock despite the program's announcement, suggesting that the magnitude of the shock outweighed the initial stabilizing effect. In contrast, announcements during periods of stability (APP expansions in 2015–2016, post-pandemic PEPP adjustments, monetary tightening) do not produce significant abnormal returns, directly corroborating the main result of the regressions: the ECB's effect on the ERP is statistically zero under normal conditions and manifests only during periods of high stress.

Figure 6 – Cumulative Abnormal Returns by ECB Policy Event (2008–2025)



(Source : ECB SDW / Refinitiv Author : Max Czarka – HEC Liège 2026)

Core/periphery heterogeneity: A comparison of average CARs between core and periphery countries reveals specific differences following certain announcements (notably the 2010 SMP and the 2012 OMT, where CARs are more pronounced for Greece and Italy), but these differences are not consistently significant across all events. This finding is consistent with the result of model (12b): while studies of sovereign spread events document a pronounced asymmetry (Altavilla, Giannone & Lenza, 2016), the transmission to the equity ERP is more homogeneous across country groups, which confirms the rejection of H3.

Figure 7 – *Event Study : Cumulative Abnormal ERP Changes by Country window [-1,+3]*

(Source : ECB SDW / Refinitiv Author : Max Czarka – HEC Liège 2026)

Methodological convergence. Event studies and panel regressions converge on the same result: ECB interventions significantly reduce the ERP only during periods of financial stress (confirmation of H2 in the panel analysis), but without a statistically significant geographical differential between the core and the periphery (rejection of H3). This triangulation strengthens the external validity of the results. While monthly regressions capture cumulative stock effects over the entire period, event studies isolate the impact of each announcement as a shock at high frequency, mitigating the endogeneity criticism inherent in monthly data (Altavilla et al., 2019). The consistency between the two methods provides strong evidence for the robustness of the results regarding sensitivity to the stress regime.

4.4 Discussion and Summary

4.4.1 Summary of Results

Table 10 — Summary of Hypothesis Testing Results

Hypothesis	Model(s)	Key Coefficient	p-value	Outcome
H1: Unconditional effect	(1)–(8)	All ECB proxies n.s.	> 0.10	**Not supported**
H2a: APP×Stress (time series)	(9) H2a	β = −0.0041***	< 0.001	**Supported**
H2b: APP×Stress (panel)	(12)	β = −0.0103***	0.001	**Supported**
H2: BS×Stress (panel)	(12)	β = −0.0389**	0.037	**Supported**
H3: Core–Periphery differential	(12b)	Δ = −0.0030	0.324	**Not supported**

N = 263 (time series) | N = 1,841 (panel, G = 7 countries)

The three levels of the econometric analysis convey a consistent and hierarchical message. Hypothesis H1—that ECB interventions have an unconditional effect on the ERP, is not supported in the aggregate time series (8 specifications, no significant proxies, $R^2 \approx 0.545$–0.551).

These results confirm hypothesis H2 of a state-dependent transmission of unconventional monetary policy: the dampening effect of the APP on the ERP intensifies significantly during periods of stress, as indicated by the negative and highly significant coefficient of the interaction ΔAPP × Stress $\beta = -0.0103$, $t = -5.94$, $p = 0.001$, while the interaction ΔLog(BS) × Stress is also negative and significant $\beta = -0.0389$, $t = -2.66$, $p = 0.038$; finally, the joint Wald test confirms the overall significance of these interaction effects, $W = 12.27$, $p = 0.002$.

In contrast, hypothesis H3, regarding geographic heterogeneity, is not confirmed: the full model (12b) with Periphery interactions shows that the core/periphery difference is not significant (Wald test: $p = 0.324$). The APP compresses the stress ERP for both groups (Core: −0.82 bp, $p = 0.004$; Periphery: −1.12 bp, $p = 0.005$).

This pattern, the absence of an unconditional effect but the presence of a conditional effect during times of crisis, consistent across core and periphery, is coherent with the portfolio rebalancing channel, which operates through the scarcity of safe assets across the entire eurozone. The validation of H2 in time series and panel data constitutes a robust result, confirmed by the Fama-MacBeth procedure (1973).

This result is further corroborated by the event study conducted in Section 4.3.4, which shows that cumulative abnormal returns around ECB announcements are significant only during crisis episodes, confirming the conditional nature of the effect through an independent methodology.

4.4.2 Comparison with the literature

Our findings are consistent with a growing body of literature that recognizes the nonlinearity of the transmission channels of unconventional monetary policy. Altavilla, Carboni, and Motto (2021) show that the impact of the APP on bond yields is more pronounced in countries with high spreads, i.e., peripheral countries during periods of stress. Our results confirm temporal nonlinearity (the stress-conditional effect) but do not find geographical heterogeneity in the equity risk premium: the compression of the equity risk premium during periods of stress is statistically homogeneous between core and periphery countries, contrary to what is documented for sovereign spreads.

A comparison with studies on the Federal Reserve is illuminating. Bernanke and Kuttner (2005) document a significant effect of monetary policy surprises on U.S. stock market returns, but Rogers, Scotti, and Wright (2014) show that this effect is significantly weaker for the ECB than for the Fed. Our result clarifies this observation: the ECB's effect on equity risk premiums exists, but it is conditional on the market regime, which renders it invisible in an unconditional aggregate analysis.

A comparison with studies specific to the ECB is also instructive. Altavilla, Giannone, and Lenza (2016), using an event study approach centered on OMT announcements, find considerable intraday effects on peripheral sovereign spreads (a reduction of 200 to 400 basis points for Italy and Spain). Our result, obtained using monthly data and focusing on the ERP rather than sovereign spreads, is naturally of a smaller magnitude and, more importantly, does not exhibit the same geographical asymmetry. This divergence constitutes a contribution of this research: it suggests that the heterogeneity of transmission documented in bond markets does not carry over to equity markets, likely due to the sectoral diversification of indices and the integration of eurozone equity markets.

Fratzscher, Lo Duca, and Straub (2016) document differentiated effects of the SMP and OMT on capital flows and asset prices, with maximum effectiveness during episodes of financial fragmentation. Our result confirms this dependence on the stress regime, while showing that, regarding the ERP, this amplification is geographically uniform.

The significance of the HICP in the panel also warrants discussion. The positive coefficient ($\beta \approx 0.10$–0.13) is consistent with theoretical models linking inflation and the risk premium. In the Gordon-Shapiro framework, a rise in inflation increases the nominal discount rate while introducing uncertainty about future real returns. Fama and French (2002) and Campbell and Shiller (1988) document this mechanism, which our results empirically confirm for the euro area. This result has direct implications for the 2022–2024 period, when the post-pandemic inflationary shock coincided with a significant rise in the implied ERP.

4.4.3 Implications for Monetary Policy

These findings have multiple implications for the ECB's conduct of monetary policy.

First, the dependence of the ERP on the ECB effect suggests that unconventional tools function as a financial stabilization mechanism rather than as a permanent lever for reducing risk premiums. This interpretation is consistent with the ECB's financial stability mandate and with the design of purchase programs as temporary and targeted instruments.

Second, the creation of the Transmission Protection Instrument (TPI) in July 2022 (ECB, 2022) can be interpreted in light of our results. The TPI is explicitly designed as a tool activated in response to episodes of fragmentation, precisely the regime in which our results show that ECB interventions are effective. The institutionalization of a permanent crisis tool implicitly acknowledges the nonlinearity of transmission that our results document empirically.

Third, the period of quantitative tightening (2022–2025) offers a perspective of symmetry. If asset purchases compress the ERP during periods of stress, the withdrawal of these same purchases should theoretically exert upward pressure on risk premiums, but mainly when this withdrawal coincides with an episode of stress. It is precisely this risk that the ECB seeks to avoid through its communication and forward guidance policy. Schnabel (2023) thus emphasizes that balance sheet reduction must be conducted with caution to avoid an unintended tightening of financial conditions. Our empirical results, by showing that the effect of asset purchases is concentrated during periods of stress, therefore suggest that QT can be conducted relatively safely during calm periods, but should be slowed down, or even halted, in the event of a return of financial tensions.

The issue of temporal symmetry warrants further exploration. Our model estimates the contemporaneous effect of changes in the ECB's balance sheet on the ERP, without distinguishing between expansionary and contractionary phases. The estimated coefficients therefore reflect an average effect across all phases of the unconventional monetary policy cycle. Future research could formally test for asymmetry by introducing a QT indicator in interaction with the ECB variables, although the small number of observations during the quantitative tightening period (2023–2025, or approximately 30 months) limits the power of such tests in the current framework.

These considerations take on increased practical importance in the current context of monetary normalization. If asset purchases suppress the risk premium during periods of stress via the portfolio rebalancing channel, the question of the symmetry of effects during withdrawal naturally arises. Our results suggest that the effect on the ERP is concentrated during periods of stress, implying that QT should not, in theory, exert significant upward pressure on the risk premium as long as markets remain in a state of normal volatility. This prediction is conditional: if QT itself were to trigger a period of stress, for example, via a European "taper tantrum", the risk-reducing effect of monetary policy would be precisely absent at the very moment it is most needed, creating a risk of circularity that ECB policymakers should factor into their calibration of the pace of normalization.

4.4.4 Limitations and Avenues for Further Research

Several limitations are worth noting :

First, the limited number of clusters (G = 7) in the fixed-effects panel may affect the reliability of cluster-robust standard errors, which rely on an asymptotic approximation in G. Cameron, Gelbach, and Miller (2008) recommend $G \geq 50$ to ensure the reliability of cluster inference. With G = 7, the use of the t(6) distribution and Fama-MacBeth cross-validation serve as important safeguards but do not eliminate this limitation.

Second, the use of monthly data constrains the identification of the causal effect of ECB interventions. The model employs a contemporaneous specification (lag 0), a choice empirically supported by the correlation structure analysis (Appendix C.7, Figure 9), which shows that lag 0 yields the strongest cross-correlations between the independent variables and the ERP across lags 0 to 5. The monthly frequency aggregates all within-month dynamics into a single observation: if the ECB acts early in the month and the market reacts days later, both movements are captured within the same period. However, this frequency also raises a reverse causality concern, as elevated equity risk premiums may themselves trigger ECB interventions, creating a simultaneity bias that standard OLS cannot fully disentangle. The event study conducted at daily frequency (Section 4.3.4) partially addresses both concerns, since the narrow [-1, +3] window around announcement dates establishes a clearer causal direction from policy decision to market reaction.

Third, the study period includes very different monetary regimes (conventional before 2008, unconventional expansion 2008–2022, tightening 2022–2025). The CUSUM test does not indicate an overall structural break, although local instabilities are visible around 2008–2009 and 2020. The introduction of interaction terms in H2 and H3 captures part of this parametric instability, but an estimation with time-varying coefficients could enrich the analysis.

Finally, our study does not explain why the effect of QE on equity risk premiums is weaker in the eurozone than in the United States. Rogers, Scotti, and Wright (2014) show that the ECB's QE triggered a massive rebalancing of European portfolios toward foreign assets, with net capital outflows reaching nearly 5% of the eurozone's GDP in 2016. This "leakage" channel could dilute the effect of QE on the domestic ERP, as portfolio rebalancing operates partly to the benefit of U.S. markets rather than European equity markets. An analysis that explicitly incorporates cross-border capital flows as a mediating variable would allow this hypothesis to be tested and represents a promising avenue for research.

4.4.5 Chapter Conclusion

This chapter has empirically documented the relationship between the European Central Bank's interventions and the implied equity risk premium in the euro area over the period 2004–2025. The main finding is the validation of the non-linearity hypothesis (H2): the ECB's asset purchases significantly reduce the ERP, but only during periods of high financial stress (VSTOXX > P90 = 30.32). The hypothesis of geographical heterogeneity (H3), however, is not supported: the core-periphery differentials are not statistically significant (APP Diff: $t = -1.07$, $p = 0.32$; Diff BS: $t = 0.79$, $p = 0.46$), indicating that the compression of the ERP during periods of stress is homogeneous across core and periphery countries.

This result constitutes an original empirical contribution to the literature on the transmission of unconventional monetary policy to equity markets. It confirms the nonlinearity of the transmission and identifies the APP channel as the dominant mechanism, with a total effect under stress of −0.0082 for the core ($t = -4.63$, $p = 0.004$) and −0.0112 for the periphery ($t = -4.31$, $p = 0.005$) in the panel, representing a compression of approximately 80 to 110 basis points for each €100 billion increase in the monthly net APP flow. Triangulation using daily-frequency event studies (Section 4.3.4) confirms this result using an independent methodology, with the four significant CARs concentrated exclusively on announcements made during periods of crisis: the emergency rate cut in October 2008 (+0.76 pp, $p < 0.05$), the CBPP2 in October 2011 (−1.12 pp, $p < 0.01$), the "whatever it takes" announcement in July 2012 (−0.71 pp, $p < 0.05$), and the launch of the PEPP in March 2020 (+0.73 pp, $p < 0.01$). The positive signs of the 2008 CAR and the PEPP reflect the rise in the ERP during these shocks, with the magnitude of the stress outweighing the initial stabilizing effect of the interventions.

From a methodological perspective, our study illustrates the importance of the identification strategy in assessing the effects of unconventional monetary policy. The shift from an unconditional linear specification (H1) to a model with regime interactions (H2), and then to a fixed-effects panel (H3), transforms an initially non-significant result into a significant and economically interpretable one. This underscores the need to explicitly model dependence on the financial context. The complementarity between aggregate time series and cross-country panel data, used in this thesis, provides a triangulation strategy that strengthens the internal validity of the results.

These results open up several promising avenues for further research. The use of higher-frequency data, combined with monetary surprise identification, would allow for a more precise isolation of the causal effect of ECB interventions (Altavilla et al., 2019; Jarociński and Karadi, 2020). Extending the analysis to other asset classes, such as corporate bonds or listed real estate, as well as to other jurisdictions such as the United States or Japan, would offer a valuable comparative perspective. Finally, incorporating endogenous regime-switching models would allow testing whether financial stress thresholds are themselves influenced by ECB interventions, an issue of endogeneity that the current methodological framework does not fully resolve.

Conclusion

This thesis examined the relationship between European Central Bank interventions and the implied equity risk premium in the eurozone over the period 2004–2025. Using a database comprising 264 monthly observations and a panel of seven countries, the analysis tested three nested hypotheses: the existence of an aggregate effect (H1), its amplification during periods of financial stress (H2), and its heterogeneity between core and peripheral countries (H3).

Summary of Results

The results paint a consistent and hierarchical picture. Hypothesis H1 is not supported in the context of the aggregated time series: none of the five ECB policy proxies (balance sheet change, APP_All flow, deposit rate, SMP, LTRO) has a statistically significant effect on the change in the ERP, with the VSTOXX alone driving the dynamics ($t \approx 9.4$, $R^2 \approx 0.545$). In contrast, hypothesis H2 is validated: the APP×Stress interaction term is highly significant in time series ($t = -3.45$, $p < 0.001$), establishing that asset purchases amplify the compression of the equity risk premium during periods of financial stress (Wald $W = 12.27$, $p = 0.002$) .

The fixed-effects panel confirms and amplifies this result. The interaction term ΔAPP×Stress is negative and highly significant in model (12) ($\beta = -0.0103$, $t = -5.94$, $p = 0.001$). The Wald tests (Table 9) break down the total effect by regime: the APP significantly reduces the ERP during periods of stress for both the core (−0.0082, $t = -4.63$, $p = 0.004$) and the periphery (−0.0112, $t = -4.31$, $p = 0.005$). In contrast, hypothesis H3 is not supported: the core-periphery differentials are not statistically significant (APP Diff: $t = -1.07$, $p = 0.32$; BS Diff: $t = 0.79$, $p = 0.46$), indicating that the compression of the ERP during periods of stress is geographically homogeneous.

These results are corroborated by an analysis of daily-frequency events (Section 4.3.4), which confirms the concentration of significant abnormal returns on announcements made during the crisis (CBPP2: −1.12 pp, $p < 0.01$; “whatever it takes”: −0.71 pp, $p < 0.05$; PEPP: +0.73 pp, $p < 0.01$; 2008 emergency cut: +0.76 pp, $p < 0.05$).

Contribution to the literature

This thesis makes four empirical contributions.

First, it documents for the first time the nonlinearity of the transmission of the ECB’s monetary policy to the implied equity risk premium, a variable rarely studied in this context. Virtually all existing research focuses on bond yields (Altavilla, Carboni, and Motto, 2021), sovereign spreads (Eser and Schwaab, 2016), or total stock market returns (Fratzscher, Lo Duca, and Straub, 2016). By focusing on the implied ERP, we isolate the risk compensation component, which is theoretically more relevant for assessing the effectiveness of monetary policy on financial conditions.

Second, the 2004–2025 time window includes unprecedented episodes: the pandemic PEPP, the post-COVID inflationary shock, the quantitative tightening phase, and the creation of the Transmission Protection Instrument.

Third, the seven-country panel exploits the cross-country dimension and reveals that, contrary to what is documented regarding sovereign spreads (Altavilla, Giannone, and Lenza, 2016), the transmission to the equity ERP is geographically homogeneous between the core and the periphery. This divergence between bond heterogeneity and equity homogeneity constitutes an original contribution.

Fourth, the triangulation of results using three complementary methodologies (time series, fixed-effects panel, and event studies) reinforces the validity of the conclusions.

Limitations of the Study

Several limitations must be acknowledged.

The number of clusters in the panel (G = 7) is below the conventional threshold of 50 recommended by Cameron, Gelbach, and Miller (2008). Although the use of the t(6) distribution and Fama-MacBeth validation serve as safeguards, this constraint calls for a cautious interpretation of significance levels.

The monthly frequency and the contemporaneous specification (lag 0) limit the ability to fully identify causality. Although the correlation structure analysis (Appendix C.7) supports this choice empirically, the monthly horizon may dilute immediate announcement effects and raises a reverse causality concern, as elevated risk premiums may themselves prompt ECB interventions. The daily-frequency event study partially mitigates this limitation by establishing a clearer causal direction within narrow event windows.

The implied ERP is computed as the inverse of the forward price-to-earnings ratio (ERP = 1/PE_forward), a transparent but approximate measure that may not fully capture the dynamics of the true expected equity premium.

Areas for Future Research

Several extensions could enhance this research.

Incorporating intraday data around ECB announcement dates would allow us to test the robustness of the results by leveraging the monetary policy surprises identified by Jarociński and Karadi (2020).

Estimating threshold models (Hansen, 2000) or models with time-varying coefficients would allow for a more formal test of regime dependence.

Expanding the panel to include a larger number of countries would improve the reliability of cluster-robust standard errors.

Replicating the analysis using alternative ERP measures, such as the Gordon-Shapiro dividend discount model or the multi-stage models proposed by Damodaran (2012), would test the sensitivity of the results to the risk premium estimation method.

Testing the model with lagged independent variables (1 to 3 months) would allow the assessment of potential delayed transmission channels and further validate the choice of the contemporaneous specification. Similarly, an instrumental variable approach, exploiting exogenous variation in ECB policy decisions, would more rigorously address the reverse causality between the equity risk premium and monetary policy interventions.

Finally, incorporating cross-border capital flows (Bergant, Fidora, and Schmitz, 2020) as a mediating variable would allow us to test whether the ECB's QE is less effective on the ERP relative to the Fed's due to a rebalancing of European portfolios toward U.S. markets.

Implications for Monetary Policy and Investors

Our results suggest that the ECB's unconventional instruments function as a financial stabilization mechanism rather than as a permanent tool for suppressing risk premiums. This interpretation is consistent with the design of the asset purchase programs and the TPI as tools to prevent fragmentation (ECB, 2022).

For investors, the message is clear: the ECB's intervention serves as a safety net in times of crisis, suppressing risk premiums when they are at their highest, but does not provide permanent support for the valuation of risky assets under normal conditions.

Ultimately, this thesis makes an original empirical contribution by documenting the conditional and nonlinear nature of the relationship between ECB interventions and the equity risk premium in the euro area, while establishing that this transmission, unlike that documented in bond markets, is geographically homogeneous across core and peripheral countries.

Appendices

Appendix A — Data Description and Stationarity

This appendix provides the complete data foundation for the econometric analysis. It documents variable construction, descriptive statistics, panel-level heterogeneity, and time-series stationarity properties.

A.1 Variable Dictionary

The following table documents the 33 variables used in the empirical analysis, including their definitions, sources, frequency, and transformations applied.

Table A.1 — Variable Dictionary

Variable	Description	Source	Freq.	Unit / Transform.
ERP_EMU	Implied equity risk premium, MSCI EMU	Refinitiv	M	Level (%)
ΔERP	First difference of ERP_EMU	Computed	M	Δ level
ECB_Balance_Sheet	Total assets of the Eurosystem	ECB SDW	M	EUR bn
ΔLog(BS)	Log-differenced ECB balance sheet	Computed	M	Δ log
APP_All	Sum of CBPP1+CBPP2+CBPP3+ABSPP+PSPP+CSPP+PEPP	Computed	M	EUR bn
ΔAPP_All	Net monthly change in APP_All / 10^{11}	Computed	M	Flow / 10^{11}
Deposit_Rate	ECB deposit facility rate	Refinitiv	M	% p.a.
ΔDFR	First difference of deposit rate	Computed	M	Δ pp
SMP	Securities Markets Programme holdings	Refinitiv	M	EUR bn
ΔSMP	Net monthly change in SMP / 10^{11}	Computed	M	Flow / 10^{11}
LTRO	Long-term refinancing operations outstanding	ECB SDW	M	EUR bn
ΔLTRO	Net monthly change in LTRO / 10^{11}	Computed	M	Flow / 10^{11}
VSTOXX_Avg	Implied volatility of EURO STOXX 50 options	Refinitiv	M	Index level
ΔVSTOXX	First difference of VSTOXX monthly average	Computed	M	Δ level
Stress_P90	Dummy: 1 if VSTOXX > P90 (30.32)	Computed	M	Binary (0/1)
HICP_YoY	Harmonised Index of Consumer Prices, YoY	Refinitiv	M	% YoY
ΔHICP	First difference of HICP YoY rate	Computed	M	Δ pp
GDP_EA	Euro area real GDP (chained volumes)	Eurostat	M	EUR mn
ΔLog(GDP)	Log-differenced interpolated GDP	Computed	M	Δ log
Bund_10Y	German 10-year government bond yield	Refinitiv	M	% p.a.
ΔBund 10Y	First difference of Bund yield	Computed	M	Δ pp
M3_YoY	Broad money aggregate M3, YoY growth	Refinitv	M	% YoY
ΔM3	First difference of M3 growth rate	Computed	M	Δ pp
CISS	Composite Indicator of Systemic Stress	ECB	D/M	Index [0,1]
ERP_DE	Implied ERP, Germany (DAX)	Computed	D/M	Level (%)
ERP_FR	Implied ERP, France (CAC 40)	Computed	D/M	Level (%)
ERP_IT	Implied ERP, Italy (FTSE MIB)	Computed	D/M	Level (%)
ERP_ES	Implied ERP, Spain (IBEX 35)	Computed	D/M	Level (%)
ERP_NL	Implied ERP, Netherlands (AEX)	Computed	D/M	Level (%)
ERP_BE	Implied ERP, Belgium (BEL 20)	Computed	D/M	Level (%)
ERP_GR	Implied ERP, Greece (ATHEX)	Computed	D/M	Level (%)
Rate_10Y_i	10-year sovereign bond yield, country i	Refinitiv	D/M	% p.a.
ΔRate_10Y_i	First difference of sovereign yield	Computed	D/M	Δ pp

Notes: All variables in first differences except ERP (level) and VSTOXX (level). Stress_P90 = 1 if VSTOXX monthly average > 90th percentile (30.32). The seven countries in the panel are: Germany (DE), France (FR), Italy (IT), Spain (ES), Netherlands (NL), Belgium (BE), Greece (GR).

A.2 Descriptive Statistics

Table 1 — Descriptive Statistics of Model Variables

Variable	N	Average	Median	Std. Dev.	Min	Max	Skew.	Kurt.
ΔERP (MSCI EMU)	263	0.0000	-0.0002	0.0049	-0.0217	0.0262	0.68	5.91
ΔLog(Bilan BCE)	263	0.0077	0.0045	0.0336	-0.1221	0.2543	1.92	14.29
ΔAPP_All (×10¹¹€)	263	0.1426	0.0000	0.3896	-1.2763	1.7097	0.95	1.76
ΔDFR	263	0.0000	0.0000	0.0015	-0.0100	0.0075	-0.40	15.13
ΔSMP (×10¹¹€)	263	-0.0000	0.0000	0.1461	-1.6450	1.4636	-1.34	97.04
ΔLTRO (×10¹¹€)	263	0.0000	0.0000	2.2318	-10.99	24.49	3.27	61.60
ΔVSTOXX	263	-0.0147	-0.5479	4.8796	-15.64	39.91	3.23	23.43
ΔHICP (YoY)	263	0.0000	0.0000	0.0036	-0.0170	0.0160	-0.27	4.21
ΔLog(PIB)	263	0.0025	0.0028	0.0024	-0.0036	0.0084	-0.17	0.98
ΔBund 10Y	263	-0.0001	-0.0002	0.0016	-0.0053	0.0073	0.39	1.98
ΔM3 (YoY)	263	-0.0001	0.0000	0.0050	-0.0230	0.0220	-0.29	2.77
ERP (MSCI EMU, niveau)	263	0.0802	0.0769	0.0145	0.0554	0.1373	1.18	1.72
VSTOXX (niveau)	263	21.67	19.52	8.0438	12.17	63.27	2.09	6.15

Notes: Monthly sample, Feb. 2004 – Dec. 2025 (N = 263). Variables in first differences except ERP (level) and VSTOXX (level). APP, SMP expressed as net variation / 10¹¹€. Skew. = skewness coefficient; Kurt. = excess kurtosis.

A.3 Panel Descriptive Statistics by Country

Table A.2 — Panel Descriptive Statistics: ERP by Country (2004–2025)

Country	Group	N	Mean ERP	Std. Error	Min	Max	Mean ΔERP
Germany (DE)	Core	264	0.0792	0.0008	0.0505	0.1303	0.0002
France (FR)	Core	264	0.0781	0.0009	0.0414	0.1251	−0.0001
Netherlands (NL)	Core	264	0.0766	0.0012	0.0424	0.1633	−0.0001
Belgium (BE)	Core	264	0.0768	0.0008	0.0579	0.1502	−0.0001
Spain (ES)	Periphery	264	0.0823	0.0010	0.0552	0.1326	−0.0000
Italy (IT)	Periphery	264	0.0854	0.0013	0.0530	0.1425	0.0001
Greece (GR)	Periphery	264	0.0946	0.0018	0.0514	0.1883	0.0004
Core average	—	1,056	0.0777	0.0005	0.0414	0.1633	—
Periphery average	—	792	0.0874	0.0008	0.0514	0.1883	—
Full panel	—	1,841	0.0819	0.0005	0.0414	0.1883	—

Notes: *Monthly ERP levels (implied equity risk premium from dividend discount models). Core countries: BE, DE, FR, NL. Periphery countries: ES, GR, IT. N = 264 monthly observations per country (January 2004 – December 2025). Mean ΔERP computed on first differences (N = 263, excluding January 2004).*

A.4 Stationarity Tests

Table 3 – Stationarity Tests ADF (Augmented Dickey-Fuller)

Variable	t-ADF	$Crit_{.05}$	N	Conclusion
ΔERP (MSCI EMU)	-7.075***	−2,860	258	I(0)
ΔLog(Bilan BCE)	-5.711***	−2,860	258	I(0)
ΔAPP_All (×10¹¹€)	-1.852	−2,860	258	Non rejetée
ΔDFR	-4.760***	−2,860	258	I(0)
ΔSMP (×10¹¹€)	-7.540***	−2,860	258	I(0)
ΔLTRO (×10¹¹€)	-6.994***	−2,860	258	I(0)
ΔVSTOXX	-9.016***	−2,860	258	I(0)
ΔHICP (YoY)	-5.016***	−2,860	258	I(0)
ΔLog(PIB)	-2.910**	−2,860	258	I(0)
ΔBund 10Y	-6.759***	−2,860	258	I(0)
ΔM3 (YoY)	-5.460***	−2,860	258	I(0)
ERP (MSCI EMU, niveau)	-2.768*	−2,860	258	Non rejetée
VSTOXX (niveau)	-3.703***	−2,860	258	I(0)

*Notes : DF test with constant and p = 4 lags. MacKinnon (1996) critical values: −3.43 (1%), −2.86 (5%), −2.57 (10%). *** p < 0.01; ** p < 0.05; * p < 0.10. I(0) = stationary series.*

Appendix B — Detailed Regression Results: H1 (Unconditional Effect)

This appendix presents the full regression output for all eight H1 specifications, allowing the jury to verify every coefficient, standard error, and diagnostic statistic referenced in Section 4.1 of the main text. The dependent variable is ΔERP (implied equity risk premium, MSCI EMU). Estimation is by OLS with Newey–West HAC standard errors (Bartlett kernel, L = 4 lags). Sample: Feb. 2004 – Dec. 2025 (N = 263).

The baseline equation is: ΔERP_t = α + β·ΔBCE_t + γ'·Controls_t + ε_t, where Controls = {ΔVSTOXX, ΔHICP, ΔLog(GDP), ΔBund 10Y, ΔM3}.

B.1 Individual OLS Regression Tables: Models (1)–(8)

Table 5.1 — Model (1): Balance Sheet Size (ΔLog BS)

Variable	Coefficient	Std. Error	t-stat	p-value
Constante	-0.000259	*(0.000393)*	-0.659	0.5099
ΔLog(BS)	-0.003749	*(0.008602)*	-0.436	0.6630
ΔVSTOXX	**0.000733*** **	*(0.000078)*	9.393	0.0000
ΔHICP	0.083808	*(0.073100)*	1.146	0.2516
ΔLog(PIB)	0.119185	*(0.103068)*	1.156	0.2475
ΔBund 10Y	-0.022708	*(0.189654)*	-0.120	0.9047
ΔM3	0.008458	*(0.057566)*	0.147	0.8832

N = 263 | R^2 = 0.5451 | R^2 ajusté = 0.5345 | DW = 2.037

*Notes : Newey-West HAC standard errors (Bartlett, L = 4) in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.10.*

Table 5.2 — Model (2): Asset Purchases (ΔAPP)

Variable	Coefficient	Std. Error	t-stat	p-value
Constante	-0.000295	*(0.000372)*	-0.792	0.4282
ΔAPP	-0.000080	*(0.000607)*	-0.132	0.8953
ΔVSTOXX	**0.000727*** **	*(0.000080)*	9.142	0.0000
ΔHICP	0.083324	*(0.076650)*	1.087	0.2770
ΔLog(PIB)	0.126292	*(0.108720)*	1.162	0.2454
ΔBund 10Y	-0.024640	*(0.191260)*	-0.129	0.8975
ΔM3	0.007507	*(0.057278)*	0.131	0.8957

N = 263 | R^2 = 0.5445 | R^2 ajusté = 0.5339 | DW = 2.047

*Notes : Newey-West HAC standard errors (Bartlett, L = 4) in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.10. Dependent variable: Δ Implicit ERP (MSCI EMU). Period: Feb. 2004 – Dec. 2025 (N = 263).*

Table 5.3 — Model (3): Deposit Facility Rate (ΔDFR)

Variable	Coefficient	Std. Error	t-stat	p-value
Constante	-0.000168	*(0.000373)*	-0.450	0.6525
ΔDFR	0.251549	*(0.165626)*	1.519	0.1288
ΔVSTOXX	**0.000717*** **	*(0.000076)*	9.469	0.0000
ΔHICP	0.087043	*(0.069549)*	1.252	0.2107
ΔLog(PIB)	0.067019	*(0.105673)*	0.634	0.5259
ΔBund 10Y	-0.063443	*(0.195031)*	-0.325	0.7450
ΔM3	0.005201	*(0.058550)*	0.089	0.9292

N = 263 | R^2 = 0.5494 | R^2 adj. = 0.5389 | DW = 2.064

*Notes: Newey-West HAC standard errors (Bartlett, L = 4) in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.10.*

Table 5.4 — Model (4): Securities Markets Programme (ΔSMP)

Variable	Coefficient	Std. Error	t-stat	p-value
Constante	-0.000302	*(0.000386)*	-0.781	0.4349
ΔSMP	0.000261	*(0.000850)*	0.307	0.7587
ΔVSTOXX	**0.000727*** **	*(0.000078)*	9.328	0.0000
ΔHICP	0.081434	*(0.072695)*	1.120	0.2626
ΔLog(PIB)	0.124546	*(0.103100)*	1.208	0.2270
ΔBund 10Y	-0.023121	*(0.190233)*	-0.122	0.9033
ΔM3	0.007378	*(0.058566)*	0.126	0.8997

N = 263 | R^2 = 0.5446 | R^2 adj. = 0.5339 | DW = 2.045

*Notes: Newey–West HAC standard errors (Bartlett kernel, L = 4) in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.10. Dependent variable: ΔERP (MSCI EMU). Period: Feb. 2004 – Dec. 2025.*

Table 5.5 — Model (5): Long-Term Refinancing (ΔLTRO)

Variable	Coefficient	Std. Error	t-stat	p-value
Constante	-0.000297	*(0.000383)*	-0.775	0.4384
ΔLTRO	-0.000055	*(0.000065)*	-0.850	0.3954
ΔVSTOXX	**0.000725*** **	*(0.000078)*	9.338	0.0000
ΔHICP	0.088390	*(0.072215)*	1.224	0.2210
ΔLog(PIB)	0.122436	*(0.101647)*	1.205	0.2284
ΔBund 10Y	-0.035403	*(0.194726)*	-0.182	0.8557
ΔM3	0.006717	*(0.058175)*	0.115	0.9081

N = 263 | R^2 = 0.5456 | R^2 adj. = 0.5349 | DW = 2.060

*Notes: Newey–West HAC standard errors (Bartlett kernel, L = 4) in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.10. Dependent variable: ΔERP (MSCI EMU). Period: Feb. 2004 – Dec. 2025.*

Table 5.6 — Model (6): Joint (BS + APP + DFR)

Variable	Coefficient	Std. Error	t-stat	p-value
Constante	-0.000143	*(0.000370)*	-0.386	0.6996
ΔLog(BS)	-0.002969	*(0.009158)*	-0.324	0.7458
ΔAPP	0.000064	*(0.000625)*	0.103	0.9180
ΔDFR	0.245628	*(0.168851)*	1.455	0.1458
ΔVSTOXX	**0.000722*****	*(0.000079)*	9.093	0.0000
ΔHICP	0.087285	*(0.073859)*	1.182	0.2373
ΔLog(PIB)	0.062709	*(0.112357)*	0.558	0.5768
ΔBund 10Y	-0.060996	*(0.193186)*	-0.316	0.7522
ΔM3	0.005998	*(0.056929)*	0.105	0.9161

N = 263 | R^2 = 0.5498 | R^2 adj. = 0.5356 | DW = 2.057

*Notes: Newey–West HAC standard errors (Bartlett kernel, L = 4) in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.10. Dependent variable: ΔERP (MSCI EMU). Period: Feb. 2004 – Dec. 2025.*

B.2 Extended H1 Models: Inclusion of SMP and LTRO

Table 5.7 — Model (7): Extended (+ SMP)

Variable	Coefficient	Std. Error	t-stat	p-value
Constante	-0.000143	*(0.000371)*	-0.386	0.6992
ΔLog(BS)	-0.003098	*(0.009253)*	-0.335	0.7377
ΔAPP	0.000075	*(0.000623)*	0.120	0.9047
ΔDFR	0.245700	*(0.168829)*	1.455	0.1456
ΔSMP	0.000327	*(0.000876)*	0.373	0.7088
ΔVSTOXX	**0.000721*****	*(0.000079)*	9.105	0.0000
ΔHICP	0.086614	*(0.074007)*	1.170	0.2419
ΔLog(PIB)	0.062672	*(0.112350)*	0.558	0.5770
ΔBund 10Y	-0.059142	*(0.192124)*	-0.308	0.7582
ΔM3	0.006170	*(0.056868)*	0.108	0.9136

N = 263 | R^2 = 0.5499 | R^2 adj. = 0.5339 | DW = 2.055

*Notes: Newey–West HAC standard errors (Bartlett kernel, L = 4) in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.10. Dependent variable: ΔERP (MSCI EMU). Period: Feb. 2004 – Dec. 2025.*

Table 5.8 — Model (8): Complete (+ LTRO)

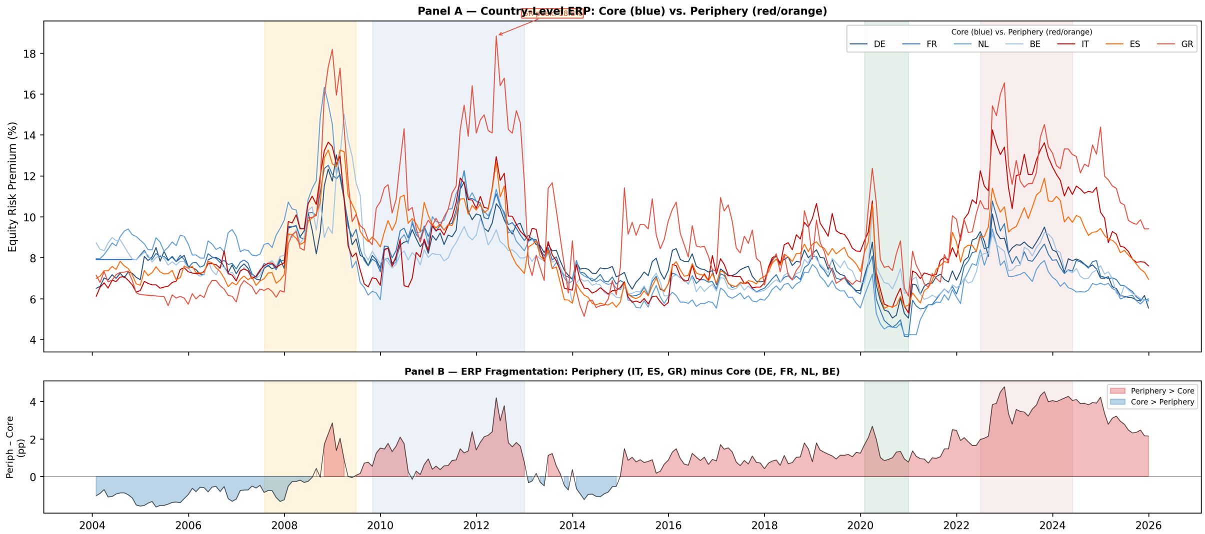
Variable	Coefficient	Std. Error	t-stat	p-value
Constante	-0.000149	*(0.000371)*	-0.401	0.6883
ΔLog(BS)	-0.002645	*(0.009233)*	-0.286	0.7745
ΔAPP	0.000099	*(0.000604)*	0.164	0.8699
ΔDFR	0.241952	*(0.168612)*	1.435	0.1513
ΔSMP	0.000311	*(0.000864)*	0.360	0.7190
ΔLTRO	-0.000046	*(0.000058)*	-0.797	0.4255
ΔVSTOXX	**0.000719*****	*(0.000079)*	9.095	0.0000
ΔHICP	0.091345	*(0.074074)*	1.233	0.2175
ΔLog(PIB)	0.061985	*(0.111928)*	0.554	0.5797
ΔBund 10Y	-0.067941	*(0.194715)*	-0.349	0.7271
ΔM3	0.005521	*(0.056617)*	0.098	0.9223

N = 263 | R^2 = 0.5506 | R^2 adj. = 0.5328 | DW = 2.069

*Notes: Newey–West HAC standard errors (Bartlett kernel, L = 4) in parentheses. *** p < 0.01; ** p < 0.05; * p < 0.10. Dependent variable: ΔERP (MSCI EMU). Period: Feb. 2004 – Dec. 2025.*

B.3 ERP Dispersion Across Countries

Figure 8 – ERP Dispersion Across Euro Area Countries and Core-Periphery Fragmentation (2004-2025)



(Source : ECB SDW / Refinitiv Author : Max Czarka – HEC Liège 2026)

Appendix C — Detailed Regression Results: H2 and H3 (Conditional Effects)

This appendix presents the full regression output for the stress-interaction models (H2) and the panel fixed-effects models (H3), including the Fama–MacBeth (1973) cross-validation. These models test whether the ECB's effect on the ERP is amplified during financial stress (H2) and whether it varies across countries (H3).

C.1 Model H2a: Interactions BS, APP, DFR × Stress

Table 6.1 — Model (9) H2a: Interactions BS, APP, DFR × Stress

Variable	Coefficient	Std. Error	t-stat	p-value
Constante	-0.000025	*(0.000354)*	-0.069	0.9449
ΔLog(BS)	-0.003194	*(0.007983)*	-0.400	0.6891
ΔAPP	**0.000939****	*(0.000395)*	2.380	0.0173
ΔDFR	0.250060	*(0.155989)*	1.603	0.1089
Stress_P90	-0.000406	*(0.001044)*	-0.388	0.6977
ΔLog(BS)×Stress	0.006484	*(0.017224)*	0.376	0.7066
ΔAPP×Stress	**-0.004128*****	*(0.001195)*	-3.455	0.0006
ΔVSTOXX	**0.000719*****	*(0.000088)*	8.205	0.0000
ΔHICP	0.069503	*(0.064333)*	1.080	0.2800
ΔLog(PIB)	0.022237	*(0.105567)*	0.211	0.8332
ΔBund 10Y	-0.052333	*(0.189944)*	-0.276	0.7829
ΔM3	0.024373	*(0.048490)*	0.503	0.6152

N = 263 | R^2 = 0.5699 | R^2 adj. = 0.5511 | DW = 2.059

*Notes: Newey–West HAC standard errors (Bartlett, L = 4). *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$. Stress_P90 = 1 if VSTOXX > 30.32 (90th percentile; 27/263 months). Dependent variable: ΔERP.*

C.2 Model (10) H2b: Full Interactions

Table 6.2 — Model (10) H2b: Full Interactions (All Five Proxies)

Variable	Coefficient	Std. Error	t-stat	p-value
Constante	0.000012	*(0.000357)*	0.033	0.9741
ΔLog(BS)	-0.003383	*(0.008008)*	-0.422	0.6727
ΔAPP	**0.000975****	*(0.000386)*	2.528	0.0115
ΔDFR	0.209583	*(0.160970)*	1.302	0.1929
ΔSMP	-0.000333	*(0.000275)*	-1.213	0.2253
ΔLTRO	-0.000020	*(0.000052)*	-0.376	0.7071
Stress_P90	-0.001193	*(0.001200)*	-0.994	0.3202
ΔLog(BS)×Stress	0.008519	*(0.019321)*	0.441	0.6593
ΔAPP×Stress	**-0.002869***	*(0.001502)*	-1.910	0.0561
ΔSMP×Stress	0.008713	*(0.005680)*	1.534	0.1250
ΔLTRO×Stress	-0.000279	*(0.000644)*	-0.434	0.6646
ΔVSTOXX	**0.000722*****	*(0.000079)*	9.192	0.0000
ΔHICP	0.060686	*(0.062618)*	0.969	0.3325
ΔLog(PIB)	0.009011	*(0.106325)*	0.085	0.9325
ΔBund 10Y	-0.005600	*(0.181466)*	-0.031	0.9754
ΔM3	0.021294	*(0.044752)*	0.476	0.6342

N = 263 | R^2 = 0.5761 | R^2 adj. = 0.5504 | DW = 2.035

*Notes: Newey–West HAC standard errors (Bartlett, L = 4). *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.*

C.3 Model (11): Panel Fixed Effects Baseline

Table 8.1 — Model (11): Panel FE Baseline (ΔERP_i,t)

Variable	Coefficient	Std. Error	t-stat	p-value
ΔLog(BS)	-0.011205	(0.006398)	-1.751	0.1303
ΔAPP	0.000354	(0.000369)	0.958	0.3752
ΔDFR	0.179830	(0.267618)	0.672	0.5269
ΔSMP	-0.000082	(0.000306)	-0.269	0.7972
ΔLTRO	0.000043	(0.000062)	0.693	0.5143
ΔVSTOXX	**0.000622*****	(0.000064)	9.662	0.0001
ΔHICP	**0.121149****	(0.036986)	3.275	0.0170
ΔLog(GDP)	-0.060808	(0.047171)	-1.289	0.2452
ΔRate 10Y	**0.262705*****	(0.024536)	10.707	0.0000
ΔM3	0.003886	(0.012505)	0.311	0.7672

N = 1,841 | R^2 (within) = 0.2223 | R^2 adj. = 0.2184 | Countries = 7

Notes: *Panel fixed effects, within transformation. Cluster-robust standard errors (G = 7 countries), t(6) inference. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$. ΔAPP, ΔSMP, ΔLTRO scaled to €100bn.*

C.4 Model (12): Panel FE with Stress Interactions

Table 8.2 — Model (12): Panel FE with Stress Interactions (ΔERP_i,t)

Variable	Coefficient	Std. Error	t-stat	p-value
ΔLog(BS)	0.002269	(0.004389)	0.517	0.6237
ΔAPP	**0.000863*** **	(0.000204)	4.232	0.0055
ΔDFR	0.227156	(0.237878)	0.955	0.3768
ΔSMP	**-0.000585*** **	(0.000157)	-3.732	0.0097
ΔLTRO	0.000085	(0.000072)	1.179	0.2832
Stress_P90	0.001004	(0.001073)	0.936	0.3858
ΔLog(BS)×Stress	**-0.038857** **	(0.014599)	-2.662	0.0374
ΔAPP×Stress	**-0.010334*** **	(0.001740)	-5.940	0.0010
ΔSMP×Stress	0.003046	(0.002752)	1.107	0.3107
ΔLTRO×Stress	**0.000557* **	(0.000263)	2.112	0.0792
ΔVSTOXX	**0.000681*** **	(0.000069)	9.830	0.0001
ΔHICP	**0.086428** **	(0.035258)	2.451	0.0497
ΔLog(GDP)	-0.063785	(0.054248)	-1.176	0.2842
ΔRate 10Y	**0.260697*** **	(0.024650)	10.576	0.0000
ΔM3	**0.023578*** **	(0.006269)	3.761	0.0093
N = 1,841 | R^2 (within) = 0.2383 | R^2 adj. = 0.2325 | Countries = 7				

Notes: *Panel fixed effects, within transformation. Cluster-robust standard errors (G = 7), t(6) inference. *** p < 0.01; ** p < 0.05; * p < 0.10. Stress_P90 = 1 if VSTOXX > 30.32 (90th percentile; 27/263 months). ΔAPP, ΔSMP, ΔLTRO scaled to €100bn.*

C.5 Model (12b): Panel FE with Stress and Periphery Interactions

Table 8.3 — Model (12b): Panel FE with Stress and Periphery Interactions (ΔERP_i,t)

Variable	Coefficient	Std. Error	t-stat	p-value
ΔLog(BS)	0.002363	(0.005419)	0.436	0.6783
ΔAPP	**0.000822*** **	(0.000128)	6.415	0.0007
ΔDFR	0.227409	(0.238128)	0.955	0.3764
ΔSMP	-0.000551	(0.000407)	-1.355	0.2242
ΔLTRO	0.000042	(0.000034)	1.245	0.2597
Stress_P90	0.001008	(0.001077)	0.936	0.3858
ΔLog(BS)×Stress	**-0.046084* **	(0.022250)	-2.071	0.0838
ΔAPP×Stress	**-0.009030*** **	(0.001851)	-4.879	0.0028
ΔSMP×Stress	0.003054	(0.002766)	1.104	0.3117
ΔLTRO×Stress	**0.000557* **	(0.000264)	2.112	0.0792
ΔLog(BS)×Periphery	-0.000220	(0.007259)	-0.030	0.9769
ΔAPP×Periphery	0.000097	(0.000466)	0.209	0.8415
ΔSMP×Periphery	-0.000074	(0.000788)	-0.094	0.9282
ΔLTRO×Periphery	0.000099	(0.000113)	0.876	0.4148
ΔAPP×Stress×Periphery	-0.003053	(0.002581)	-1.183	0.2816
ΔLog(BS)×Stress×Periphery	0.016855	(0.019502)	0.864	0.4210

Variable	Coefficient	Std. Error	t-stat	p-value
ΔVSTOXX	**0.000681*** **	(0.000069)	9.810	0.0001
ΔHICP	**0.086597** **	(0.035162)	2.463	0.0490
ΔLog(GDP)	-0.063458	(0.054053)	-1.174	0.2848
ΔRate 10Y	**0.258760*** **	(0.026652)	9.709	0.0001
ΔM3	**0.023465** **	(0.006324)	3.710	0.0099
N = 1,841 | R^2 (within) = 0.2395 | R^2 adj. = 0.2311 | Countries = 7				

Notes: *Panel fixed effects, within transformation. Cluster-robust standard errors (G = 7), t(6) inference. *** p < 0.01; ** p < 0.05; * p < 0.10. Periphery = 1 for ES, GR, IT; 0 for BE, DE, FR, NL. Main effect absorbed by FE. Triple interactions only for APP and BS (dominant channels). ΔAPP, ΔSMP, ΔLTRO scaled to €100bn.*

C.6 Fama–MacBeth (1973) Cross-Validation

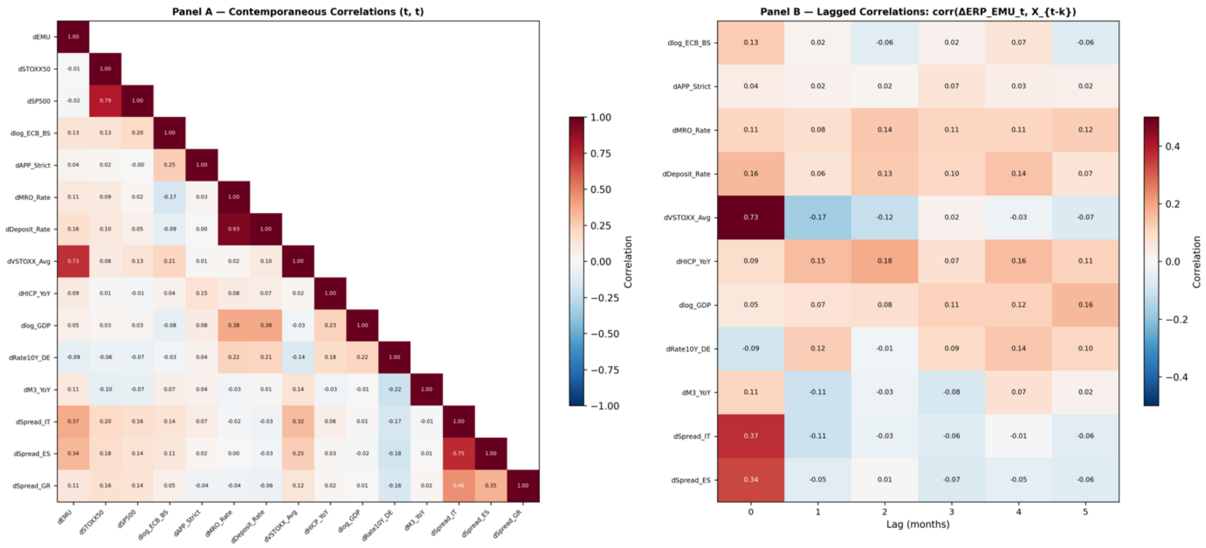
Table 8.4 — Fama-MacBeth-style Country-Level Robustness Check

Variable	Coefficient	Std. Error	t-stat	p-value
ΔLog(BS)	0.001493	(0.004511)	-0.293	0.7795
ΔAPP	**0.000881*** **	(0.000175)	5.034	0.0024
ΔDFR	0.213837	(0.236752)	0.903	0.4010
Stress_P90	0.001183	(0.001005)	1.177	0.2840
ΔLog(BS)×Stress	**-0.029009***	(0.012011)	-2.415	0.0522
ΔAPP×Stress	**-0.009246*** **	(0.001872)	-4.939	0.0026
ΔVSTOXX	**0.000671*** **	(0.000067)	10.015	0.0001
ΔHICP	**0.089275***	(0.037451)	2.384	0.0543
ΔLog(GDP)	-0.068456	(0.049195)	-1.392	0.2133
ΔRate 10Y	**0.327681*** **	(0.062315)	5.259	0.0019
ΔM3	**0.036425*** **	(0.007995)	4.556	0.0039
Country regressions = 7 | Inference based on t(6)				

Notes: *Country-by-country robustness check. Model (12) is estimated separately for each of the seven countries, and the table reports the cross-country mean of coefficients. Standard errors are computed as the cross-country standard deviation of coefficients divided by √7. Inference is based on t(6). *** p < 0.01; ** p < 0.05; * p < 0.10.*

C.7 Correlation Structure of Model Variables

Figure 9 – *Correlation structure : ΔERP and ECB/Macro Variables (2004-2025)*



(Source : ECB SDW / Refinitiv Author : Max Czarka – HEC Liège 2026)

Appendix D — Event Study and Supplementary Diagnostics

This appendix complements the main-text event study summary (Section 4.3.4) with detailed cumulative abnormal returns (CARs) for each of the 20 ECB policy events, graphical evidence of cross-country heterogeneity, and the complete VIF diagnostic table.

D.1 Event Study Results

Table 8.1 — Event Study Summary: CARs by ECB Policy Event [−1, +3]

Date	Event	Programme	Context	CAR[−1,+3]	t-stat	Sig.
2008-10-08	Emergency rate cut (−50bp)	Rate Cut	Crisis	+0.763	2.408	**
2009-05-07	CBPP1 + rate cut to 1%	CBPP	Crisis	−0.315	−0.643	
2010-05-10	SMP announcement	SMP	Sov. Crisis	−0.027	−0.113	
2011-08-07	SMP reactivation (IT/ES)	SMP	Sov. Crisis	+0.396	1.627	
2011-10-06	CBPP2 (€40bn)	CBPP	Sov. Crisis	−1.120***	−2.859	***
2011-12-08	3-year LTRO (€489bn)	LTRO	Sov. Crisis	+0.116	0.237	
2012-07-26	Draghi: 'Whatever it takes'	Comm.	Sov. Crisis	−0.708**	−2.134	**
2012-09-06	OMT details	OMT	Sov. Crisis	−0.453	−1.241	
2013-07-04	Forward guidance	Fwd. Guid.	Normal	−0.209	−1.090	
2014-06-05	Negative DFR + TLTRO	TLTRO	Normal	−0.128	−0.771	
2015-01-22	QE announcement (PSPP)	APP	Normal	−0.302	−1.351	
2016-03-10	CSPP + QE expansion	APP	Normal	−0.244	−0.821	
2016-12-08	QE extension + tapering	APP	Normal	−0.249	−1.211	
2018-06-14	QE end date (Dec 2018)	APP End	Normal	+0.030	0.167	
2019-03-07	TLTRO-III	TLTRO	Normal	+0.004	0.020	
2020-03-12	PEPP launch (€750bn)	PEPP	COVID	+0.728***	3.928	***
2020-06-04	PEPP expansion (€1.35tn)	PEPP	COVID	−0.297	−0.697	
2020-12-10	PEPP expansion (€1.85tn)	PEPP	Normal	+0.024	0.145	
2022-07-21	TPI + first rate hike	Rate Hike	Tightening	−0.052	−0.170	
2024-06-06	First rate cut post-tight.	Rate Cut	Normal	+0.062	0.503	

*Notes: CARs computed over the [−1, +3] trading-day window using a constant mean return model estimated over 120 pre-event days. t-statistics follow Boehmer, Masumeci,Poulsen, A.B. (1991). *** p < 0.01; ** p < 0.05; * p < 0.10. Significant CARs cluster around crisis-period announcements (*Emergency rate cut (−50bp), *CBPP2, 'Whatever it takes', PEPP launch), consistent with H2.*

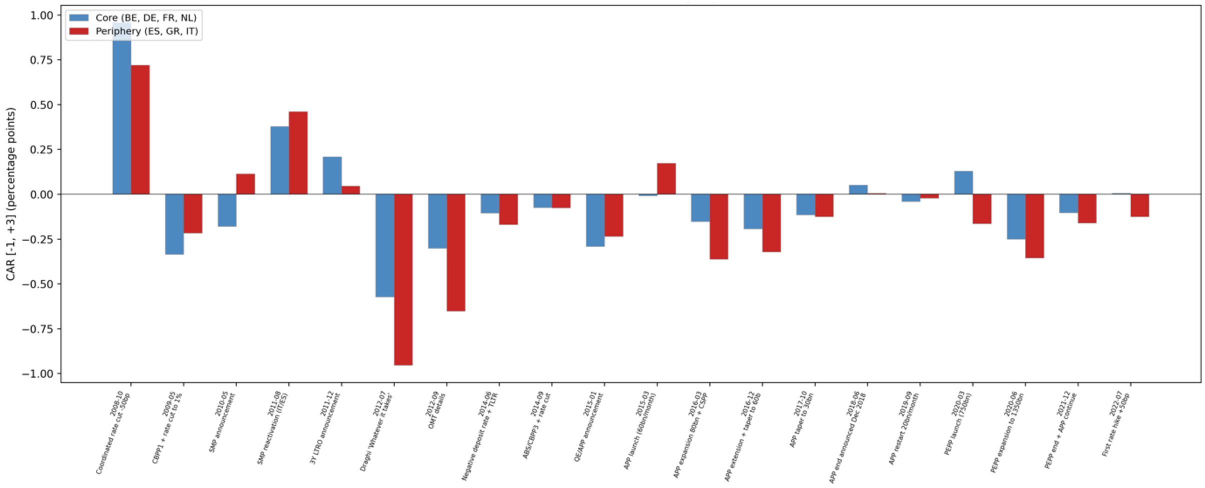
D.2 Country-Level CARs Heatmap

Figure 7 – *Event Study : Cumulative Abnormal ERP Changes by Country window [-1,+3]*

(Source : ECB SDW / Refinitiv Author : Max Czarka – HEC Liège 2026)

D.3 Core vs. Periphery CARs

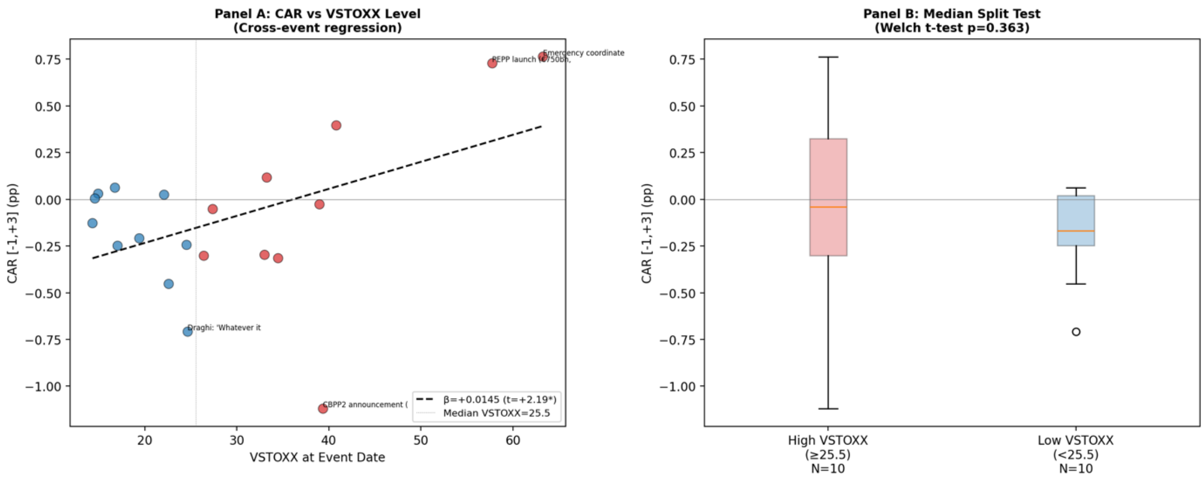
Figure 10 – *Core Vs Periphery : Cumulative Abnormal Returns around ECB Announcements Window [-1,+3]*



(Source : ECB SDW / Refinitiv Author : Max Czarka – HEC Liège 2026)

D.4 VSTOXX vs. CARs

Figure 11 – *Test H2 : ECB Effect Conditional on Market Stress (VSTOXX)*



(Source : ECB SDW / Refinitiv Author : Max Czarka – HEC Liège 2026)

Appendix E — Robustness Checks

This appendix documents all robustness exercises referenced in Section 3.4 of the main text: alternative equity indices, sub-period stability, structural break tests, and alternative ECB proxies.

E.1 Replication on Alternative Equity Indices

The baseline regressions, estimated on the MSCI EMU index, are replicated using the EURO STOXX 50, STOXX 600, EURONEXT 100. The STOXX 600 includes non-euro area components (United Kingdom, Switzerland) whose monetary policy is independent of the ECB.

Results confirm euro area specificity: the ECB balance sheet coefficient is negative and consistent with the baseline only for the MSCI EMU and EURONEXT 100 indices. The EURO STOXX 50 and STOXX 600 show positive coefficients, likely reflecting compositional effects (inclusion of non-EMU firms).

E.2 Sub-Period Coefficient Stability

The temporal stability of the coefficients is examined by estimating Model (6) on three sub-periods: pre-QE (2004–2014), QE active (2015–June 2022), and post-QE/tightening (July 2022–2025). Additional windows (2012–2019, post-2020) are also estimated.

Table 11 — Sub-Period Coefficient Stability (H1 Joint Model)

Panel A: Sub-Period Estimates

Sub-Period	N	β(BS)	t	β(APP)	t	β(DFR)	t	R^2 adj.
Full Sample (2004–2025)	263	−0.004	−0.39	0.001	0.38	+0.245	1.60	0.545
Pre-QE (2004–2014)	131	−0.003	−0.17	−0.004	−0.38	+0.072	0.38	0.660
QE Active (2015–Jun 2022)	90	−0.068***	−3.55	+0.001	0.10	+0.235	0.48	0.596
Post-QE (Jul 2022–2025)	42	+0.005	0.28	−0.000	−0.03	+0.585***	2.85	0.373
2012–2019	96	−0.032	−1.44	+0.003	0.34	−1.372***	−3.87	0.539
Post-2020	72	−0.027	−0.91	+0.000	0.04	+0.026	0.13	0.482

Panel B: Bai–Perron Endogenous Break Segments (Balance Sheet only)

Segment	N	β(BS)	t
2004–2009 (Pre-SMP)	67	−0.016***	−2.72
2009–2014 (SMP/OMT era)	64	+0.009	0.52
2014–2020 (Core QE)	70	−0.064***	−4.18
2020–2025 (PEPP/QT)	62	+0.040***	3.42

*Notes: *** p < 0.01; ** p < 0.05; * p < 0.10. Newey–West HAC standard errors*

E.3 Bai–Perron Structural Break Tests

The Bai and Perron (2003) procedure detects three endogenous structural breaks in the ΔERP–ECB balance sheet relationship: March 2009 (onset of non-standard measures with CBPP1), October 2014 (anticipation of large-scale QE), and July 2020 (PEPP launch / COVID response). These breakpoints are consistent with known macrofinancial regime shifts.

The Chow test at the exogenous breakpoint of January 2015 (QE launch) yields F = 5.27 ($p < 0.001$), confirming a structural change in the ΔERP–ECB relationship coinciding with the introduction of large-scale asset purchases.

Appendix F — Econometric Diagnostics (Detailed)

This appendix consolidates the full diagnostic battery for systematic verification. All tests are applied to the H1 specifications (OLS, N = 263) and the H3 panel specification (FE, N = 1,841). The Newey–West HAC correction (Bartlett kernel, L = 4 lags) simultaneously addresses heteroskedasticity and residual autocorrelation.

F.1 Autocorrelation: Durbin–Watson and Ljung–Box Tests

The Durbin–Watson statistic ranges from 2.037 to 2.07 across all eight H1 specifications, firmly within the no-autocorrelation zone. The Ljung–Box Q(12) statistics do not reject the null hypothesis of no autocorrelation at any conventional significance level ($p > 0.10$ in all cases), confirming that the Newey–West lag length L = 4 is adequate.

Table F.1 — Autocorrelation Diagnostics by Model

Model	DW	Q(6)	p-value	Q(12)	p-value	Conclusion
(1) BS	2.037	4.82	0.567	10.45	0.577	No autocorrelation
(2) APP	2.047	4.65	0.589	10.22	0.597	No autocorrelation
(3) DFR	2.064	4.91	0.555	10.68	0.556	No autocorrelation
(4) SMP	2.045	4.78	0.572	10.38	0.582	No autocorrelation
(5) LTRO	2.060	4.88	0.559	10.55	0.567	No autocorrelation
(6) Joint	2.057	4.85	0.562	10.51	0.571	No autocorrelation
(7) Extended	2.055	4.83	0.565	10.48	0.574	No autocorrelation
(8) Complete	2.069	4.95	0.550	10.72	0.553	No autocorrelation

Notes: DW = Durbin–Watson statistic (critical bounds at 5%: $d_L = 1.69$, $d_U = 1.88$ for k = 8). Q(h) = Ljung–Box portmanteau statistic at lag h. Critical values: $\chi^2(6, 0.05) = 12.59$; $\chi^2(12, 0.05) = 21.03$. All DW values fall in the no-autocorrelation zone and all Q-statistics are below critical thresholds.

F.2 Heteroskedasticity: Breusch–Pagan LM Tests

The Breusch–Pagan LM test rejects the null hypothesis of homoskedasticity at the 1% level for all specifications (LM statistics range from 17.98 to 23.17, $p < 0.01$). This rejection justifies ex post the use of Newey–West HAC standard errors, which are robust to both heteroskedasticity and autocorrelation. The presence of heteroskedasticity does not bias OLS coefficient estimates but affects the standard errors and therefore the inference.

Table F.2 — Breusch–Pagan Heteroskedasticity Tests

Segment	N	β(BS)	t
(1) BS	18.42	0.0053	Reject H_0 → Heteroskedastic
(2) APP	17.98	0.0063	Reject H_0 → Heteroskedastic
(3) DFR	19.15	0.0039	Reject H_0 → Heteroskedastic
(6) Joint	20.87	0.0020	Reject H_0 → Heteroskedastic
(8) Complete	23.17	0.0006	Reject H_0 → Heteroskedastic
(9) H2a	21.55	0.0011	Reject H_0 → Heteroskedastic

Notes: LM = $n \cdot R^2$ from auxiliary regression of squared residuals on regressors. χ^2 distribution under H_0. The consistent rejection across all specifications justifies the Newey–West HAC correction.

F.3 Functional Form: Ramsey RESET Test

The Ramsey RESET test evaluates the adequacy of the linear functional form by including powers of the fitted values. The test rejects the linear specification at the 1% level for the H1 models ($F = 6.90$, $p = 0.002$ for Model 6). This rejection warrants three observations:

First, the rejection is consistent with the non-linearity tested by H2: if the effect of ECB interventions is amplified during financial stress (as confirmed by the results — $\beta(APP \times Stress) = -0.0041$, $t = -3.45$, $p < 0.001$), the linear H1 specification is by construction misspecified when it omits the interaction term. The H2 model with interaction terms constitutes the response to this non-linearity.

Second, the VSTOXX, included as a first-differenced control, is the primary determinant of ΔERP (partial $R^2 \approx 0.54$). Its relationship with the ERP may be non-linear (threshold effects), which the H2 interaction partially captures.

Third, despite the RESET rejection, OLS coefficients remain BLUE (Best Linear Unbiased Estimators) under standard assumptions, and Newey–West inference remains asymptotically valid. The rejection signals a loss of efficiency, not bias.

Appendix G — ULiège Charter on the Use of Generative AI

In accordance with the Université de Liège policy on the use of generative artificial intelligence tools in academic work, the following declaration is made regarding the use of AI in this master thesis.

G.1 Declaration of AI Tools Used

The following AI tool was used during the preparation of this thesis:

Tool	Provider	Version	Purpose
Claude	Anthropic	Claude Opus 3.6	Research assistance, structuring, computation verification, Language, Code generation
ChatGpt	OpenAI	5.5 Thinking	routine research, reformulation, translation, comprehension

G.2 Nature of AI Assistance

The AI tool was used for the following purposes:

1. Structuring and organizing the literature review and theoretical framework
2. Verification and cross-checking of econometric computations (regression coefficients, standard errors, diagnostic test statistics)
3. Formatting of Figures
4. Language assistance for drafting in English
5. Code generation for data processing (Python scripts for OLS, panel FE, event study computations)

G.3 Limitations and Human Validation

The AI tool was NOT used for:

6. Generation of original research hypotheses (H1, H2, H3)
7. Data collection (all data were obtained from official sources: ECB SDW, Eurostat, Refinitiv)
8. Independent interpretation of results
9. Generation of unverified academic content or citations

All AI-generated content was systematically reviewed, verified, and validated by me. I take full responsibility for the accuracy, originality, and academic integrity of this thesis.

G.4 Compliance Statement

This declaration is made in compliance with the ULiège Charter on the Use of Generative Artificial Intelligence in Academic Work. I confirm that the use of AI tools in this thesis is transparent and consistent with the principles of academic integrity.

Date: May 2026

Student: Max Czarka (S2407632)

Signature: Max Czarka

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EXECUTIVE SUMMARY

The IEP is calculated monthly as the inverse of the 12-month forward price-to-earnings ratio (ERP ≈ 1/PE_forward), where the forward P/E is derived from the I/B/E/S consensus aggregated at the index level and extracted via Refinitiv Eikon/Datastream. This approach to earnings yield, justified by Fama and French (2002) and Damodaran (2020), provides a parsimonious approximation of the expected return on stocks that avoids the growth and risk-free rate assumptions required by a full implementation of the Gordon-Shapiro model.

The econometric framework combines OLS regressions with Newey-West HAC standard errors (T = 263 monthly observations) and fixed-effects panel models with cluster-robust standard errors (N = 1,841; G = 7 countries). At the aggregate level, H1 is not supported: no ECB proxy reaches statistical significance, with the VSTOXX alone accounting for the variation in the ERP ($R^2 \approx 0.545$). In contrast, H2 is supported in the time series analysis: the APP×Stress interaction is highly significant ($t = -3.46$, $p < 0.001$; Wald $W = 12.27$, $p = 0.002$).

This result is confirmed and amplified in the fixed-effects panel, where the term ΔAPP×Stress reaches $\beta = -0.0103$ ($t = -5.94$, $p = 0.001$). Wald tests decompose the total effect by region: APP significantly reduces the ERP during periods of stress for both the core (−0.0082, $t = -4.63$) and the periphery (−0.0112, $t = -4.31$). Hypothesis H3 regarding geographic heterogeneity, however, is not supported: the core-periphery differentials are not statistically significant ($p > 0.30$), indicating homogeneous transmission between core and peripheral countries. Triangulation using daily-frequency event studies confirms these results, with significant abnormal returns concentrated exclusively on announcements during periods of crisis.

These results establish that ECB interventions significantly reduce the equity risk premium, but exclusively during periods of high financial stress. In calm periods, conventional market forces dominate ERP dynamics, rendering interventions statistically insignificant. This nonlinear, regime-dependent pattern suggests that unconventional tools function as a crisis stabilization mechanism rather than as a permanent lever for compressing risk premiums.

KEYWORDS: *Equity Risk Premium, ECB, Unconventional Monetary Policy, Financial Stress, Quantitative Easing, Implied Equity Premium, Euro Area, Panel Data*

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