ESTIMATING THE CONTRIBUTION OF MACROECONOMIC FACTORS TO SOVEREIGN BOND SPREADS IN THE EURO AREA

2024

BANCO DE ESPAÑA
Eurosistema

Documentos de Trabajo
N.º 2408

Pablo Burriel, Mar Delgado-Téllez, Camila Figueroa,
Iván Kataryniuk and Javier J. Pérez

ESTIMATING THE CONTRIBUTION OF MACROECONOMIC FACTORS TO SOVEREIGN BOND SPREADS IN THE EURO AREA

ESTIMATING THE CONTRIBUTION OF MACROECONOMIC FACTORS TO SOVEREIGN BOND SPREADS IN THE EURO AREA (*)

Pablo Burriel

BANCO DE ESPAÑA

Mar Delgado-Téllez

EUROPEAN CENTRAL BANK

Camila Figueroa

AFI

Iván Kataryniuk

BANCO DE ESPAÑA

Javier J. Pérez

BANCO DE ESPAÑA

(*) The views expressed in this paper are the authors' and do not necessarily reflect those of the Banco de España or the Eurosystem. We thank Begoña Lara, José Antonio Cuenca, Aitor Erce, José Ramón Martínez-Resano, José Manuel Montero, Ana del Río, Carlos Thomas, Ángel Gavilán and participants at Banco de España research seminar, XXX Encuentro de Economía Pública, ESCB Working Group on Public Finance's annual workshop and 11th UECE Conference on Economic and Financial Adjustments, for their help and comments. This work was carried out during Camila Figueroa's time at the Banco de España and before she joined AFI. Correspondence to: Pablo Burriel (pburriel@bde.es), Mar Delgado-Téllez (Mar.Delgado-Tellez@ecb.europa.eu), Iván Kataryniuk (ivan.kataryniuk@bde.es) and Javier J. Pérez (javierperez@bde.es).

Documentos de Trabajo. N.º 2408

March 2024

https://doi.org/10.53479/36257

ISSN: 1579-8666 (on line)

Abstract

This paper proposes a novel approach to estimating the contribution of macroeconomic factors to sovereign spreads in the euro area, defined as the spread level consistent with the country's prevailing macroeconomic conditions. Despite the wealth of papers estimating sovereign spreads, model-dependency and lack of robustness remain key considerations. Accordingly, we propose a "thick modeling" empirical framework, based on the estimation of a wide range of models. We focus on 10-year sovereign bond yields for nine euro area countries, using a sample that covers the period January 2000 to December 2023. Our results show that observed spreads behave in line with macro-financial determinants in "normal" times. Macroeconomic determinants are also able to account for a significant fraction of the observed sovereign spread dynamics in most episodes of financial turbulence, such as the pandemic and the aftermath of the Russian invasion of Ukraine. However, we find evidence of some deviations of sovereign spreads from their estimated values during the 2010-2012 euro area sovereign debt crisis. In this period, macroeconomic indicators are able to explain at most 26% of the observed peaks in spreads among non-core countries.

Keywords: sovereign bond spreads, euro area, macroeconomic fundamentals.

JEL classification: E44, O52, G15.

Resumen

En este documento proponemos un enfoque novedoso para estimar la contribución de los factores macroeconómicos a los diferenciales soberanos de la zona del euro, definida como el nivel de diferencial coherente con las condiciones macroeconómicas del país. A pesar de la abundancia de trabajos que estiman los diferenciales soberanos, la falta de robustez y la dependencia en ciertos aspectos que presentan los modelos siguen jugando un papel fundamental. Por ello, planteamos un marco empírico de *thick modeling,* basado en la estimación de una amplia gama de modelos. Nos centramos en los rendimientos de los bonos soberanos a 10 años de nueve países de la zona del euro, sobre una muestra que abarca desde enero de 2000 hasta diciembre de 2023. Nuestros resultados revelan que los diferenciales observados se comportan de acuerdo con los determinantes macrofinancieros en tiempos «normales». Los determinantes macroeconómicos también son capaces de explicar una fracción significativa de la dinámica constatada en los diferenciales soberanos en la mayoría de los episodios de turbulencias financieras, como la pandemia y las secuelas de la invasión rusa de Ucrania. Sin embargo, encontramos evidencia de algunas desviaciones de los diferenciales soberanos con respecto al valor estimado durante la crisis de deuda soberana de la zona del euro de 2010-2012. Durante este período, los indicadores macroeconómicos son capaces de explicar como máximo el 26 % de los picos observados en los diferenciales de los países no centrales.

Palabras clave: diferenciales de bonos soberanos, zona del euro, determinantes macroeconómicos.

Códigos JEL: E44, O52, G15.

1 Introduction

This paper proposes a novel estimation of the sovereign spread level consistent with the country's macroeconomic determinants. We study the dynamic relationship between sovereign spreads and their main macroeconomic drivers. To do so, we build a panel with nine original euro area countries[1] from January 2000 to December 2023. Motivated by previous literature, we estimate a wide range of model specifications, considering the horizon of macroeconomic variables (last available data or in expectations), different combinations of period interactive variables to control for structural breaks in the impact of the variables, idiosyncratic factors (fixed effects by country or by core-periphery group of countries), the inclusion of monetary policy purchase programmes (substituting the debt-to-GDP ratio for the net debt-to-GDP ratio, where the numerator is the government consolidated debt net of debt securities under ECB purchasing programs), and the sample period (full sample or excluding the Covid-19 crisis period).

Once we have estimated the set of models, we compute the part of the sovereign spread which is driven by macroeconomic determinants as the predicted values of solely macroeconomic variables (mainly, expectations about debt and budget balance as a percentage of GDP, GDP growth, and inflation) and fixed effects coefficients. This means that we leave out variables that could potentially affect sovereign spreads but do not directly impact the government's ability to service their debt, such as liquidity risk measures or market sentiment variables. We adopt a thick modelling approach (Granger and Jeon (2004)) and compute the average spread as determined by macroeconomic factors across all models estimated. By averaging across models, we take into consideration the fact that spread estimations and fitting are generally sensitive to model specification, and could vary across countries. The main advantage of this approach is the reduction of the influence of modelling choices on the expected outcome.

In line with previous literature, we find that macroeconomic drivers are key in determining the dynamics of sovereign bonds and that the main determinant is the (expected) debt-to-GDP ratio, explaining on average a 47% of the contribution of macroeconomic factors to spreads levels. Yet, when examining the steep rise of spreads after 2008 we find that changes in macroeconomic conditions can only explain up to 26% of the peak in their observed

[1] Luxembourg is excluded from the sample due to its small size.

spreads. After the GFC and the subsequent euro area sovereign debt turmoil, observed spreads have declined significantly but display a higher volatility. During this latter period, estimated spreads tend to remain stable and normally below observed spreads. Our results highlight the importance of model selection to compute the contribution of macroeconomic variables to spreads. However, we find that not all macroeconomic drivers are immune to the chosen specification. While the coefficients for debt-to-GDP ratios and GDP growth are robust to different specifications, the coefficients for budget balance and inflation are more volatile, and often non-significant.

We additionally perform various robustness exercises. First, we show that the composition of the country panel is very relevant. Reducing the panel to include only the biggest euro area countries significantly changes the estimated coefficients for macroeconomic determinants. Second, we find that including longer-term expectations of macroeconomic variables do not change the estimations. Third, we test the existence of potential country-specific perception of risk by adding interactive variables between macroeconomic drivers and country dummies to our benchmark models. We find a much larger dispersion in estimated coefficients for peripheral countries.

The rest of the paper is organized as follows. Section 2 reviews the main contributions from the literature and emphasizes the sensitivity of coefficients' estimates. In Section 3 some stylized factors on the behaviour and determinants of sovereign spreads inside the euro area and the data employed are described. In section 4 the model strategy is presented and the main results are discussed in Section 5. Section 6 reports robustness exercises. Finally, Section 7 concludes.

2 Literature

A wealth of literature has focused over the last two decades on the reasons underlying the observed heterogeneity in government bond yields. There is a broad literature on the estimation of the determinants of sovereign yields and spreads, which hinge on empirical regularities (see, among others, Barrios et al., 2009; Sgherri and Zoli, 2009; Von Hagen et al., 2011; Barbosa et al., 2010; Poghosyan, 2014; Beirne and Fratzscher, 2013; Aizenman et al., 2013; Costantini et al., 2014; Afonso et al., 2015; Georgoutsos and Migiakis, 2018; Ceci and Pericoli, 2022). According to this literature, the dynamics of sovereign returns are governed by: (i) macro-fiscal variables of individual countries and the EMU (proxies of credit risk); (ii) liquidity risk, related to the size and depth of government bond markets;[2] (iii) international risk aversion, which affects the behavior of investors and their appetite for certain types of securities; (iv) macroeconomic announcements, monetary policy or fiscal policy events. Idiosyncratic factors are often included in the form of individual fixed effects, while transmission or contagion channels are explored by principal component analysis.

How these factors determine sovereign yields and spreads in the euro area can vary over time, and it also depends on the operation of ECB's monetary policy, which could have weakened the link between spreads/yields and macroeconomic conditions (some of these factors are shown in Paniagua et al., 2017; Afonso et al., 2018; De Santis, 2016; Delatte et al., 2017; Afonso and Verdial, 2019; Guirola and Pérez, 2023). Before the GFC, most studies for the euro area identified credit risk, global risk and liquidity-related variables as the main determinants of sovereign bond yield spreads, without unanimity about the relative importance of each group of explanatory factors. Barbosa et al. (2010) offers an exhaustive table summarizing the empirical results for the euro area sovereign bond yield spreads prior and during the financial crisis.

The sharp increase of sovereign spreads during the 2007-09 crisis led to an outbreak of works aiming to explain the hike and divergence of sovereign spreads across the euro area. Although international risk was clearly identified as the major factor behind the rise of spreads during the crisis period, the literature also established an increase in the sensitivity of sovereign spreads to public debt ratios and other fiscal indicators, amplified by the interaction with global risk aversion (see Ejsing and Sihvonen (2009), Sgherri and Zoli (2009), Barrios et al. (2009), Attinasi et al. (2010), Beirne and Fratzscher (2013), Afonso et al. (2015)). Barrios et al. (2009) and others afterwards, have linked the rise in the sensitivity of spreads to macro-variables to the Lehman default in September 2008, after which markets penalized fiscal and macro-imbalances much more strongly than before the crisis (see Delatte et al. (2017) for a quantification of the stronger penalization of macroeconomic conditions deterioration during the crisis).

Within the euro area, the literature has also documented systematically larger prediction errors for the sovereign spreads of periphery countries since the financial crisis period (e.g., Aizenman et al. (2013), Afonso et al. (2015), Paniagua et al. (2017)). In the face of credit rating downgrades, Greece, Ireland and Portugal were forced to comply during 2010 and

[2]Smaller, less liquid markets are penalized when compared to bigger markets, as investors may face additional costs or difficulties when selling their holdings.

2011 with several financial rescue schemes, and from mid-2011, also Spanish and Italian sovereign bond yields were subject to higher risk premia.

The literature has identified three main regime switches in ECB's monetary policy, marked by Unconventional Monetary Policy (UMP) intervention packages. The first one is associated to the GFC and dated mid-2009, when the ECB implemented the Covered Bond Purchase Programme (CBPP) and the Securities Markets Programme (SMP), in May and July of that year, respectively. The second regime switch is linked to the Euro Debt Crisis and set off by the creation of the Single Supervisory Mechanism in June 2012 and the posterior announcement of the Outright Monetary Transactions (OMT), which although implemented has not been used to date. Finally, the launch of the Pandemic Emergency Purchase Programme (PEPP) in March 2020 marked the latest regime switch in monetary policy.

The use of UMP interventions by the ECB has affected international risk aversion towards beneficiary countries, which - as argued by Afonso et al. (2018) - translates into a source of time-variation in the relationship between sovereign bond yield spreads and their macroeconomic determinants. The literature accounted for regime switches in their estimations of sovereign spreads by doing one of these three adjustments: (i) splitting the sample, simply re-estimating the models for each regime period (e.g., Barrios et al., 2009; Georgoutsos and Migiakis, 2018), (ii) including interactive variables between macro variables and regimes time dummies, in order to recover the effect of each regime on relevant regressors (e.g., Von Hagen et al., 2011; Afonso and Verdial, 2019), and (iii) estimating models with time-varying coefficients, trying to endogenously estimate the dynamic of coefficients (e.g., Costantini et al., 2014; Delatte et al., 2017; Afonso and Jalles, 2019).

The more frequent use of UMP onset a new branch of literature focused on estimating the impact of quantitative easing on sovereign spread trajectories. In an early study, Szczerbowicz (2015) studied the effect of the ECB's unconventional monetary policy interventions by using dummy variables covering the period from announcement to implementation of the programmes. She finds that ECB's UMP has a decreasing effect on spreads, which is most pronounced among peripheral countries. Kinateder and Wagner (2017) report that a one per cent increase in the ECB's total assets decreases, on average, the relative cross-sectional yield spread by 0.41 per cent (0.14 per cent prior to the crisis). Eser et al. (2019) estimate the stock of current and expected future APP holdings to reduce the 10y term premium by 95bps, they find the reduction being persistent and with a half-life of five years.

Model uncertainty associated with the estimation of sovereign spreads has been recently addressed. Afonso and Jalles (2019), for instance, takes a 2-step approach to assess the determinants of sovereign bond yield spreads in the euro area, first confirming and estimating the determinants of sovereign spreads and then computing time-varying coefficient (TVC) models of each determinant. In this way, the authors account for both the uncertainty in the list of variables explaining sovereign spread movements, and the potential changes in risk factors sensitivities that could imply temporal dynamics on the estimated coefficients.

To illustrate the relevance of model uncertainty, we perform a simple comparison exercise. Table 1 reports the debt-to-GDP estimated coefficients of six empirical papers that aim to estimate the determinants of sovereign bond yields relative to the German Bund using countries in the euro area. As we have pointed out, sovereign debt as share of GDP is consistently the most relevant fiscal indicator when explaining sovereign spread changes. The papers cited use different methods of estimation but are comparable in terms of variable specification and coefficient interpretation. From the Table, it can be noticed that the effect of 1pp higher debt-to-GDP ratio on sovereign spreads can go from 1.2bps to 7.7bps, which we consider is a quite sizeable range when the average debt-to-GDP ratio increased on average around 50pp from 2009 to 2013 across peripheral countries.

Table 1: Impact on the 10-year Sovereign Bond Yield relative to the German Bund of a 1pp higher Debt Ratio - EA Countries Studies

Reference	Method[a]	Debt-to-GDP Exp.[b]	Debt-to-GDP /DE[c]	Impact on Spreads[d] of +1pp Debt (bps)
Von Hagen et al. (2011)	PDFE	No	Yes	+0.16 / +1.25 (pre/post Sept. 2008)
Costantini et al. (2014)	PC	Yes	Yes	+7.6
Afonso et al. (2015)	P2SLS	Yes	Yes	+0 / +2 (pre/post March 2009)
Delatte et al. (2017)	TV-PSTR	No	No	+0.3 / +6.6 (non crisis / crisis)
Afonso and Jalles (2019)	TVP, P2SLS	Yes	Yes	From +2.5 to + 7.7
Ceci and Pericoli (2022)	PDFE	No	No	+1.42

Source: Own calculations.
[a] PDFE (Panel Data with Fixed Effects), PC (Panel Cointegration), P2SLS (Panel Two Stage Least Squares), TV-PSTR (Time-Varying Panel Smooth Threshold Regression), TVP (Time Varying Parameters).
[b] The Debt-to-GDP ratio is included as an expectation.
[c] The Debt-to-GDP is measured as a difference relative to Germany.
[d] Spread measured in basis points with respect to German Bund.

3 Stylized factors and data

Episodes of market stress may lead investors to change how they price sovereign risk,[3] or to follow a behaviour not governed by the evolution of macroeconomic drivers, causing

[3] On theoretical models see De Grauwe and Ji (2012) or Pouzo and Presno (2016).

fragmentation in sovereign markets. Deviations of observed spreads from the value of the yield consistent with prevailing macro-financial conditions may end up in 'excess spreads', jeopardizing the appropriate transmission of monetary policy.

Taking this literature as a reference, we analyze the determinants of euro area government bond spreads and provide an estimation of their value according to the evolution of macroeconomic variables. We construct a panel for nine of the original euro area members[4] from January 2000 to September 2022. We focus on the 10-year bond spreads with respect to the German Bund.[5] As variables we include the most standard four macroeconomic variables: debt-to-GDP ratio, budget balance, real GDP growth and inflation, which are expected to directly determinate public debt sustainability. As a robustness exercise, we estimate our set of models including a measure of the country's external position, namely, the cumulative net exports over GDP (both in past data and expectations).

We estimate models using the last available data and models including expectations of the macroeconomic variables, which are calculated as a moving average of the forecast of three international institutions: the International Monetary Fund (IMF), the Organisation for Economic Co-operation and Development (OECD) and the European Commission (AMECO). In addition, they are calculated and interpolated to take into account the different horizons of the published data (see Dovern et al., 2012). Thus, the forecast for next year's macro variable would be a timely weighted average, an interpolation, between current and next year forecasts, in line with:

$$\tilde{y}_{t+12|t} = \frac{k}{12}\,\hat{y}_{t+k|t} + \frac{12-k}{12}\,\hat{y}_{t+k+12|t} \tag{1}$$

where $\tilde{y}_{t+12|t}$ is the composite 12-month-ahead forecast of variable y based on the information as of time t. For each month, we have two survey forecasts $\{\hat{y}_{t+k|t}, \hat{y}_{t+k+12|t}\}$ with horizons $k \in \{1, 2, ..., 12\}$ and $k + 12$ months, which we average to obtain a fixed-horizon forecast. Since survey questions refer to calendar end-of-year values for the current and next year, k denotes the remaining months from period t to next December. Thus, this new variable enables us to include consistent expectations of macroeconomic variables.

[4]With the exception of Luxembourg and Greece due to the lack of complete series for all the variables considered in our analysis.

[5]We also run estimations for the sovereign spread with respect to the OIS yield, and for the five- and two-year bonds. Results are available upon request.

Secondly, we include measures of liquidity risk, typically captured by variables describing the size and depth of the government bond market or bid-ask spreads. We consider two variables: the bid-ask spread in the secondary market and the Chicago Board Options Exchange Market Volatility Index or VIX (spread between the yield on AAA US corporate bonds and the yield on 10-year US government bonds).

Finally, we take into consideration non-conventional policy measures, as the sum of the three main ECB programmes of public securities purchases: the Securities Market Program (SMP), the Public Securities Purchase Programme (PSPP) and the Pandemic Emergency Purchase Programme (PEPP). The first one was in force from May 2010 to September 2012, being its target to buy UEM government securities. During those more than two years, around €220 billions of public bonds were purchased by the ECB (par value, excluding redemptions).[6] The second one was first implemented in March 2015. Finally, the ECB implemented the PEPP in March 2020 to mitigate the economic impact of the Covid-19 pandemic, up to November 2020 this program has acquired €652 billion of Public assets (see Table 2 for purchases evolution). Using this data we construct for each country the ratio of assets purchased by ECB programmes over their total government debt, interacted with the total amount purchased in the EMU ($\text{Asset}_i/\text{Debt}_i \times$ Assets EMU / Debt_{EMU}).

Additionally, we include two dummies for the main EU events, differentiating between countries' bailouts and major EU fiscal decisions. The first one takes value one in the relevant dates for the following European countries' bailouts: Greece (May 2010, February

Table 2: Accumulated ECB Programmes until March 2023

	PSPP			PEPP		
Country	% GDP[a]	In % public debt[b]	in % of total	% GDP[a]	In % public debt[b]	in % of total
Austria	17.1	21.9	3.2	10.1	12.9	3.1
Belgium	17.3	16.5	4.0	10.2	9.8	3.9
Germany	17.1	25.8	27.6	10.3	15.6	27.5
Spain	23.7	21.0	13.1	14.8	13.0	13.5
Finland	17.0	23.3	1.9	10.1	13.8	1.9
France	20.1	18.0	22.2	11.2	10.1	20.5
Ireland	8.2	18.3	1.7	5.0	11.2	1.7
Italy	23.1	16.0	18.4	15.2	10.5	20.0
The Netherlands	14.1	27.6	5.5	8.7	17.0	5.6
Portugal	22.9	20.1	2.3	14.2	12.5	2.3

Source: ECB.
[a] in terms of 2022 GDP.
[b] in terms of 2022Q4 Stock of debt.

[6] For a detailed description see for instance Eser and Schwaab (2013).

2012, August 2015); Ireland (November 2010); Portugal (May 2011); Spain (June 2012). The second one takes value one whenever there was one of this set of EU fiscal decisions: European Semester (October 2010); Euro Plus Pact (March 2011); Six-Pack (October 2011); Fiscal Compact (January 2012); Two-Pack (May 2013); Main features of the budgetary instrument for convergence and competitiveness or BICC (June 2019); Final approval of the BICC (October 2019) and the approval of the Next Generation EU (August 2020).

4 Model strategy

Since the value of the sovereign spread consistent with macroeconomic conditions is not observable, its estimation poses particular challenges in terms of model specification. In the literature, single specification models have been typically used to estimate these spreads (for recent studies see Ceci and Pericoli (2022), Hondroyiannis and Papaoikonomou (2022)), relating it to macroeconomic variables. However, as we will prove next, estimation results tend to be highly sensitive to model specification, even when using the most standard set of determinants. Estimations of the contribution of macroeconomic determinants may differ significantly depending on the list of countries included in the panel or the horizon of the forecasts.

To address model uncertainty, we adopt a thick modelling approach (Granger and Jeon (2004)) that will take advantage of alternative specifications and provide robust estimates. Other possibilities, such as the use of model averaging techniques (Moral-Benito (2015)), are more suitable to control for uncertainty about the variables included in the model, while we also want to explore other model choices, such as different definitions of a given variable.

Overall, existing studies provide an adequate theoretical framework to analyse the main factors that govern the dynamics of spreads, and may inform policy-makers choices. In formal terms, the standard regression-type model in the literature links country i spreads, s_{it}, of a given government bond return with respect to some "safe" yield (the German bund or the OIS),[7] with a matrix of macroeconomic drivers, market conditions and others. We follow a similar strategy taking as our main model specification the following:

$$S_{it} = \gamma + \gamma_M M_{it} + \gamma_f F_t + \gamma_e U_{it} + \alpha_i + \epsilon_{it} \tag{2}$$

[7] The spread between the given sovereign yield and the overnight indexed swap (OIS) rate of the same maturity is a measure widely used in the literature to gauge fragmentation in the government bond market.

where S_{it} is the sovereign spread for a country i in period t. M_{it} encompasses the four macroeconomic variables, F_{it} includes the financial variables (volatility and liquidity), U_{it} denotes additional controls for ECB's actions (dummies for relevant ECB events and Monetary Policy Asset purchase programmes), α_i is the unobserved time-invariant individual effect and, finally, ϵ_{it} represents the error term.

We estimate a fixed effects regression model on a data panel of 279 months and nine European countries. We rely on Driscoll and Kraay (1998)'s specification, as they demonstrate that the standard non-parametric time series covariance matrix estimator can be modified such that it is robust to very general forms of cross-sectional as well as temporal dependence in a large T asymptotic scenario. We do not include time fixed effects as we already include some interactive variables between macroeconomic drivers and time dummies.

The sovereign spreads and the macroeconomic explanatory variables display a non-linear evolution over the sample considered, with higher volatility from January 2008 to July 2012, a period that includes the effects of the financial crisis and the European sovereign debt crisis. Previous studies tried to tackle this issue by estimating a time-variant coefficient model (see Afonso and Jalles, 2019). We follow a different estimation strategy based on the segmentation of the main macroeconomic variables in three periods: the first one from 2000 to December 2007, the second one from January 2008 to June 2012 (the crisis period), the third one from July 2012 (the beginning of the implementation of the non-conventional monetary policy) to February 2020 and the last one from the beginning of the Covid-19 pandemic in March 2020 onwards.

Our thick modelling approach consists in running numerous models and combining them to get a robust estimation of the contribution of macroeconomic variables to spreads. We will focus on the estimation of sovereign spreads with respect to the German Bund, since it is the most common spread definition used in literature, but results are similar when using the spread with respect to the OIS yield[8].

The specifications considered differ across five dimensions. First, macroeconomic variables in forward-looking terms (following Afonso and Jalles (2019)), then, using the last

[8]Table 5 in the Appendix shows the sample averages of the 10-year sovereign spread with respect to the OIS yield, the estimated and the contribution of macroeconomic variables to the spread, while Table 6 shows the contributions of each variable to the spread. Results remain qualitatively the same.

available data, and finally, a mix of both approaches[9]. Second, we estimate models with time-invariant macroeconomic coefficients, then models that include time-variant coefficients for GDP growth and the debt-to-GDP ratio, then we add them for the budget balance, and finally for inflation. Third, we consider models including country fixed effects, and with periphery and core fixed effects. Fourth, we consider the gross debt-to-GDP ratio and, alternatively, the net debt-to-DGP ratio, excluding ECB purchases[10]. Finally, we use the full sample period to run our estimations, and then restrict our sample to the pre-Covid period. We trim our estimations to get rid of possible outliers, discarding the worst performing 10% of models by country.

5 Main results

Table 3 reports the sample average of the contribution of macroeconomic determinants estimates over the 96 models previously described and across countries, as well as the average across the relevant subsamples and differentiating between core countries (France, Belgium, Austria, Netherlands and Finland) and the rest (Italy, Spain, Portugal and Ireland). Notice that prior to 2008, observed spreads were on average above the level consistent with the macroeconomic and fiscal position for core countries, while they were overall aligned for the rest of countries. This result is most likely associated with the lower and steady sovereign spread levels among euro area countries, alongside the less favourable macroeconomic conditions of the core compared to the rest countries during this period.

Table 3: Spread Estimations by Sample Period, 10Y Bond against German Bund.

	all countries				core countries				rest of countries			
Sample period	obs.	est.	macro	s.d. obs	obs.	est.	macro	s.d. obs	obs.	est.	macro	s.d. obs
2000m1-2007m12	11	14	-8	11	8	-8	-30	9	15	43	19	13
2008m1-2012m7	150	148	63	213	55	66	22	43	270	251	114	272
2012m8-2020m2	96	96	64	112	30	42	20	17	179	165	118	125
2020m3-2023m12	50	59	23	41	25	25	-14	11	82	101	69	42
Full sample period	76	76	35	127	30	29	0	29	133	134	79	171

Source: Own calculations.
Note: 'obs' refers to observed spreads, 'est.' to estimated spreads, 'macro' to macro-consistent spreads and 's.d.' to the standard deviation of observed spreads across the countries included in the sample. Core countries are: France, Belgium, Austria, Netherlands and Finland, while the rest are: Italy, Spain, Portugal and Ireland.

[9]The mix of both approaches consists in including GDP growth, debt over GDP and budget balance in forward-looking terms, while the inflation rate is included as the last available data, given its shorter publication lag.

[10]It could be argued that markets weight differently debt held by the public and foreign governments and debt that has been acquired by the common monetary authority in programs such as the SMP, PSPP and PEPP. In fact, it has been documented that these purchase programs have a negative effect on sovereign spreads and the probability of a sovereign default (Costain et al. (2022)).

During the GFC and posterior euro area sovereign debt crisis, we see an increase in spread values consistent with the deterioration of macroeconomic conditions, especially among non-core countries. However, the worsening of macroeconomic variables is only able to explain up to 25% of non-core spread peaks during this period. After the crisis, and particularly since the Covid-19 crisis in 2020, we notice a higher variability of the contribution of macroeconomic variable to spreads estimates.

With respect to the contribution of macroeconomic determinants, Table 4 reports the part of sovereign spreads estimates explained by each variable, differentiating by monetary policy regime period. The first thing to notice is that the debt-to-GDP ratio explains by itself the biggest part of spread levels throughout the full sample period, although its contribution is higher (above 40%) after the debt crisis. Altogether, the other macroeconomic determinants - namely: GDP growth, budget balance and inflation - account on average for only 13% of the contribution. In particular, the budget balance explains a bigger part of spreads during the crisis period (15%) and GDP growth has a bigger contribution between the end of the debt crisis and the beginning of the Covid-19 crisis (8%). As expected, liquidity risk and global risk measures explain a bigger part of spread levels during the crisis period, accounting for 29% of spread levels during the 2008-2012 period, while on average they explain 24% of spread levels through the whole sample period.

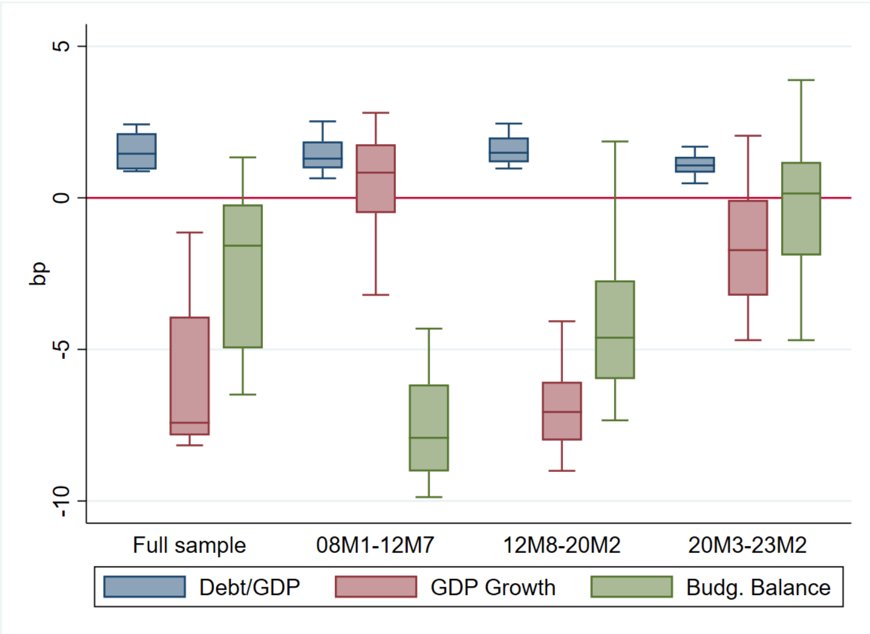
Table 4: Mean Contributions to Spread Estimations by Sample Period, 10Y Bond against German Bund.

	Contribution of macro variables								Contribution of			
	all countries				non-core countries				financial variables			
Sample period	GDP	Debt	BB	CPI	GDP	Debt	BB	CPI	Bidask	VIX	UMP	FE
2000m1-2007m12	0.07	0.31	0.02	0.01	0.09	0.38	0.02	0.02	0.08	0.13	0.00	0.39
2008m1-2012m7	0.01	0.30	0.15	0.04	0.01	0.31	0.19	0.04	0.15	0.11	0.03	0.20
2012m8-2020m2	0.08	0.43	0.05	0.03	0.10	0.46	0.06	0.02	0.09	0.07	0.01	0.24
2020m3-2023m12	0.03	0.40	0.04	0.01	0.04	0.54	0.05	0.02	0.07	0.13	0.04	0.27
2022m1-2023m12	0.01	0.37	0.02	0.06	0.02	0.48	0.03	0.07	0.14	0.11	0.03	0.27
full sample	0.05	0.36	0.06	0.03	0.07	0.41	0.07	0.03	0.10	0.10	0.1	0.28

Source: Own calculations.
Note: 'FE' includes contribution of constant and individual fixed effects coefficients. Core countries are: France, Belgium, Austria, Netherlands and Finland, while the rest are: Italy, Spain, Portugal and Ireland.

During the most recent period, the contribution of inflation to the total macroeconomic contribution has increased (see before last row of Table 4). Before 2022, the debt-to-GDP ratio explained the biggest part of spread changes, with GDP growth changes in second place. However, the inflationary pressures in the euro area that started in the second semester of 2021 led to a significant increase in the contribution of inflation to spread changes. In particular, European annual inflation rates reached the two digits at the end of 2022 and remained well above the 2% target during 2023. As a consequence inflation accounted for 6% of the estimated contribution of macroeconomic variables to spreads on average during 2022-2023.

Figure 1: Distribution of Regression Coefficients of Macroeconomic Determinants across Models

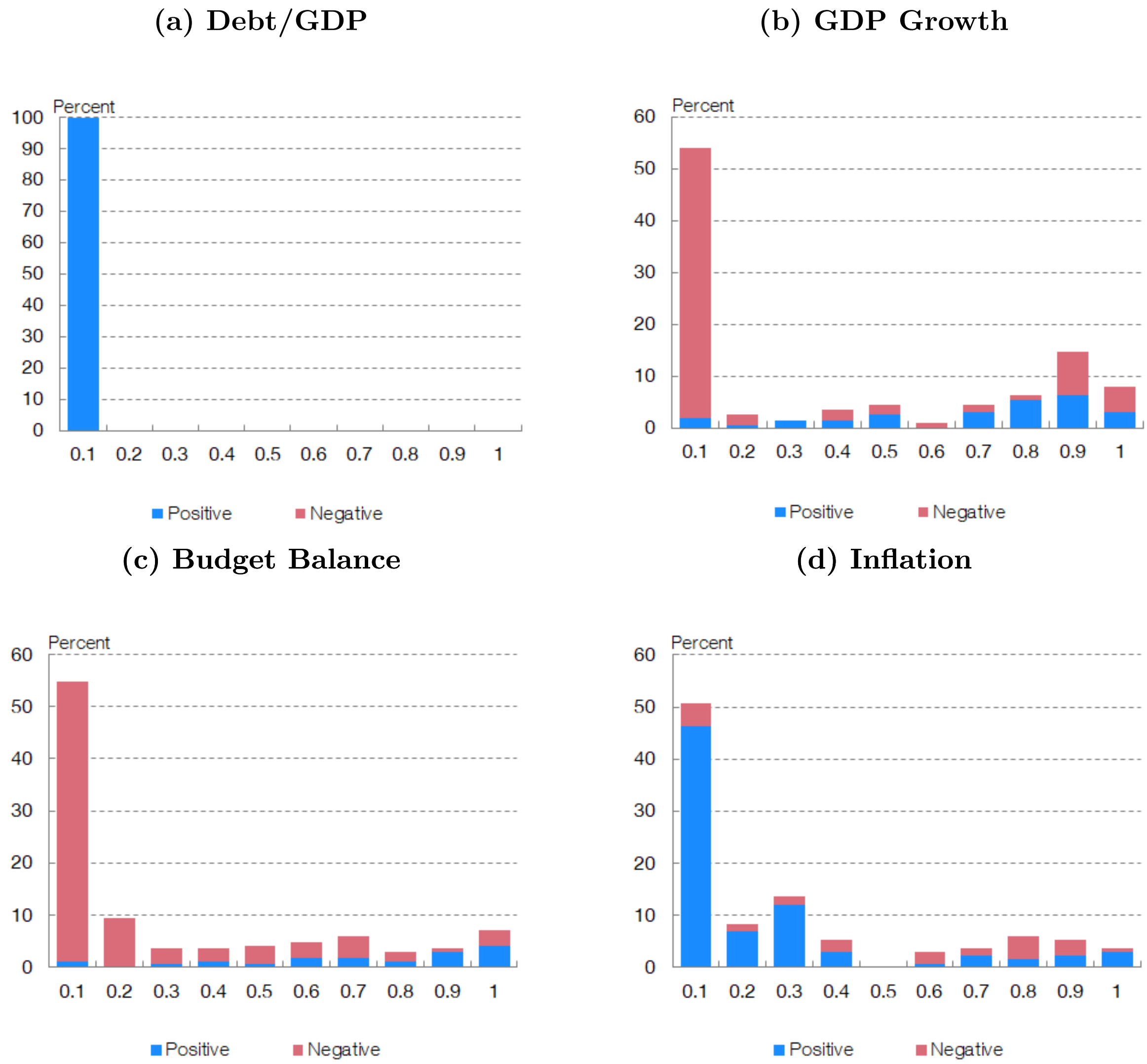


Source: Own calculations.
Notes: "Full sample" refers to time-invariant coefficients, while the rest to the interaction between the macro var and the time-period dummy. In the case of GDP Growth and Debt/GDP we have 24 estimated time-invariant coefficients and 72 coefficients each, while in the case of the Budget Balance we have 48 coefficients. The solid boxes represent the 25th and 75th percentile, while the line inside the boxes indicates the median (outliers are omitted).

The thick modelling approach also allows us to check the stability of the coefficients across the different specifications. As can be seen in Figure 2, the coefficients of the debt-to-GDP ratio are always positive and statistically significant, and as shown in Figure 1, fairly stable around 2bp across specifications and time periods. However, while, in general, more GDP growth and a higher 2 decrease spreads, this is not the case in some of the models. Moreover, these variables display high variability when considering structural changes. Nevertheless, as can be noticed in Figure 2, for both GDP growth and budget balance, half of the coefficients are economically significant and from these statistically significant coefficients, almost all of them have positive sign; negative coefficients tend to be rather non-significant.

In the case of inflation, we find that half of the coefficients are statistically significant, and most of them have a positive effect on sovereign spreads. However, in line with the lack consensus in literature about the expected impact of a higher inflation rate on sovereign spread levels, we find less precise evidence about the magnitude of this effect. Figure 8 in the Appendix shows the distribution of regression coefficients including inflation coefficients, which show a significantly wider range of values compared to the rest of macro determinants.

Figure 2: Distribution of P-Values for Coefficients of Macroeconomic Determinants



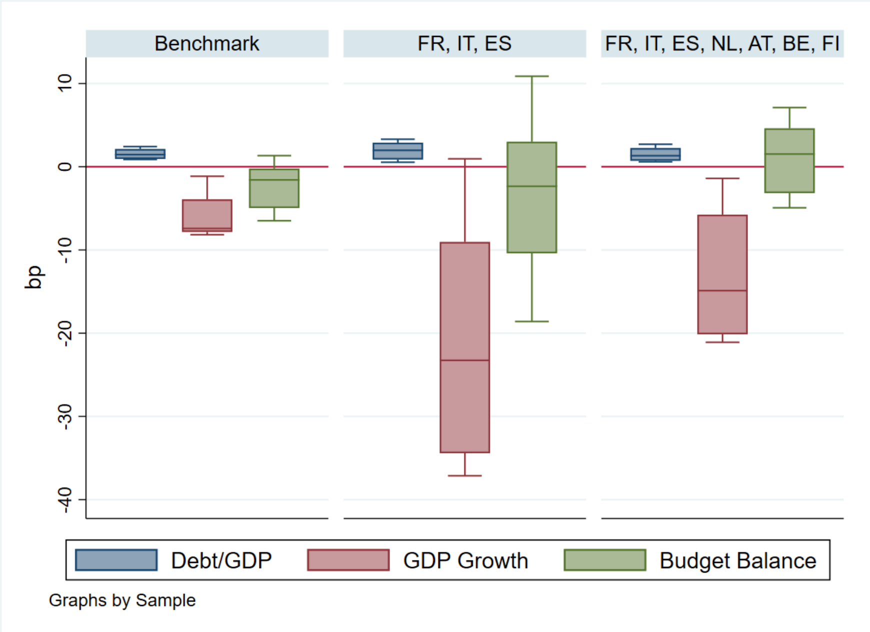
Source: Own calculations.
Note: P-Values for time-invariant and period-interactive coefficients across 96 estimated models (including period-interactive macroeconomic variables, some models have four coefficients for each variable).

6 Robustness

6.1 Country composition of the panel

Our benchmark specification includes in the panel all nine countries that were part of the euro area over the whole sample, except for Luxembourg, due to its size. However, reducing the number of countries included in the sample, like other papers in the literature, is not innocuous. In particular, as shown by the lines of Figure 3, reducing the sample can dramatically increase the interval of estimated coefficients, in particular for GDP growth and the budget balance. Notice that excluding only Portugal and Ireland, two of the four peripheral countries, more than doubles the size of the interval for GDP growth coefficients.

Figure 3: Regression Coefficients of Macroeconomic Determinants across Models
Varying the Countries Included in the Panel



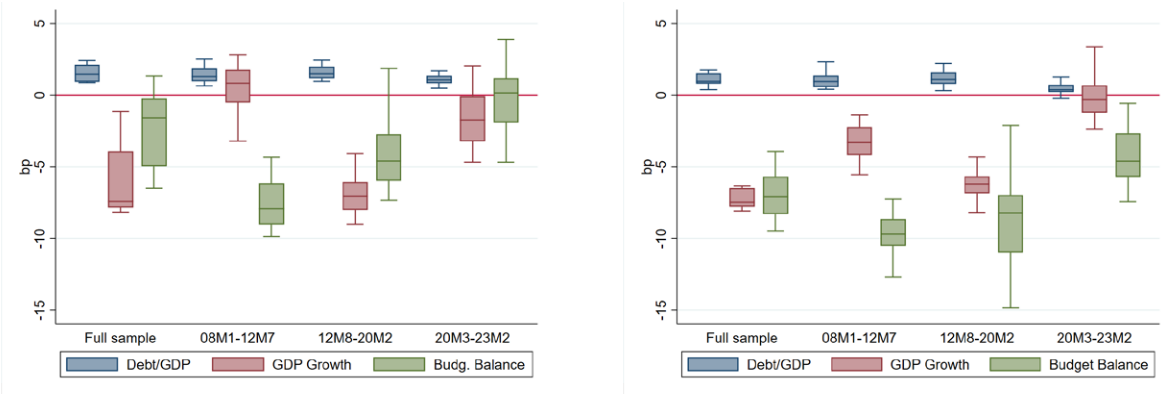
Source: Own calculations.
Notes: Figure displays time-invariant coefficients, graph titles indicate the list of countries included in the estimations. Benchmark estimations include: France (FR), The Netherlands (NL), Austria (AU), Belgium (BE), Finland (FI), Italy (IT), Spain (ES), Portugal (PT) and Ireland (IE). Average number of observations by specification is 2,276 (Benchmark), 760 (FR, IT, ES), 1,263 (FR, IT, ES, NL, AT) and 1,773 (FR, IT, ES, NL, AT BE, FI). The solid boxes represent the 25th and 75th percentile, while the line inside the boxes indicates the median (outliers are omitted).

6.2 Longer horizon for expectations

Since we are estimating 10-year sovereign spreads, it could be argued that expectations longer than one year ahead of macroeconomic variables should be considered as determinants. Consensus Forecast provides biannually five-years-ahead projections for inflation and GDP growth for Germany, France, Italy and Spain from April 2000. In order to incorporate these longer horizon expectations, we reestimate our pool of models reducing our panel to the four countries for which we have available these data (using spreads with respect to the OIS yield to include Germany in the estimations). As displayed in Figure 4, including 5-year expectations of GDP and inflation to our 4-country panel does not seem to have an impact on our estimations. However, as was shown in subsection 6.1, cutting the panel in more than half (from 10 to 4 countries) is not innocuous.

Figure 4: Regression Coefficients of Macroeconomic Determinants across Models, 10Y Bond vs OIS, Including 5-year Expectations of GDP and Inflation

(a) Benchmark **(b) Including 5Y GDP and inflation exp.**

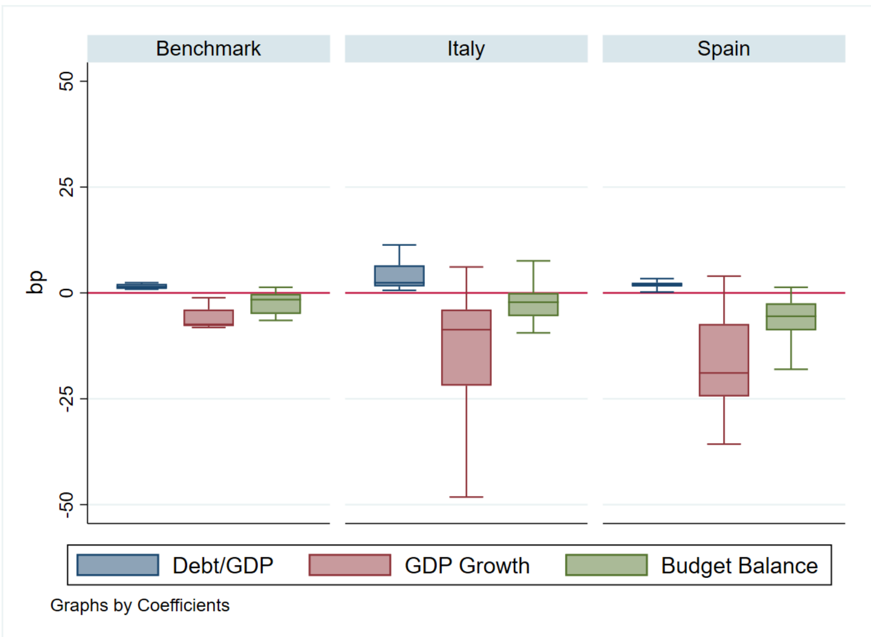


Source: Own calculations.
Notes: "Full sample" refers to time-invariant coefficients, while the rest to the interaction between the macro var and the time-period dummy. The estimation refers to spreads of the 10Y Bond vs OIS, including: Germany (DE), France (FR), Italy (IT) and Spain (ES). We restrict the sample of the benchmark estimation to have the same number of observations: 1,935. The solid boxes represent the 25th and 75th percentile, while the line inside the boxes indicates the median (outliers are omitted).

6.3 Including interactions between macroeconomic variables and country fixed effects

Since each country in the EMU is responsible for their own sovereign debt issuance and obligations, it could be argued that the pricing of fiscal and macro-imbalances in terms of

Figure 5: Regression Coefficients of Macroeconomic Determinants across Models, Including Interactions between Macro Variables and Country Dummies



Source: Own calculations.
Notes: Figure displays time-invariant coefficients for each country, including the effect of interactive variables between macroeconomic determinants and country dummies. Number of observations: 2,275. The solid boxes represent the 25th and 75th percentile, while the line inside the boxes indicates the median (outliers are omitted).

sovereign spreads varies across countries in the euro area. To explore this hypothesis we include in our models interactive variables between macroeconomic variables and country dummies, allowing each country's sovereign spreads to react differently to macroeconomic variables. As reported in Figure 5, the inclusion of country interactive variables broadly increases the interval of coefficients for each country. In general, we find more negative coefficients for GDP Growth and budget balance, except for Ireland in the case of GDP growth and Italy for the budget balance's coefficient.

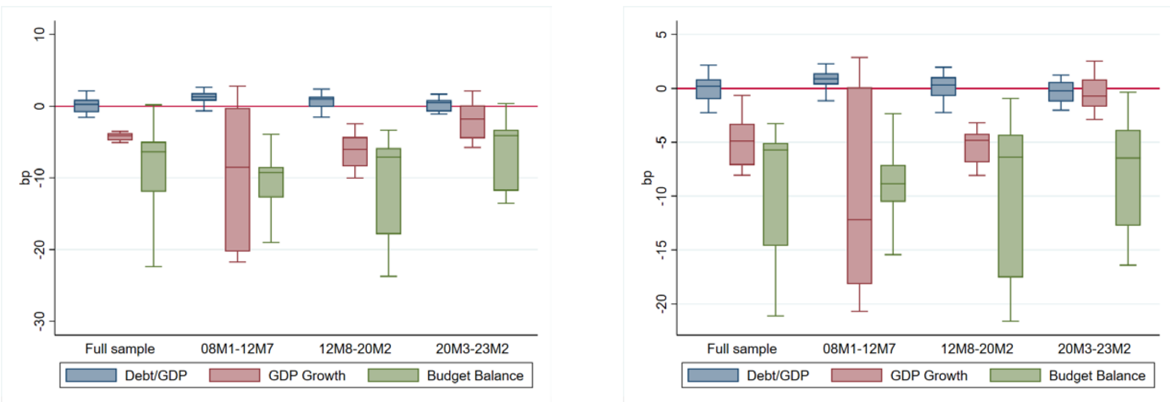
6.4 Controlling by an external macroeconomic factor

Part of the literature includes additional variables to account for the country's external position - such as the current account deficit or the real exchange rate. Following De Grauwe and Ji (2013), in this robustness exercise, we add the accumulated net exports over GDP as an explanatory variable. The country's net exports is chosen as external indicator because we have quarterly historical data and the European Commission's projections (available in the AMECO database since 2011), allowing us to estimate our full set of models. Estimated coefficients are displayed in Figure 6.

We re-estimate our benchmark set of models using the sample period since May 2011, since AMECO expectations data is available, in order to have results comparable to those of models including net exports as regressor. As shown in Figure 6, adding net exports over GDP does not significantly change the estimated coefficients for any of the variables of interest.

Figure 6: Observed and Estimated Contribution of Macroeconomic Variables to Spreads, 10Y Bond vs German Bund Including Net Exports over GDP

(a) Benchmark **(b) Including Net Exports over GDP**



Source: Own calculations.
Notes: "Full sample" refers to time-invariant coefficients, while the rest to the interaction between the macro var and the time-period dummy. The sample period is restricted to start in May 2011 to have the same number of observations: 1,503. The solid boxes represent the 25th and 75th percentile, while the line inside the boxes indicates the median (outliers are omitted).

7 Conclusions

We provide a rigorous estimation of the contribution of macroeconomic factors to spreads in the euro area. Using monthly data from January 2000 to December 2023, we build a panel of the nine original euro area countries to estimate sovereign spreads, except Luxembourg, we then compute spreads considering only the impact of macroeconomic variables and fixed effects. Since empirical models tend to be highly sensitive to specification, we consider a wide variety of models and adopt a thick modeling approach.

Focusing on 10-year government bonds, we find that, from 2009 to mid 2014, peripheral spreads experimented a dramatic rise, reaching at the peak two to six times their estimated macro-consistent values in Italy, Spain, Portugal and Ireland. During this period, macroeconomic conditions evidently deteriorated - with lower GDP growth expectations and higher levels of public indebtedness - which led to an increase in the contribution of macroeconomic variables for all countries in the euro area. However, changes in these variables can only explain up to 26% of the maximum variation of spreads during this period for any of the peripheral countries included in our panel. Since mid-2014, we report a gradual reduction of the contribution of macroeconomic variables to spreads towards pre-GFC values, with observed spreads close to that contribution.

The robustness of our spreads estimates to a wide range of model specifications is one of the main contributions of this paper. Moreover, we show that the inclusion of a representative sample of core and peripheral countries, like in our benchmark model is key to properly capture the relative sovereign risk pricing inside the euro area. We conclude that relying on a robust estimation of the contribution of macroeconomic factors of sovereign spreads - as the one proposed in this paper - is crucial to understand the factors driving their evolution within a monetary union like the euro area.

8 Appendix

Table 5: Spread Estimations by Sample Period. 10-year Bond against OIS Yield

	all countries				core countries				rest of countries			
Sample period	obs.	est.	macro	s.d. obs	obs.	est.	macro	s.d. obs	obs.	est.	macro	s.d. obs
2000m1-2007m12	-3	7	-10	11	2	-16	-24	11	2	44	27	13
2008m1-2012m7	152	151	76	212	34	53	33	45	272	263	138	270
2012m8-2020m2	84	84	64	116	7	15	21	22	166	159	125	132
2020m3-2023m12	26	18	27	42	0	-12	21	18	58	69	78	44
Full sample period	77	61	37	141	10	7	1	31	148	128	89	185

Source: Own calculations.
Note: 'obs' refers to observed spreads, 'est.' to estimated spreads, 'macro' to macro-consisten spreads and 's.d.' to the standard deviation of observed spreads across the countries included in the sample. Core countries are: France, Belgium, Austria, Netherlands and Finland, while the rest are: Italy, Spain, Portugal and Ireland.

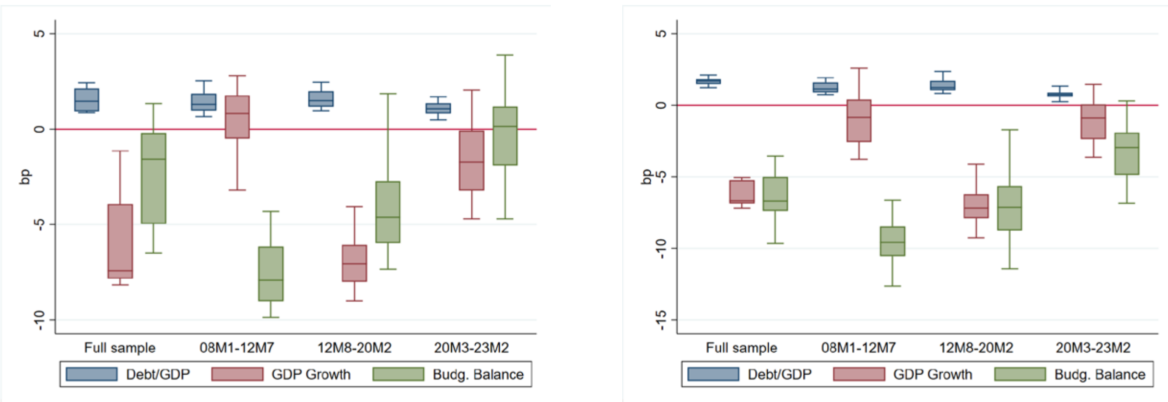
Table 6: Mean Contributions to Spread Estimations by Sample Period. 10-year Bond against OIS Yield

	Contribution of macro variables								Contribution of financial variables			
	all countries				non-core countries							
Sample period	GDP	Debt	BB	CPI	GDP	Debt	BB	CPI	Bidask	VIX	UMP	FE
2000m1-2007m12	0.12	0.25	0.05	0.03	0.17	0.32	0.06	0.04	0.07	0.08	0.00	0.40
2008m1-2012m7	0.02	0.28	0.19	0.06	0.02	0.29	0.25	0.06	0.14	0.07	0.03	0.22
2012m8-2020m2	0.08	0.37	0.09	0.04	0.10	0.41	0.10	0.03	0.08	0.04	0.04	0.25
2020m3-2023m12	0.02	0.29	0.12	0.01	0.04	0.39	0.14	0.01	0.06	0.07	0.19	0.24
2022m1-2023m12	0.02	0.23	0.06	0.06	0.04	0.31	0.07	0.06	0.10	0.05	0.27	0.22
full sample	0.07	0.30	0.10	0.04	0.10	0.35	0.12	0.04	0.09	0.06	0.06	0.29

Source: Own calculations.
Note: 'FE' includes contribution of constant and individual fixed effects coefficients. Core countries are: France, Belgium, Austria, Netherlands and Finland, while the rest are: Italy, Spain, Portugal and Ireland.

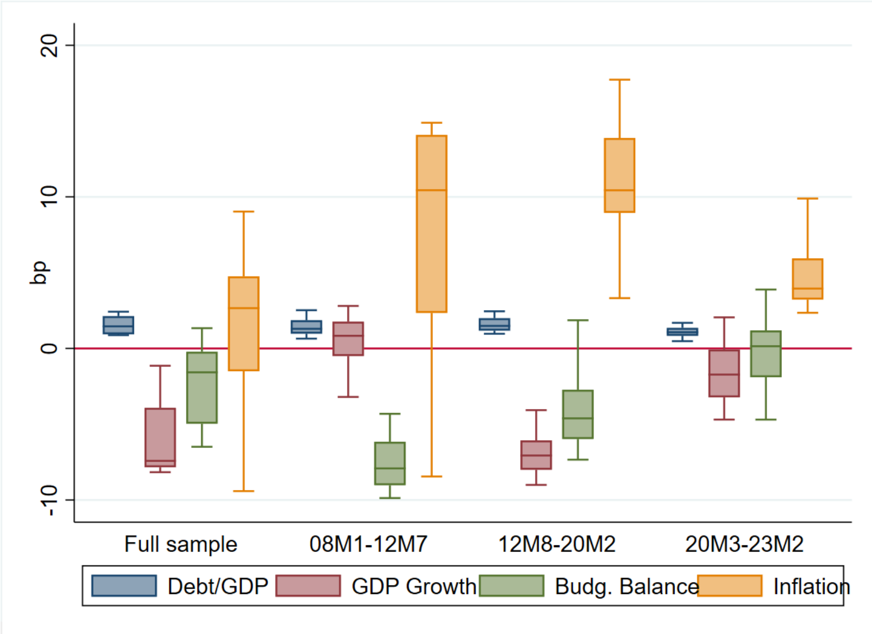
Figure 7: Regression Coefficients of Macroeconomic Determinants across Models
10Y Bond spread vs German Bund or OIS yield

(a) vs German Bund (b) vs OIS yield



Source: Own calculations.
Notes: "Full sample" refers to time-invariant coefficients, while the rest to the interaction between the macro var and the time-period dummy. The solid boxes represent the 25th and 75th percentile, while the line inside the boxes indicates the median (outliers are omitted).

Figure 8: Distribution of Regression Coefficients of Macroeconomic Determinants across Models - Including Inflation Coefficients



Source: Own calculations.

Notes: "Full sample" refers to time-invariant coefficients, while the rest to the interaction between the macro var and the time-period dummy. In the case of GDP Growth and Debt/GDP we have 24 estimated time-invariant coefficients and 72 coefficients each, while in the case of the Budget Balance we have 48 coefficients. The solid boxes represent the 25th and 75th percentile, while the line inside the boxes indicates the median (outliers are omitted).

References

Afonso, António, Michael G. Arghyrou, George Bagdatoglou and Alexandros Kontonikas. (2015). "On the time-varying relationship between EMU sovereign spreads and their determinants". *Economic Modelling*, 44, pp. 363-371. https://doi.org/10.1016/j.econmod.2014.07.025

Afonso, António, Michael G. Arghyrou, María Dolores Gadea and Alexandros Kontonikas. (2018). "`Whatever it takes' to resolve the European sovereign debt crisis? Bond pricing regime switches and monetary policy effects". *Journal of International Money and Finance*, 86, pp. 1-30. https://doi.org/10.1016/j.jimonfin.2018.04.005

Afonso, António, and João Tovar Jalles. (2019). "Quantitative easing and sovereign yield spreads: Euro-area time-varying evidence". *Journal of International Financial Markets, Institutions and Money*, 58, pp. 208-224. https://doi.org/10.1016/j.intfin.2018.10.003

Afonso, António, and Nuno Verdial. (2019). "Sovereign debt crisis in Portugal and in Spain". EconPol Working Paper, 40, ifo Institute - Leibniz Institute for Economic Research at the University of Munich. https://www.econstor.eu/bitstream/10419/219502/1/econpol-wp-40.pdf

Aizenman, Joshua, Michael Hutchison and Yothin Jinjarak. (2013). "What is the risk of European sovereign debt defaults? Fiscal space, CDS spreads and market pricing of risk". *Journal of International Money and Finance*, 34, pp. 37-59. https://doi.org/10.1016/j.jimonfin.2012.11.011

Attinasi, Maria-Grazia, Cristina Checherita and Christiane Nickel. (2010). "What explains the surge in euro area sovereign spreads during the financial crisis of 2007-09?". *Public Finance and Management*, 10(4), pp. 595-645. https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp1131.pdf

Barbosa, Luciana, and Sónia Costa. (2010). "Determinants of sovereign bond yield spreads in the euro area in the context of the economic and financial crisis". Working Papers, 22/2010, Banco de Portugal. https://www.bportugal.pt/sites/default/files/anexos/papers/wp201022.pdf

Barrios, Salvador, Per Iversen, Magdalena Lewandowska and Ralph Setzer. (2009). "Determinants of intra-euro area government bond spreads during the financial crisis". Economic Papers, 388, Directorate General Economic and Financial Affairs (DG ECFIN), European Commission. https://ec.europa.eu/economy_finance/publications/pages/publication16255_en.pdf

Beirne, John, and Marcel Fratzscher. (2013). "The pricing of sovereign risk and contagion during the European sovereign debt crisis". *Journal of International Money and Finance*, 34, pp. 60-82. https://doi.org/10.1016/j.jimonfin.2012.11.004

Ceci, Donato, and Marcello Pericoli. (2022). "Sovereign spread and econometric fundamentals: an empirical analysis". Questioni di Economia e Finanza (Occasional Papers), 713, Banca d'Italia. https://www.bancaditalia.it/pubblicazioni/qef/2022-0713/QEF_713_22.pdf?language_id=1

Costain, James, Galo Nuño and Carlos Thomas. (2022). "The term structure of interest rates in a heterogeneous monetary union". Working Paper Series, 9844, CESifo. https://www.cesifo.org/DocDL/cesifo1_wp9844.pdf

Costantini, Mauro, Matteo Fragetta and Giovanni Melina. (2014). "Determinants of sovereign bond yield spreads in the EMU: An optimal currency area perspective". *European Economic Review*, 70, pp. 337-349. https://doi.org/10.1016/j.euroecorev.2014.06.004

De Grauwe, Paul, and Yuemei Ji. (2012). "Mispricing of sovereign risk and macroeconomic stability in the eurozone". *JCMS: Journal of Common Market Studies*, 50(6), pp. 866-880. https://doi.org/10.1111/j.1468-5965.2012.02287.x

De Grauwe, Paul, and Yuemei Ji. (2013). "Self-fulfilling crises in the eurozone: An empirical test". *Journal of International Money and Finance*, 34(C), pp. 15-36. https://doi.org/10.1016/j.jimonfin.2012.11.003

De Santis, Roberto A. (2016). "Credit spreads, economic activity and fragmentation". Working Paper Series, 1930, European Central Bank. https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp1930.en.pdf

Delatte, Anne-Laure, Julien Fouquau and Richard Portes. (2017). "Regime-dependent sovereign risk pricing during the euro crisis". *Review of Finance*, 21(1), pp. 363-385. https://doi.org/10.1093/rof/rfw050

Dovern, Jonas, Ulrich Fritsche and Jiri Slacalek. (2012). "Disagreement among forecasters in G7 countries". *The Review of Economics and Statistics*, 94(4), pp. 1081-1096. https://www.jstor.org/stable/23355342

Driscoll, John C., and Aart C. Kraay. (1998). "Consistent covariance matrix estimation with spatially dependent panel data". *The Review of Economics and Statistics*, 80(4), pp. 549-560. https://doi.org/10.1162/003465398557825

Ejsing, Jacob, and Jukka Sihvonen. (2009). "Liquidity premia in German government bonds". Working Paper Series, 1081, European Central Bank. https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp1081.pdf

Eser, Fabian, Wolfgang Lemke, Ken Nyholm, Sören Radde and Andreea Liliana Vladu. (2019). "Tracing the impact of the ECB's asset purchase programme on the yield curve". Working Paper Series, 2293, European Central Bank. https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2293~41f7613883.en.pdf

Eser, Fabian, and Bernd Schwaab. (2013). "Assessing asset purchases within the ECB's securities markets programme". Working Paper Series, 1587, European Central Bank. https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp1587.pdf

Georgoutsos, Dimitris, and Petros Migiakis. (2018). "Risk perceptions and fundamental effects on sovereign spreads". Working Papers, 250, Bank of Greece. https://www.bankofgreece.gr/Publications/Paper2018250.pdf

Granger, Clive W. J., and Yongil Jeon. (2004). "Thick modeling". *Economic Modelling*, 21(2), pp. 323-343. https://doi.org/10.1016/S0264-9993(03)00017-8

Guirola, Luis, and Javier J. Pérez. (2023). "The decoupling between public debt fundamentals and bond spreads after the European sovereign debt crisis". *Applied Economics*, 55(34), pp. 3971-3979. https://doi.org/10.1080/00036846.2022.2120959

Hondroyiannis, George, and Dimitrios Papaoikonomou. (2022). "The effect of Eurosystem asset purchase programmes on euro area sovereign bond yields during the COVID-19 pandemic". *Empirical Economics*, 63(6), pp. 2997-3026. https://doi.org/10.1007/s00181-022-02225-5

Kinateder, Harald, and Niklas Wagner. (2017). "Quantitative easing and the pricing of EMU sovereign debt". *The Quarterly Review of Economics and Finance*, 66(C), pp. 1-12. https://doi.org/10.1016/j.qref.2017.04.013

Moral-Benito, Enrique. (2015). "Model averaging in economics: An overview". *Journal of Economic Surveys*, 29(1), pp. 46-75. https://doi.org/10.1111/joes.12044

Paniagua, Jordi, Juan Sapena and Cecilio Tamarit. (2017). "Sovereign debt spreads in EMU: The time-varying role of fundamentals and market distrust". *Journal of Financial Stability*, 33, pp. 187-206. https://doi.org/10.1016/j.jfs.2016.06.004

Poghosyan, Tigran. (2014). "Long-run and short-run determinants of sovereign bond yields in advanced economies". *Economic Systems*, 38(1), pp. 100-114. https://doi.org/10.1016/j.ecosys.2013.07.008

Pouzo, Demian, and Ignacio Presno. (2016). "Sovereign default risk and uncertainty premia". *American Economic Journal: Macroeconomics*, 8(3), pp. 230-266. https://doi.org/10.1257/mac.20140337

Sgherri, Silvia, and Edda Zoli. (2009). "Euro area sovereign risk during the crisis". IMF Working Papers, 2009/222, International Monetary Fund, pp. 1-23. https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Euro-Area-Sovereign-Risk-During-the-Crisis-23325

Szczerbowicz, Urszula. (2015). "The ECB unconventional monetary policies: Have they lowered market borrowing costs for banks and governments?". *International Journal of Central Banking*, 11(4), pp. 91-127. https://www.ijcb.org/journal/ijcb15q5a3.pdf

Von Hagen, Jürgen, Ludger Schuknecht and Guido Wolswijk. (2011). "Government bond risk premiums in the EU revisited: The impact of the financial crisis". *European Journal of Political Economy*, 27(1), pp. 36-43. https://doi.org/10.1016/j.ejpoleco.2010.07.002

BANCO DE ESPAÑA PUBLICATIONS

WORKING PAPERS

2231 DANIEL SANTABÁRBARA and MARTA SUÁREZ-VARELA: Carbon pricing and inflation volatility.

2232 MARINA DIAKONOVA, LUIS MOLINA, HANNES MUELLER, JAVIER J. PÉREZ and CRISTOPHER RAUH: The information content of conflict, social unrest and policy uncertainty measures for macroeconomic forecasting.

2233 JULIAN DI GIOVANNI, MANUEL GARCÍA-SANTANA, PRIIT JEENAS, ENRIQUE MORAL-BENITO and JOSEP PIJOAN-MAS: Buy Big or Buy Small? Procurement Policies, Firms' Financing and the Macroeconomy*.

2234 PETER PAZ: Bank capitalization heterogeneity and monetary policy.

2235 ERIK ANDRES-ESCAYOLA, CORINNA GHIRELLI, LUIS MOLINA, JAVIER J. PÉREZ and ELENA VIDAL: Using newspapers for textual indicators: which and how many?

2236 MARÍA ALEJANDRA AMADO: Macroprudential FX regulations: sacrificing small firms for stability?

2237 LUIS GUIROLA and GONZALO RIVERO: Polarization contaminates the link with partisan and independent institutions: evidence from 138 cabinet shifts.

2238 MIGUEL DURO, GERMÁN LÓPEZ-ESPINOSA, SERGIO MAYORDOMO, GAIZKA ORMAZABAL and MARÍA RODRÍGUEZ-MORENO: Enforcing mandatory reporting on private firms: the role of banks.

2239 LUIS J. ÁLVAREZ and FLORENS ODENDAHL: Data outliers and Bayesian VARs in the Euro Area.

2240 CARLOS MORENO PÉREZ and MARCO MINOZZO: "Making text talk": The minutes of the Central Bank of Brazil and the real economy.

2241 JULIO GÁLVEZ and GONZALO PAZ-PARDO: Richer earnings dynamics, consumption and portfolio choice over the life cycle.

2242 MARINA DIAKONOVA, CORINNA GHIRELLI, LUIS MOLINA and JAVIER J. PÉREZ: The economic impact of conflict-related and policy uncertainty shocks: the case of Russia.

2243 CARMEN BROTO, LUIS FERNÁNDEZ LAFUERZA and MARIYA MELNYCHUK: Do buffer requirements for European systemically important banks make them less systemic?

2244 GERGELY GANICS and MARÍA RODRÍGUEZ-MORENO: A house price-at-risk model to monitor the downside risk for the Spanish housing market.

2245 JOSÉ E. GUTIÉRREZ and LUIS FERNÁNDEZ LAFUERZA: Credit line runs and bank risk management: evidence from the disclosure of stress test results.

2301 MARÍA BRU MUÑOZ: The forgotten lender: the role of multilateral lenders in sovereign debt and default.

2302 SILVIA ALBRIZIO, BEATRIZ GONZÁLEZ and DMITRY KHAMETSHIN: A tale of two margins: monetary policy and capital misallocation.

2303 JUAN EQUIZA, RICARDO GIMENO, ANTONIO MORENO and CARLOS THOMAS: Evaluating central bank asset purchases in a term structure model with a forward-looking supply factor.

2304 PABLO BURRIEL, IVÁN KATARYNIUK, CARLOS MORENO PÉREZ and FRANCESCA VIANI: New supply bottlenecks index based on newspaper data.

2305 ALEJANDRO FERNÁNDEZ-CEREZO, ENRIQUE MORAL-BENITO and JAVIER QUINTANA: A production network model for the Spanish economy with an application to the impact of NGEU funds.

2306 MONICA MARTINEZ-BRAVO and CARLOS SANZ: Trust and accountability in times of pandemic.

2307 NATALIA FABRA, EDUARDO GUTIÉRREZ, AITOR LACUESTA and ROBERTO RAMOS: Do renewable energies create local jobs?

2308 ISABEL ARGIMÓN and IRENE ROIBÁS: Debt overhang, credit demand and financial conditions.

2309 JOSÉ-ELÍAS GALLEGOS: Inflation persistence, noisy information and the Phillips curve.

2310 ANDRÉS ALONSO-ROBISCO, JOSÉ MANUEL CARBÓ and JOSÉ MANUEL MARQUÉS: Machine Learning methods in climate finance: a systematic review.

2311 ALESSANDRO PERI, OMAR RACHEDI and IACOPO VAROTTO: The public investment multiplier in a production network.

2312 JUAN S. MORA-SANGUINETTI, JAVIER QUINTANA, ISABEL SOLER and ROK SPRUK: Sector-level economic effects of regulatory complexity: evidence from Spain.

2313 CORINNA GHIRELLI, ENKELEJDA HAVARI, ELENA MERONI and STEFANO VERZILLO: The long-term causal effects of winning an ERC grant.

2314 ALFREDO GARCÍA-HIERNAUX, MARÍA T. GONZÁLEZ-PÉREZ and DAVID E. GUERRERO: How to measure inflation volatility. A note.

2315 NICOLÁS ABBATE, INÉS BERNIELL, JOAQUÍN COLEFF, LUIS LAGUINGE, MARGARITA MACHELETT, MARIANA MARCHIONNI, JULIÁN PEDRAZZI and MARÍA FLORENCIA PINTO: Discrimination against gay and transgender people in Latin America: a correspondence study in the rental housing market.

2316 SALOMÓN GARCÍA: The amplification effects of adverse selection in mortgage credit suply.

2317 METTE EJRNÆS, ESTEBAN GARCÍA-MIRALLES, METTE GØRTZ and PETTER LUNDBORG: When death was postponed: the effect of HIV medication on work, savings and marriage.

2318 GABRIEL JIMÉNEZ, LUC LAEVEN, DAVID MARTÍNEZ-MIERA and JOSÉ-LUIS PEYDRÓ: Public guarantees and private banks' incentives: evidence from the COVID-19 crisis.

2319 HERVÉ LE BIHAN, DANILO LEIVA-LEÓN and MATÍAS PACCE: Underlying inflation and asymmetric risks.

2320 JUAN S. MORA-SANGUINETTI, LAURA HOSPIDO and ANDRÉS ATIENZA-MAESO: The numbers of equality regulation. Quantifying regulatory activity on non-discrimination and its relationship with gender gaps in the labour market.

2321 ANDRES ALONSO-ROBISCO and JOSÉ MANUEL CARBÓ: Analysis of CBDC Narrative of Central Banks using Large Language Models.

2322 STEFANIA ALBANESI, ANTÓNIO DIAS DA SILVA, JUAN F. JIMENO, ANA LAMO and ALENA WABITSCH: New technologies and jobs in Europe.

2323 JOSÉ E. GUTIÉRREZ: Optimal regulation of credit lines.

2324 MERCEDES DE LUIS, EMILIO RODRÍGUEZ and DIEGO TORRES: Machine learning applied to active fixed-income portfolio management: a Lasso logit approach.

2325 SELVA BAHAR BAZIKI, MARÍA J. NIETO and RIMA TURK-ARISS: Sovereign portfolio composition and bank risk: the case of European banks.

2326 ANGEL-IVAN MORENO and TERESA CAMINERO: Assessing the data challenges of climate-related disclosures in european banks. A text mining study.

2327 JULIO GÁLVEZ: Household portfolio choices under (non-)linear income risk: an empirical framework.

2328 NATASCHA HINTERLANG: Effects of Carbon Pricing in Germany and Spain: An Assessment with EMuSe.

2329 RODOLFO CAMPOS, SAMUEL PIENKNAGURA and JACOPO TIMINI: How far has globalization gone? A tale of two regions.

2330 NICOLÁS FORTEZA and SANDRA GARCÍA-URIBE: A Score Function to Prioritize Editing in Household Survey Data: A Machine Learning Approach.

2331 PATRICK MACNAMARA, MYROSLAV PIDKUYKO and RAFFAELE ROSSI: Taxing consumption in unequal economies.

2332 ESTHER CÁCERES and MATÍAS LAMAS: Dividend Restrictions and Search for Income.

2333 MARGARITA MACHELETT: Gender price gaps and competition: Evidence from a correspondence study.

2334 ANTON NAKOV and CARLOS THOMAS: Climate-conscious monetary policy.

2335 RICARDO BARAHONA, STEFANO CASSELLA and KRISTY A. E. JANSEN: Do teams alleviate or exacerbate the extrapolation bias in the stock market?

2336 JUAN S. MORA-SANGUINETTI and ANDRÉS ATIENZA-MAESO: "Green regulation": A quantification of regulations related to renewable energy, sustainable transport, pollution and energy efficiency between 2000 and 2022.

2401 LAURA HOSPIDO, NAGORE IRIBERRI and MARGARITA MACHELETT: Gender gaps in financial literacy: a multi-arm RCT to break the response bias in surveys.

2402 RUBÉN DOMÍNGUEZ-DÍAZ, SAMUEL HURTADO and CAROLINA MENÉNDEZ: The medium-term effects of investment stimulus.

2403 CLODOMIRO FERREIRA, JOSÉ MIGUEL LEIVA, GALO NUÑO, ÁLVARO ORTIZ, TOMASA RODRIGO and SIRENIA VAZQUEZ: The heterogeneous impact of inflation on households' balance sheets.

2404 JORGE ABAD, GALO NUÑO and CARLOS THOMAS: CBDC and the operational framework of monetary policy.

2405 STÉPHANE BONHOMME and ANGELA DENIS: Estimating individual responses when tomorrow matters.

2406 LAURA ÁLVAREZ-ROMÁN, SERGIO MAYORDOMO, CARLES VERGARA-ALERT and XAVIER VIVES: Climate risk, soft information and credit supply.

2407 JESÚS FERNÁNDEZ-VILLAVERDE, JOËL MARBET, GALO NUÑO and OMAR RACHEDI: Inequality and the zero lower bound.

2408 PABLO BURRIEL, MAR DELGADO-TÉLLEZ, CAMILA FIGUEROA, IVÁN KATARYNIUK AND JAVIER J. PÉREZ: Estimating the contribution of macroeconomic factors to sovereign bond spreads in the euro area.