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Sovereign Bond Yield Synchronisation,
Fiscal Regimes, and State-Dependent
Effects of Monetary Policy in the Eurozone

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Sovereign Bond Yield Synchronisation, Fiscal Regimes, and State-Dependent Effects of Monetary Policy in the Eurozone

ABSTRACT

This study assesses the impact of the European Central Bank (ECB) monetary policy shocks on sovereign bond synchronization in the Euro Area during the 2001-2024 period. We examine the extent to which the efficacy of monetary policy transmission can be influenced by the existence of high and low-debt fiscal regimes. We use panel state-dependent local projection method, with conditioning based on the level of sovereign debt to GDP ratio. Our findings indicate that the effect of monetary policy shocks on bond yield synchronization is negligible for low-debt economies. However, we report the impact of standard and unconventional monetary policy shocks on market fragmentation which is driven by the yields of high-debt economies. Empirically derived thresholds are likely not to induce heterogeneity between high- and low-debt regime yields. In contrast, the non-linearity in response is more likely to be attributed to the country-specific maximum sustainable debt levels.

KEYWORDS: bond yield synchronization, monetary policy, fiscal regime, state dependent local projection, government debt-to-GDP ratio

JEL CLASSIFICATION: C33, E44, H63, E52

Synchronizácia výnosov štátnych dlhopisov, fiškálne režimy a stavovo-podmienенý efekt menovej politiky v eurozóne

ABSTRAKT

Táto štúdia hodnotí vplyv šokov menovej politiky Európskej centrálnej banky (ECB) na synchronizáciu mier výnosnosti štátnych dlhopisov v eurozóne v období 2001–2024. V príspevku skúmame, do akej miery môže existencia režimov s vysokým a nízkym zadlžením verejného sektora ovplyvniť účinnosť prenosu menovej politiky. Využívame podmienenú panelovú metódu lokálnej projekcie, v ktorej je podmieňujúcou premennou pomer dlhu verejného sektora k HDP. Naše zistenia naznačujú, že vplyv šokov menovej politiky na synchronizáciu výnosov štátnych dlhopisov je v prípade režimu nízkej zadlženosti zanedbateľný. Avšak v prípade krajín s vysokou úrovňou verejného dlhu sa vplyv štandardných a nekonvenčných šokov menovej politiky na fragmentáciu trhu štátnych dlhopisov stáva významným. Empiricky odvodené prahové hodnoty výšky verejného dlhu nie sú asociované s vyššou heterogenitou medzi výnosmi štátnych dlhopisov krajín s vysokým a nízkym zadlžením. Naopak, nelinearitu v reakcii evidujeme pri prahových hodnotách odvodených od maximálnej udržateľnej úrovni zadlženosti konkrétnych členských krajín.

KLÚČOVÉ SLOVÁ: synchronizácia výnosov štátnych dlhopisov, menová politika, fiškálny režim, stavovo-podmienенá metóda lokálnej projekcie, pomer verejného dlhu na HDP

JEL KLASIFIKÁCIA: C33, E44, H63, E52

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Introduction

The synchronization of long-term government bond yields is crucial for the smooth transmission of monetary policy across member states in the euro area. In the pre-financial crisis period, the empirically observed convergence in long-term bond yields has been accepted as a positive and expected outcome of convergence process in a common monetary union (Ehrmann et al., 2011). However, the synchronization decreased significantly during the Great Recession and the European Debt Crisis, gave rise to the era of fragmentation (Candelon et al., 2022), partially recovered post-2015 (Barbieri et al., 2024), only to be in decline again during the COVID pandemic (Candelon et al., 2022). In addition, the pervasive existence of two (Christou et al., 2024) or even three (Antonakakis et al., 2017) distinct convergence clubs in the European sovereign debt market has further complicated the effective conduct of common monetary policy.

Under the conditions of diverging government bond yields emerging within the fragmented financial markets, traditional monetary policy may itself be a source of unequal dynamics across the Eurozone. The asynchronous movement in bond yields affected by monetary policy could be traced to households wealth re-allocation (Hanson et al., 2021), or to the behavior of financial intermediaries who re-balance their composition of optimal portfolios (Domanski et al., 2017; Barbieri et al., 2024). As a result, asynchronous yield movements may justify the activation of unconventional monetary policy – a behavior adopted by the ECB for more than a decade.

The role of conventional and unconventional monetary policy tools utilized by the ECB has been the subject of extensive research in the context of widening government bond spreads. Whilst there is a broad consensus regarding the significance of monetary policy, albeit only limited in size for conventional tools (Eijffinger and Pieterse-Bloem, 2023) and much more impactful for unconventional ones (Eijffinger and Pieterse-Bloem, 2023; Blotevogel et al., 2024), the interest into heterogeneous transmission to individual economies, possibly caused by underlying economic and financial factors, has recently been reinvigorated. According to Leombroni et al. (2021), the different reaction of bond yields between core and peripheral countries can be attributed to the ECB communication policy during the European sovereign debt crisis affecting risk premia. van der Zwan et al. (2024) report a stronger reaction to the ECB asset purchases for Southern European countries. In a similar vein, Corradin and Schwaab (2023) provide empirical evidence that more vulnerable economies benefited from the activation of the unconventional monetary policy during the outbreak of the pandemic to a greater extent. Yet, neither of these studies formally identify and test the possible structural determinants that could be responsible for the reported diverse response.

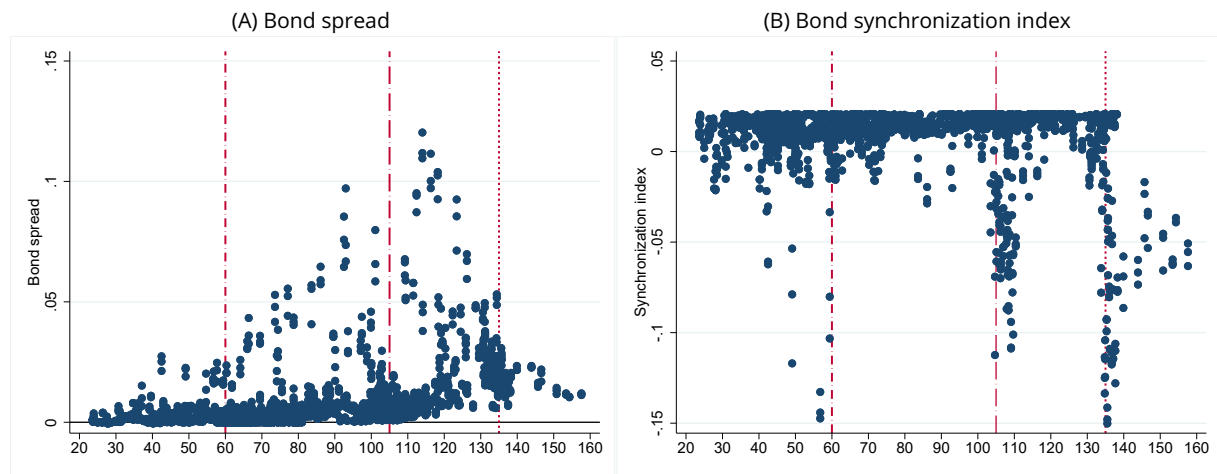
To contribute to this discussion, our aim is to investigate state-dependent effects of conventional and unconventional monetary policy shocks on bond yield synchronization in euro area. Our study expands the recent debate in few directions.

First, the bond synchronization index by Cuaresma and Fernández (2024) used in this study measures the extent to which an individual bond yield contributes to the overall range of bond yields distribution in common monetary union. As a result, this concept assesses the cross-country co-movement based on sigma-convergence analysis (Cuaresma and Fernández-Amador, 2013a,b). Compared to a commonly used bond spreads which assesses the distance of an individual bond position to an anchor country – Germany in Costantini et al. (2014); Afonso et al. (2015b); Eijffinger and Pieterse-Bloem (2023); Blotevogel et al. (2024) – this approach has a potential to serve as a suitable approximation of common market fragmentation as it focuses on the second moment of convergence in bond yields.

Second, we are interested in the state-dependent impact of monetary policy shocks during low and high-fiscal regimes, in addition to the unconditional responses. Expected change in fiscal

position has been identified as one of the three primary factors influencing government yields in euro area (Afonso et al., 2015b). Figure 1 (Panel A) shows a linear and positive link between bond spreads and debt-to-GDP ratios. There is no discernible clustering observable around a specific critical thresholds, but after the approximately 110% of GDP only the positive bond spreads are recorded. In contrast, the relationship between the synchronization index and the indebtedness levels shows some distinct features (Panel B). Weak clustering tendencies are reported below and close to the Maastricht criteria levels (60% of GDP), but the strongest de-synchronization tendencies are mostly concentrated around two distinct points – 105% and 135% of GDP.² Intriguingly, not only the 105% ratio represents the mean of the country-specific critical sovereign debt levels for countries in our sample (Table A.2), it also corresponds to the global Debt-at-Risk ratio recently estimated by Furceri et al. (2025).

Figure 1: Conditionality in the effect of government indebtedness (debt-to-GDP ratio)



Note: Bond spread calculated as the difference between a country government bond yield and the EA average. Synchronization index calculated by procedure in Cuaresma and Fernández (2024).

Source: Own compilation based on data from the Eurostat, based on Maastricht criteria 10-year government bond yields. Calculated for the sample of EA11 economies (excl. Luxembourg) for period 2001-2025. Greece and Germany are excluded from figures.

Third, this tentative empirical evidence suggests that the de-synchronization tendencies in bond markets materialized around the critical thresholds may be linked to a set of specific circumstances, being them of a real or financial matter. Our study therefore aims to provide a new piece of information about how the common monetary policy might not only (potentially) contribute to market fragmentation, but its effect could have been amplified by perceived change in sovereign debt sustainability. The empirical literature on the conditional effect of monetary policy under different fiscal regimes is rather scarce and focuses on real economic activity (Luigi and Huber, 2018) and prices (Afonso et al., 2025). Our study represents a logical extension which tracks the conditional effects of monetary policy along the intermediate stages of monetary transmission mechanism – the long-term nominal interest rates.

We employ a panel state-dependent local projection method, similar to Afonso et al. (2025), with the high- and low-debt regimes identification based on the ratio of general government debt-to-GDP. The synchronization index (Cuaresma and Fernández, 2024) is calculated for 11 founding members of the euro area and their Maastricht criteria long-term bond yields. We use monthly data for the 2001-2024 period.

²Observations higher than 135% GDP belong to only two economies (Greece is excluded) - Portugal for pandemic year 2021 and Italy for the post-2014 period.

Our findings suggest that bond yields in high-debt regimes – defined as countries with a debt-to-GDP ratio above 105% – behave more asynchronously in response to standard and unconventional monetary policy shocks. In contrast, low-debt regimes have shown no significant contribution to market fragmentation following a change in ECB monetary policy. This asynchronous response persists even when the empirically identified turning point of 105% is replaced by the concept of maximum sustainable debt, as defined in Collard et al. (2022). Given the inherent non-linearity of the response to monetary policy shocks, our analysis suggests that it may be tempting for a central bank to alleviate this market reaction in order to mitigate the risks of self-imposed fragmentation. However, this could present a challenge for the implementation of a common monetary policy, given that the ECB’s recently introduced Transmission Protection Instrument is only activated when the deterioration of financing conditions is not justified by economic fundamentals. In this scenario, the distinction between sovereign debt stress triggered by self-fulfilling belief-driven behavior (Grauwe and Ji, 2012; Callegari et al., 2023) and change in fundamentally driven increase in credit risk premiums in presence of ‘involuntary default’ (Collard et al., 2022, 2024) gains on importance.

The remainder of the paper is organized as follows. Section 1 discusses the relevant literature. Section 2 describes the econometric framework used and gives an overview of the data employed. Section 3 shows the main results of the local projection exercise for unconditional and conditional responses. This section also discusses the findings from the heterogeneous monetary policy shocks and sensitivity analysis. Section 4 concludes.

1 Literature Review

Our study is related to several strands of literature.

In fully synchronized sovereign debt markets in economic union, common monetary policy should affect all bond yields equally and unequivocally – a shock would only shift the mean of the entire bond yields distribution and leave the higher moments unaffected. If, on the other hand, we find an evidence of the heterogeneous response of different countries’ yields to the ECB conventional or unconventional monetary policy, this may signalize the existence of market fragmentation as one of the main fragility of the Eurozone capital markets (Barbieri et al., 2024). The disproportionate change in the country risk premium may be linked to a change in the perceived probability of default (Hürtgen and Rühmkorf, 2014), the risk of altering liquidity characteristics (Pooter et al., 2018), or even the non-negligible risk of exiting the common monetary union (Santis, 2015), which may come into question in stressed economies under certain economic or financial conditions.

The issue of proper identification of sovereign debt market fragmentation has been object of several studies. The first group of studies evaluate the fragmentation based on range of statistical techniques. For instance, Candelon et al. (2022) use the first and second principal components from the bond yields as a way to retrieve information regarding cross sectional dependence. While the first component can be interpreted as a common interdependence trend, the second indicates the fragility of the sovereign bond market. In a similar vein, Barbieri et al. (2024) identifies two principal components of bond yields in the Eurozone; however, their significance varies in time with second component explaining higher share of variance in post-2008 period. Using the PCA-based decomposition, Mosk and de Vette (2025) attribute the second component to the core-periphery divergence in the Euro Area. Martins (2022) explores the alignment of bond yields across G7 nations through wavelet-based analysis. In contrast, concept by Cuaresma and Fernández (2024) assesses the cross-country co-movement based on sigma-convergence analysis (Cuaresma and Fernández-Amador, 2013a,b). It is designed to measure the extent to which an individual bond yield contributes to the overall range of bond yields distribution in common monetary union.

The second group of studies aims at distinguishing between speculative and fundamentally driven change in asset prices. Fragmentation is typically measured by the residual from the interest rate spread differentials regressed on a set of fundamental factors explaining their behavior, e.g. Ceci and Pericoli (2022), or as a spread between countries with the same rating (Baele et al., 2004). The entire distribution of yields is considered in Kakes and van den End (2023), who assess to what extent the deviations of the spread distribution relative to that of macro fundamentals are excessive.

The empirical literature investigating determinants of sovereign bond spreads in Euro Area is rather rich, e.g. Maltritz (2012); Costantini et al. (2014); Afonso et al. (2015b). In contrast, the literature on the determinants of sovereign bond yield synchronization and fragmentation is practically non-existent, as this concept is often treated as speculative and self-fulfilling, therefore unexplained(able). Few exceptions exist. The study by Cuaresma and Fernández (2024) uses the Bayesian model averaging technique to statistically identify a list of robust factors contributing to de-synchronisation tendencies in the eurozone. While economic fundamentals describing fiscal positions could not systematically explain changes in yield synchronisation, inflation rates are a robust predictor; however, the association differs for GIIPS countries compared to the rest of the EMU. The role of monetary policy is addressed by including dummy variables for the zero-lower bound and the period after the Draghi 'whatever it takes' speech. During these periods, the division between the reaction of the GIIPS countries and the rest is more pronounced. Kakes and van den End (2023) regress higher moments of sovereign bond spreads distribution in the EA on higher moments of selected macroeconomic variables. They conclude that the announcement effect of monetary policy asset purchases aimed at stabilizing bond markets might be a considered a separate explanatory variable of market fragmentation.

Characterization of fiscal regimes in the Eurozone is subject to few studies. Ionta et al. (2025) distinguish between "more" (Ricardian) and "less" (non-Ricardian) sustainable fiscal regimes. In the former case, the monetary policy takes the lead and fiscal policy follows, while in the latter the government sets the primary budget balance regardless of the debt-to-GDP ratio and dominates the monetary policy. Brady and Magazzino (2018) identifies the heterogeneous fiscal regimes across EU member states by examining the long-run relationship between government revenues and expenditures from 1980 to 2015. They argue that few countries (Portugal, Ireland, Italy, Greece, and Spain) exhibit fiscal un-sustainability in contrast to more Ricardian regimes found elsewhere in the EU.

The impact of monetary policy was found to be limited by various factors, including credit market characteristics (Leroy and Lucotte, 2016), central bank independence (Gregor et al., 2021), household debt overhang (Alpanda and Zubairy, 2019) or income inequality (Domonkos et al., 2023). The empirical literature on the effect of monetary policy under different fiscal regimes is rather scarce and predominantly focuses on real economic categories – economic activity or prices. Luigi and Huber (2018) report the limited impact of monetary policy shocks on real economy during 'high' debt regimes. Economies operating in high-debt regimes face higher uncertainty which, in turn, may impact how unexpected movements in key interest rates affect the real economy and possibly hamper the increase in economic activity. Based on the fiscal theory of prices, Afonso et al. (2025) empirically illustrate the non-responsiveness of prices to monetary policy shocks in the Eurozone for high-debt regime economies. Under the fiscal dominance, the monetary policy lacks the ability to control prices which are, in turn, a fiscal phenomenon.

The existing gap in the literature is intriguing, particularly in the presence of the increased sovereign indebtedness across the globe and the exceptional monetary policy measures undertaken by most major central banks before and during the period of the COVID pandemic. Rising government debt levels may increase the likelihood of 'fiscal dominance' over monetary policy. Ac-

cording to Baig et al. (2006), high levels of debt are likely to constrain the conduct of monetary policy in emerging market economies. Although the recent empirical evidence for Euro Area rejects this possibility for the period of the ECB's existence (Darvas et al., 2024), the time-varying nature of the fiscal-monetary nexus (Bouabdallah et al., 2023) indicates the need for a constant re-evaluation of its emergence.

2 Methodology

2.1 Bond synchronization index

Our analysis assesses the response of cross-country co-movement in sovereign bond yields to monetary policy shocks. To measure the level of synchronization in bond yields, we used a time-varying measure based on sigma-convergence analysis following Cuaresma and Fernández (2024). In this approach, the synchronization measure for country i (out of the N countries that comprise the monetary union in period t) is given by:

$$synch_{it} = \log(s_{it}) - \log(s_t) \quad (1)$$

with

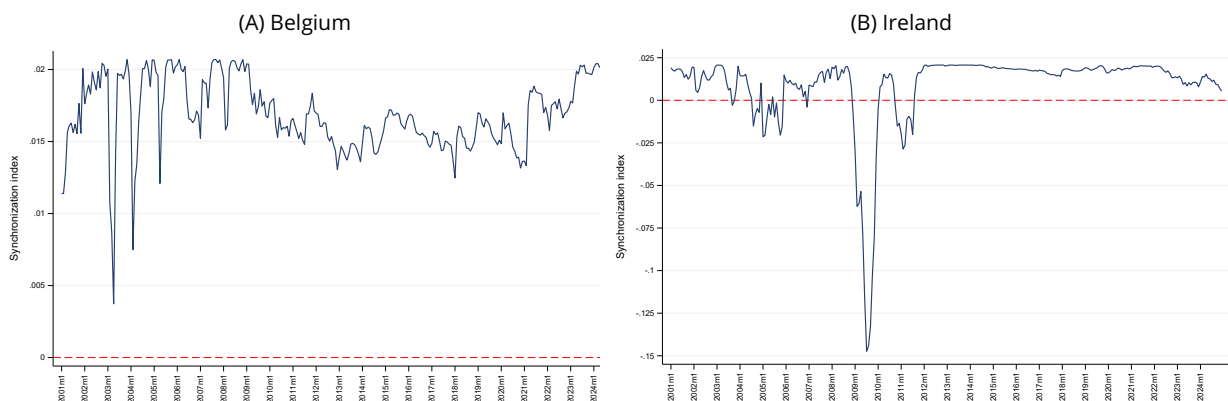
$$s_t = \sqrt{\frac{\sum_j (r_{jt} - \bar{r}_j)^2}{N}} \quad (2)$$

and

$$s_{it} = \sqrt{\frac{\sum_{j \neq i} (r_{jt} - \bar{r}_{jt})^2}{N - 1}} \quad (3)$$

where r_{jt} represents the long-term (10-year) government bond yield of a country j , s_{it} signifies the cross-country standard deviation of the long-term government bond yield value, excluding country i , s_t indicates the standard deviation of long-term government bond yields for all countries within the monetary union in period t .

Figure 2: The bond synchronisation index for selected economies



Note: Synchronization index calculated by eq. 1.

Source: Own compilation based on data from the Eurostat.

The synchronization index, $synch_{it}$, assesses the extent to which the volatility of bond yields is greater or less when a country is part of the union compared to when it is not. If the index is negative, it indicates that the variation in cross-country yields is reduced when country i is left out

of the sample. Consequently, negative values of this index suggest that omitting country i leads to a more homogeneous group of countries regarding the dispersion of long-term government bonds, and the opposite holds true as well. Thus, the country i introduces a disturbance to the group and is a source of the de-synchronization process. As a result, it can be asserted that if $synch_{it} < 0$ then country i is a disturbance, and if $synch_{it} > 0$ then country i is a stabilizer.

For example, Figure 2 compares the extent of bond synchronisation for two countries: Ireland, which introduces a disturbance to the group, and Belgium, which acts as a stabiliser. As shown, the synchronisation index for Belgium remains positive with very low variability. In contrast, the synchronisation index for Ireland drops significantly into negative territory, particularly during the euro area sovereign debt crisis.

2.2 Empirical model

The existence of the relationship between the synchronization index calculated by eq. 1 and monetary policy shocks is tested by the following baseline specification using the local projection approach developed by Jorda (2005):

$$synch_{i,t+h} = \alpha_i^h + \sum_{j=0}^{12} \beta_j^h MP_{t-j} + \sum_{j=1}^{12} \gamma_j^h synch_{i,t-j} + \sum_{j=1}^{12} \rho_j^h X_{i,t-j} + \delta_t^h + \epsilon_{i,t+h} \quad , \quad h = 0, \dots, 12 \quad (4)$$

where MP_{t-j} represents the monetary policy shock, and X_{t-j} is the vector of all other control variables, and α_i^h country and δ_t^h time fixed effects. The number of lags, $j = 12$, is determined from the conventional panel VAR according to the relevant information criteria (Olea et al., 2025) and corresponds to the standard practice in monetary policy literature using datasets with monthly frequency (Baumeister, 2025). The forecasting horizon, h , is set equal to the number of lags, i.e., 12 months, as recommended by Baumeister (2025). We focus on the first year of transmission of monetary policy shocks to bond yields synchronization, as the transmission to financial variables is usually quicker and short-lived in comparison to real economic variables. In addition, short-term horizons are preferred as local projection estimator has a lower bias than VAR estimators, but substantially higher variance at intermediate and long horizons (Li et al., 2024). As monthly data may have higher persistence, we use the lag augmentation procedure suggested by Olea et al. (2021) and control for higher lags of dependent variable, $\sum_{j=1}^{12} \gamma_j^h synch_{i,t-j}$, which allows for the use of a heteroskedasticity-robust routine to estimate standard errors (Jorda and Taylor, 2024). As government bond yields in Eurozone tend to be spatially correlated due to the contagion effects (Silvapulle et al., 2016), we follow Andres-Escayola et al. (2024) and report robust standard errors as in Driscoll and Kraay (1998).

In order to investigate the state-dependent effect of monetary policy shocks, this study employs panel state-dependent local projection regressions which augments the equation 4 as follows:

$$synch_{i,t+h} = \alpha_i^h + \sum_{j=0}^{12} \beta_j^h MP_{t-j} + \sum_{j=1}^{12} \gamma_j^h synch_{i,t-j} + \sum_{j=1}^{12} \omega_j^h MP_{i,t-j} DD_{i,t-j-13} + \sum_{j=1}^{12} \rho_j^h X_{i,t-j} + \delta_t^h + \epsilon_{i,t+h} \quad , \quad h = 0, \dots, 12 \quad (5)$$

where the MP_{t-j} is conditioned on the lagged dummy variable identifying high-debt regimes

($DD_{it-j-13} = 1$) and low-debt regimes ($DD_{it-j-13} = 0$). As argued in Gonçalves et al. (2024), for the local projection estimator to be valid at longer horizons the state variable cannot be endogenously determined. Our state variable, i.e. the high- and low-debt regime, is constructed on the basis of the debt-to-GDP ratio, which may be subject to endogeneity via direct interest payments, accumulated fiscal balance or economic growth which are likely to be affected by a monetary policy shock. Hulsewig and Rottmann (2022) show that government debt in EA economies starts reacting approximately six months after the initial monetary policy shock. For this reason, we identify the high- and low-debt regimes with a lag of 13 months, $DD_{it-j-13} = 1$, to ensure that this lag is larger than the lag $j = 12$ associated with the lagged dependent variable $synch_{i,t-j}$ in eq. 5.

The identification of high- and low-debt regimes is based on the empirical relationship observed in data, i.e., the clustering of highly negative values of synchronization index around a specific debt-to-GDP ratio (Figure 1). The first threshold identified in our data closely aligns with the policy-imposed critical point – 60% debt-to-GDP ratio for the Maastricht criteria. Further examinations indicates that the second significant threshold for the debt-to-GDP ratio linked to a significant decrease in synchronization index is set around 105%.

This is higher than the ratio usually reported and used in empirical literature. For instance, Ortman and Tripier (2021) refers to high debt-to-GDP countries for which the debt-to-GDP ratio is above the median calculated for the full sample at the end of 2019 – this procedure would result in a critical threshold of around 80% for out sample. Hürtgen and Rühmkorf (2014) finds that sovereign default risk increased significantly at a debt-to-GDP ratio above 90%. Afonso et al. (2025) also uses the turning point of 90% to distinguish between high- and low-debt regimes and Bouabdallah et al. (2017) assigns the cut-off 90% to the high-risk debt sustainability levels. As apparent in the Figure 1, the relationship between synchronization index and debt ratio exhibits different properties than that of the spread-indebtedness nexus.

2.3 Data

We use monthly data for the original 11 EMU members for the balanced dataset covering the 2001-2025 period, similar to Costantini et al. (2014); Afonso et al. (2015b); Eijffinger and Pieterse-Bloem (2023).³⁴ The use of monthly data is common in literature (Costantini et al., 2014; Afonso et al., 2015b; Eijffinger and Pieterse-Bloem, 2023).

For the monetary policy target shock, i.e. the conventional monetary policy shock, we use the Monetary Policy event database (EA-MPD) by Altavilla et al. (2019) and focus on the 3-month Overnight Index Swap (OIS) changes around the monetary policy meetings of the ECB Governing Council, similar to, e.g. Mermelas and Tagkalakis (2024); Canofari et al. (2025). We use the standardized monetary policy shock. Specifically, one standard deviation hike is equal to a 7.69 basis point increase in 3-month OIS, value close to Canofari et al. (2025).

Baumeister (2025) argues that the use of LP method requires the inclusion of a rich set of control variables in order to increase robustness of generated impulse response functions. Our list of control variables includes the determinants of sovereign bond spreads and synchronization generally used by literature (Grauwe and Ji, 2022; Eijffinger and Pieterse-Bloem, 2023; Cuaresma and Fernández, 2024). In addition, we include two separate measures of ECB balance sheet policy, the quantitative easing and credit easing policies, as identified by Domonkos et al. (2023). These are

³Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain. Luxembourg is excluded due to the exceptionally low level of government debt with a very small variation.

⁴The synchronization index is calculated for full set of 11 economies. However, we exclude Greece from the local projection panel – its inclusion strongly distorts the response functions. We follow Hulsewig and Rottmann (2022) who also exclude Greece from the EA sample based on the argument that external financing through capital markets did not take place as it was fully replaced by financial aid programs from May 2010 onward.

included to capture the post-announcement effect of actual purchases conducted by central banks (Blotevogel et al., 2024). Table A.1 lists the detailed characteristics of control variables included in vector X_{t-j} in eq. 4 and eq. 5. For all of the control variables we use month-over-month growth rates or first difference transformation, if applicable, in order to capture the short-term dynamics in underlying economic relationship. The synchronization index enters in levels as, by construction, it is already expressed in terms of the percentage deviation (see eq. 1) and as such exhibits stationary properties over the period analyzed (Figures A.1 - A.11).

The COVID period may introduce a high volatility to our outcome variable. Similar to Andres-Escayola et al. (2024) or Canofari et al. (2025), we control for COVID periods by the inclusion of a dummy variable.⁵

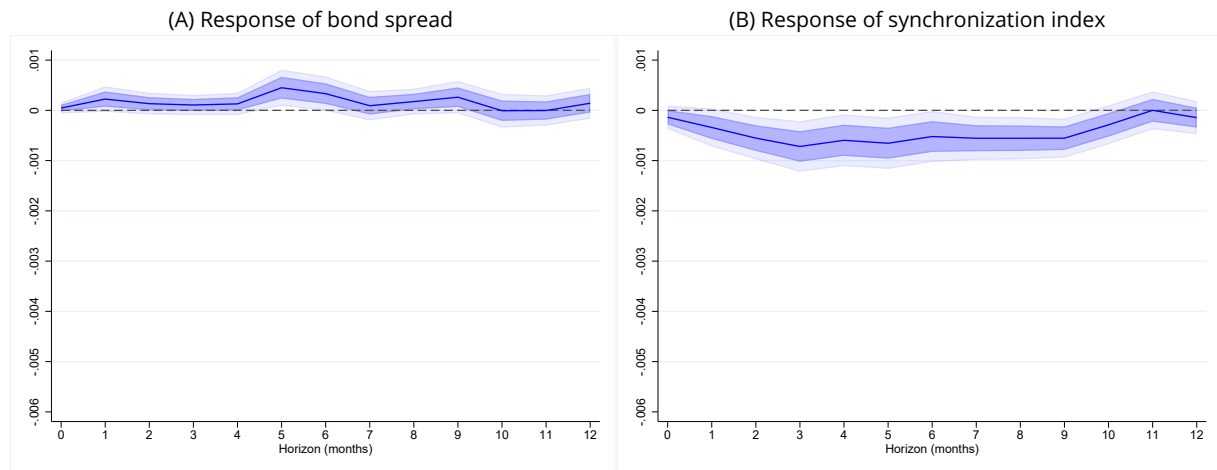
3 Results

3.1 Conventional monetary policy shock

Figure 3 shows that a tightening monetary policy shock increases the sovereign bond spreads for a brief period of time around the fifth month (Panel A) and it decreases the extent of bond synchronization at the same time (Panel B). In the case of bond synchronization, the aggregated effect is sustained over the first to ninth month after the initial shock, but it dissipates shortly afterward.

Next, we plot state-dependent impulse response functions, where the monetary policy shock is conditioned on the level of debt-to-GDP ratio. As indicated, we use two empirically observed turning points as indicative thresholds (Figure 1) - the Maastricht criteria (60%) and the Clustering criteria (105%). Interestingly, the latter one empirically corresponds to the average of the country-specific individual critical points set at 9th decile as well as the average of the individual maximum sustainable debt levels calculated by Collard et al. (2023) - see Table A.2.

Figure 3: Impulse response functions w.r. to a conventional monetary policy shock



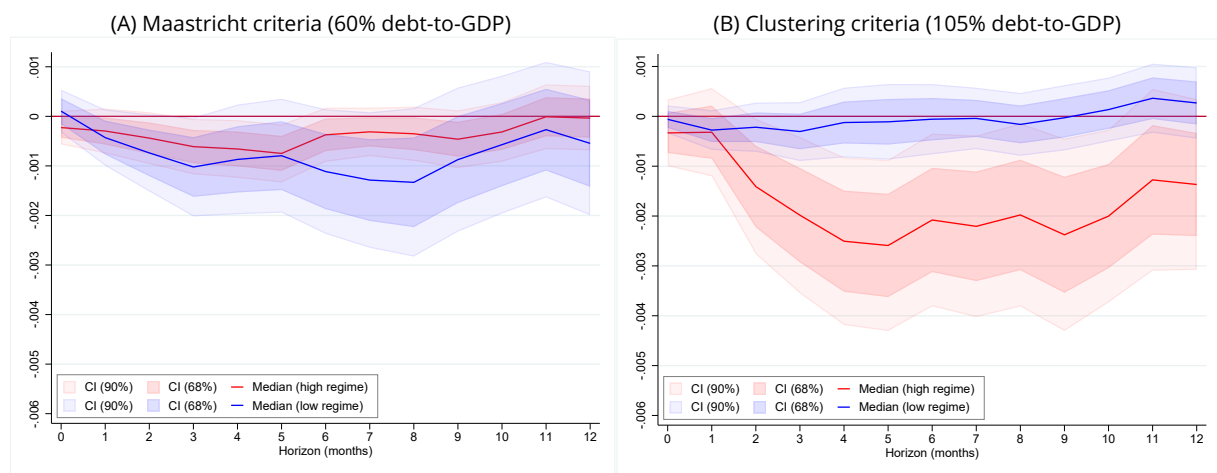
Note: Synchronization index calculated by eq. 1. Impulse response function for specification eq. 4. Confidence intervals calculated for 68th (dark blue) and 90th (light blue) percentile. Greece is excluded.

The response functions for the policy-imposed Maastricht criteria threshold are depicted in Figure 4 (Panel A). In both groups (high and low-debt regime economies) the synchronization index

⁵The dummy variable takes one during the March 2020 and December 2021. We further discuss this issue in one of our robustness checks.

initially responds negatively to the tightening MP shock – however, the tightening creates higher dispersion (lower homogeneity in bond yields) for low-regime economies. In addition, there is no noticeable difference between these two groups across a medium-term horizon (close to a year) as the effect of this shock dissipates (returns to zero). Due to the large confidence intervals reported for low-regime economies, the statistical significance of the impact of the monetary policy shock is rather low indicating the de-synchronization tendencies are subdued across multiple observations, as expected. In contrast, the de-synchronization tendencies are statistically significant at a short-term horizon for high-regime countries. However, the impact of monetary policy shock dissipates after nine months with a no sustained effect on the extent of bond de-synchronization over the longer horizon. In economic terms, the response reported for the high-regime economies is practically identical to the unconditional response (Table 3) indicating that the reaction of sovereign bonds is likely to be driven mostly by observations associated with the high-debt regime countries.

Figure 4: State-dependent impulse response functions w.r. to a monetary policy shock

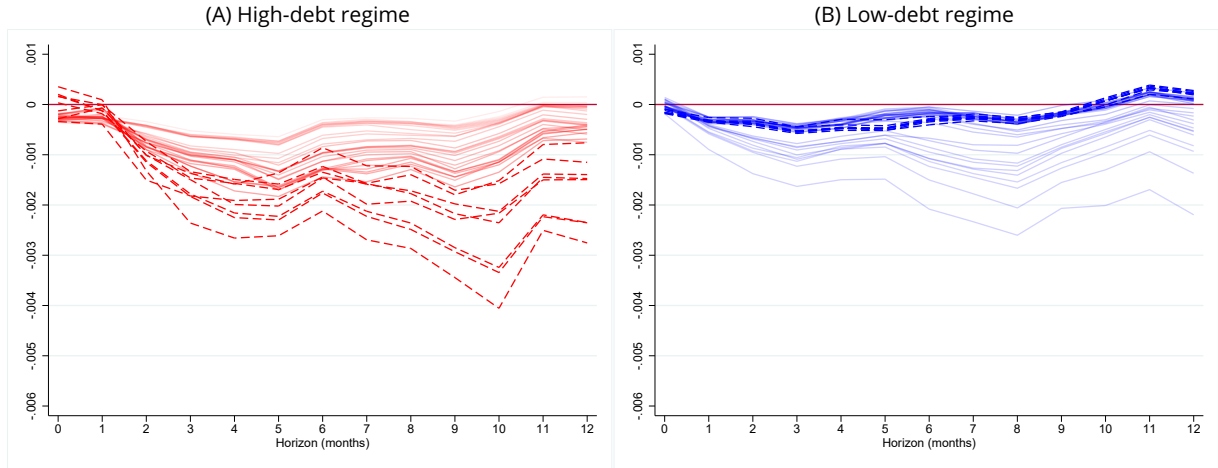


Note: Synchronization index calculated by eq. 1. Impulse response function for specification eq. 5. High regime indicates countries (observations) with debt-to-GDP ratio larger than the pre-determined threshold, i.e., $DD_{it-j-13} = 1$. Low regime indicates countries (observations) with debt-to-GDP ratio smaller than the pre-determined threshold, i.e., $DD_{it-j-13} = 0$. Greece is excluded.

The response functions for the empirically observed clustering thresholds are depicted in Figure 4 (Panel B). In the case of the low-debt regime economies, the response of synchronization index fluctuates around zero and is not statistically significant, as hypothesized for the fully synchronized and non-fragmented monetary union. For the high-debt regime economies, however, a monetary policy tightening brings about a de-synchronized response in their bond yields signifying a stronger and unequal transmission of shock. In terms of magnitude, the median response at the peak (5th month) for high-debt regimes is more than seven times larger than the unconditional one (Figure 3, Panel B). In addition, the impact of monetary policy shock in a high-debt regime, albeit weaker in nature, tends to persevere even after the twelve months – in contrast to unconditional response which dissipates at higher horizons.

To further identify the precise location of a turning point, we estimate a series of conditional impulse response functions for debt-to-GDP ratios ranging from 50% to 120% of GDP. Figure 5 depicts the median responses for high (Panel A) and low (Panel B) debt regimes. The overall shape of the median responses in high-debt regimes changes after exceeding the 105% GDP threshold (dashed lines) — not only is the lowest point achieved in the tenth month, but de-synchronisation tendencies also persist beyond the twelve-month horizon. This is in stark contrast to the state-

Figure 5: The continuity of state-dependent median impulse response functions w.r. to a monetary policy shock



Note: Synchronization index calculated by eq. 1. Impulse response function for specification eq. 5. High-debt regime indicates countries (observations) with debt-to-GDP ratio larger than the pre-determined threshold, i.e., $DD_{it-j-13} = 1$. Low-debt regime indicates countries (observations) with debt-to-GDP ratio smaller than the pre-determined threshold, i.e., $DD_{it-j-13} = 0$. The full continuity of debt ratios used as critical thresholds ranges from 50% GDP to 120% GDP and progresses by step of two percentage points. The dashed red line indicates responses for continuity of ratios between 106% GDP and 120% GDP. Greece is excluded.

dependent median responses reported for critical thresholds below 105% of GDP, which peak in the fifth month before converging towards zero. In contrast, the median responses for low debt regimes behave in the opposite manner, with threshold values above 105% reporting close to zero impact over longer prediction horizons.

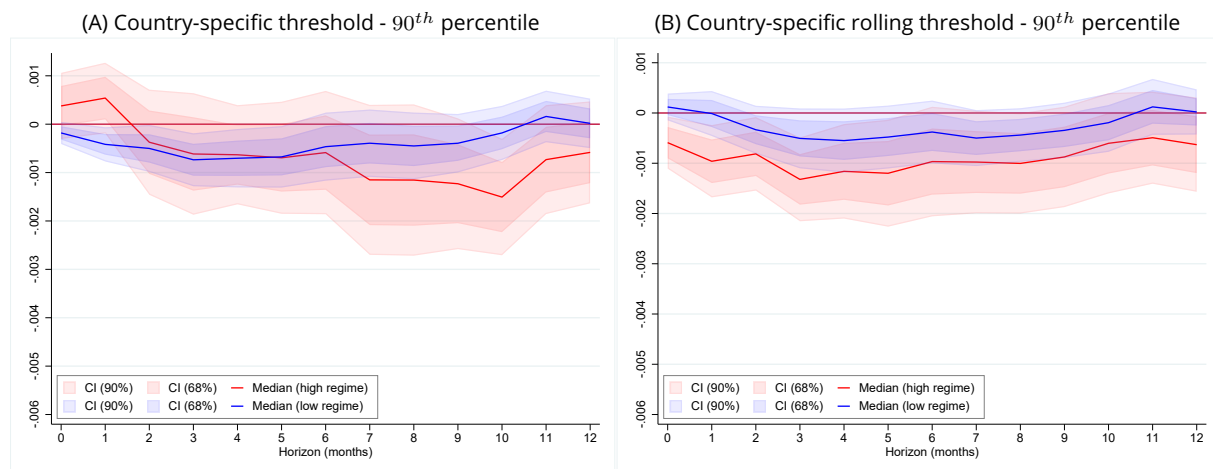
3.2 Country-specific thresholds

Country risk premiums embedded in bonds spreads should inherently reflect country-specific fundamentals (Afonso et al., 2015a). Even under the conditions of a common monetary union differences in default risk across countries or differences in liquidity could imply substantial differences in yield spreads across countries and over time (Ehrmann et al., 2011). As such, investors in fixed income markets are expected to pay heightened attention to the worsening of individual debt position, and not necessarily have their expectations anchored to some external, policy-imposed critical thresholds.

For this reason, we proceed with investigating the response of synchronization index to monetary policy shock conditional on country-specific critical thresholds. In a similar exercise, Afonso et al. (2025) uses the average of the ratio within each country's sample to discriminate between low and high debt regimes. For the purpose of our exercise, we use the 9th decile as potential turning points to focus on the most extreme realizations of sovereign debt. In addition, Bentour (2021) documents that the critical levels of government debt influencing economic growth may vary over time. We therefore consider the possibility of time-varying critical thresholds in our empirical setup. We simulate the investment decisions of backward-looking investors who assess the historical distribution of country-specific debt levels and consider critical levels to be those that exceed the 9th decile. Specifically, we assign $DD_{it-j-13} = 1$ in each month if the debt ratio exceeds the 9th decile calculated for the rolling window over the last three years. This partially emulate the recent debt-at-risk concept by Furceri et al. (2025), but with the backward-looking decision making

process.

Figure 6: State-dependent impulse response functions w.r. to a monetary policy shock



Note: Synchronization index calculated by eq. 1. Impulse response function for specification eq. 5. High regime indicates countries (observations) with debt-to-GDP ratio larger than the pre-determined threshold, i.e., $DD_{it-j-13} = 1$. Low regime indicates countries (observations) with debt-to-GDP ratio smaller than the pre-determined threshold, i.e., $DD_{it-j-13} = 0$. Greece is excluded.

Figure 6 depicts the estimated impulse response functions which reveal no discernible, sustained difference between high- and low-debt regimes at distribution-specific critical threshold. It is evident that the country-specific critical points derived from the empirical distribution of sovereign debt levels fixed for the entire time span (Panel A) or determined by the time-varying thresholds (Panel B) are less likely to capture the heterogeneous process of de-fragmentation that has been triggered by a common monetary policy shock. In the latter case, we also report the negative responses similar to the unconditional case (Figure 3) in terms of the magnitude and shape.

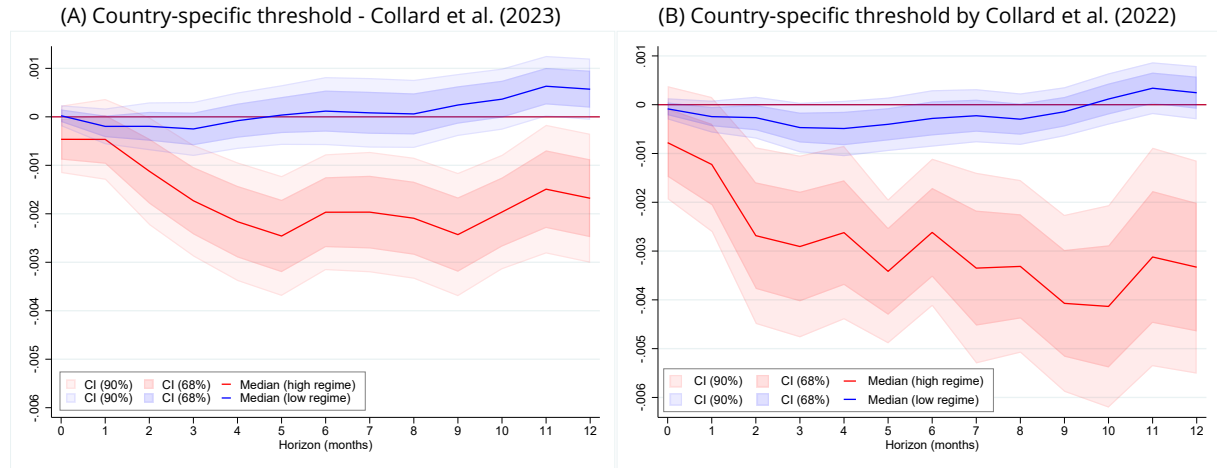
Next, we use maximum sustainability debt estimates from Collard et al. (2022) and Collard et al. (2023) which are theoretically derived under the assumption that countries always try to repay their debts but might be pushed into default because they lack the resources necessary to service existing debt. The identified turning points are reported in Table A.2.

The theory-based approach of the maximum sustainable debt (Collard et al., 2023) which satisfies the long-term government budget constraint in the presence of involuntary default (Figure 7, Panel A) is able to almost perfectly replicate our baseline findings for the common threshold of 105% GDP (Figure 4, Panel B).⁶ In addition, we also utilize published pre-2009 crisis estimates of maximum sustainable debts (Table A.2), as calculated by Collard et al. (2022), to assess the time-varying nature of our findings. We observe a strongly pronounced statistically significant difference between the high- and low-debt regimes (Figure 7, Panel B). The low-debt regimes show no

⁶In the case of a stochastic interest rate (MSD $S_k = 0.3$), the impulse response function for the high-debt regime is statistically significant and negative, resembling the baseline response. However, the difference between the high- and low-regime economies is not statistically significant. On average, the maximum sustainable levels are smaller for stochastic interest rate (71.4 per cent vs. 109.5), with the difference being most noticeable among the set of economies that did not experience the recent sovereign debt crisis (Austria, Belgium, France and the Netherlands). This is driven by the lower expected future proceeds from new fiscal borrowings (?). Assumptions made by financial markets regarding the future discount rate (i.e. the risk-free rate), which reflects monetary policy decisions, may hereby represent a crucial channel that can ignite the process of market fragmentation. As the risk-free rate is set to Germany's nominal rate (Collard et al., 2024), the possible non-linearity in response to monetary policy shock, which in turn changes the perception of maximum sustainable debt and triggers even more powerful reaction in market fragmentation.

discernible change in the level of synchronization following the monetary policy shock. For the high-debt regime, the minimum is achieved in the tenth month following the tightening shock, with a sustained negative effect preserved at the longest horizon. The negative peak in response is also almost twice larger than in the baseline specification (Figure 4, Panel B).

Figure 7: State-dependent impulse response functions w.r. to a monetary policy shock



Note: Synchronization index calculated by eq. 1. Impulse response function for specification eq. 5. High regime indicates countries (observations) with debt-to-GDP ratio larger than the pre-determined threshold, i.e., $DD_{it-j-13} = 1$. Low regime indicates countries (observations) with debt-to-GDP ratio smaller than the pre-determined threshold, i.e., $DD_{it-j-13} = 0$. The (approximate) country-specific threshold reported by (Collard et al., 2023) is for the combination of maximum sustainable debt with deterministic risk-free rate and 30% recovery rate (MSD D $k=0.3$ in Table A.2). The country-specific threshold reported by (Collard et al., 2022) is for the maximum sustainable debt with stochastic risk-free rate estimated for the pre-crisis period (Pre-crisis S in Table A.2). Greece is excluded.

From this perspective, financial markets tend to exhibit a propensity to align with more general and robust external criteria when evaluating sovereign risk, and this threshold may reflect upon a more theoretical concept of long-term fiscal sustainability.⁷ In this instance, the historical empirical distribution of sovereign debts may not provide a complete set of satisfactory information to guide monetary policy decisions.

3.3 Heterogeneity in monetary policy shocks

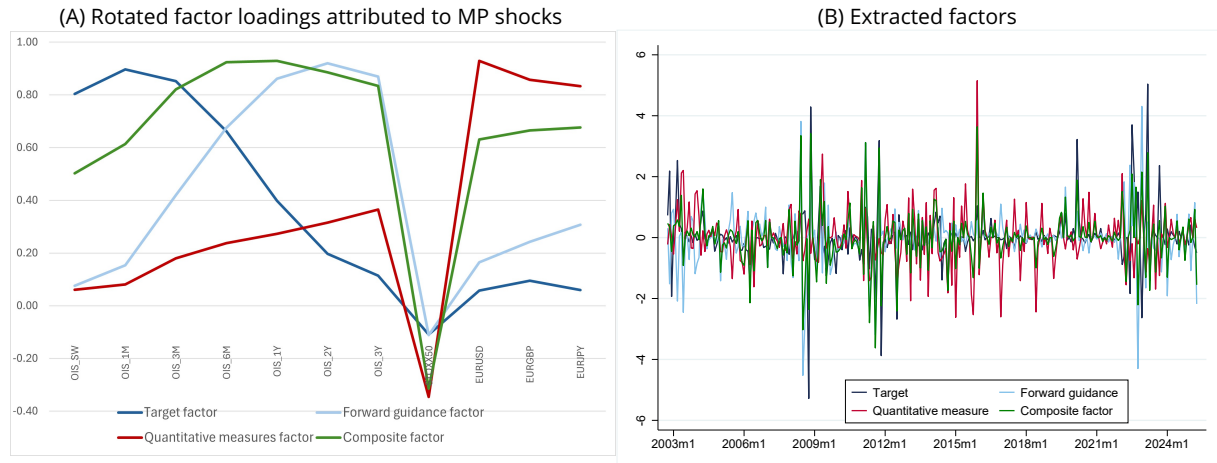
The rich EA-MPD dataset allows for disentangling different types of monetary policy surprises linked to set of conventional and unconventional monetary policy employed by the ECB (Altavilla et al., 2019). In addition, Jarocinski and Karadi (2020) identify pure monetary policy and information surprises by differentiating among policy decision announcements and additional communication events, such as policymakers' speeches or releases of policy meetings minutes. As the ECB has adopted the variety of conventional and unconventional monetary policy instruments during examined periods, we aim to extract few unique monetary policy shocks possibly representing each individual policy, similar to, e.g. Gürkaynak et al. (2005); Jarocinski (2024); Swanson (2021). In contrast, Nakamura and Steinsson (2018) and Bauer and Swanson (2023) advocate the use of a single factor in order to capture the joint effects of different policy tools, as it might be arguable whether a central bank differentiates among the separate tools in its policy making. In the European context,

⁷Yet, a word of caution is necessary – since the concept of long-term sustainability presented here is dependent on the estimation of a risk-free interest rate (Blanchard, 2019; Collard et al., 2024), if the effects of monetary policy are not fully transitory, even the sole perception of the debt sustainability may be endogenous to the effect of monetary policy shocks.

most of the unconventional measures were adopted only after the 2008 financial crisis - hence, the extraction of one single factor may better capture the monetary policy setting in the pre-crisis period. From this reason, we complement our set of individual monetary policy shocks by one additional composite factor, similar to Jung and Uhlig (2019).

First, we extract three factors from the set of eleven variables in the EA-MPD database - the OIS changes at different maturities (SW, 1 month, 3 months, 6 months, 1 year, 2 years, 3 years), stock changes represented by EUROSTOXX50, and three exchange rates (EURUSD, EURGBP, EURJPY), similar to Ricco et al. (2024).⁸

Figure 8: Heterogeneous monetary policy shocks



Note: Factors extracted by factor analysis procedure, orthogonal rotation used for first three factors. True zeros used for monthly observations for which no monetary policy policy shock was recorded.

Source: Own computation based on EA-MPD database by (Altavilla et al., 2019) for monetary event window.

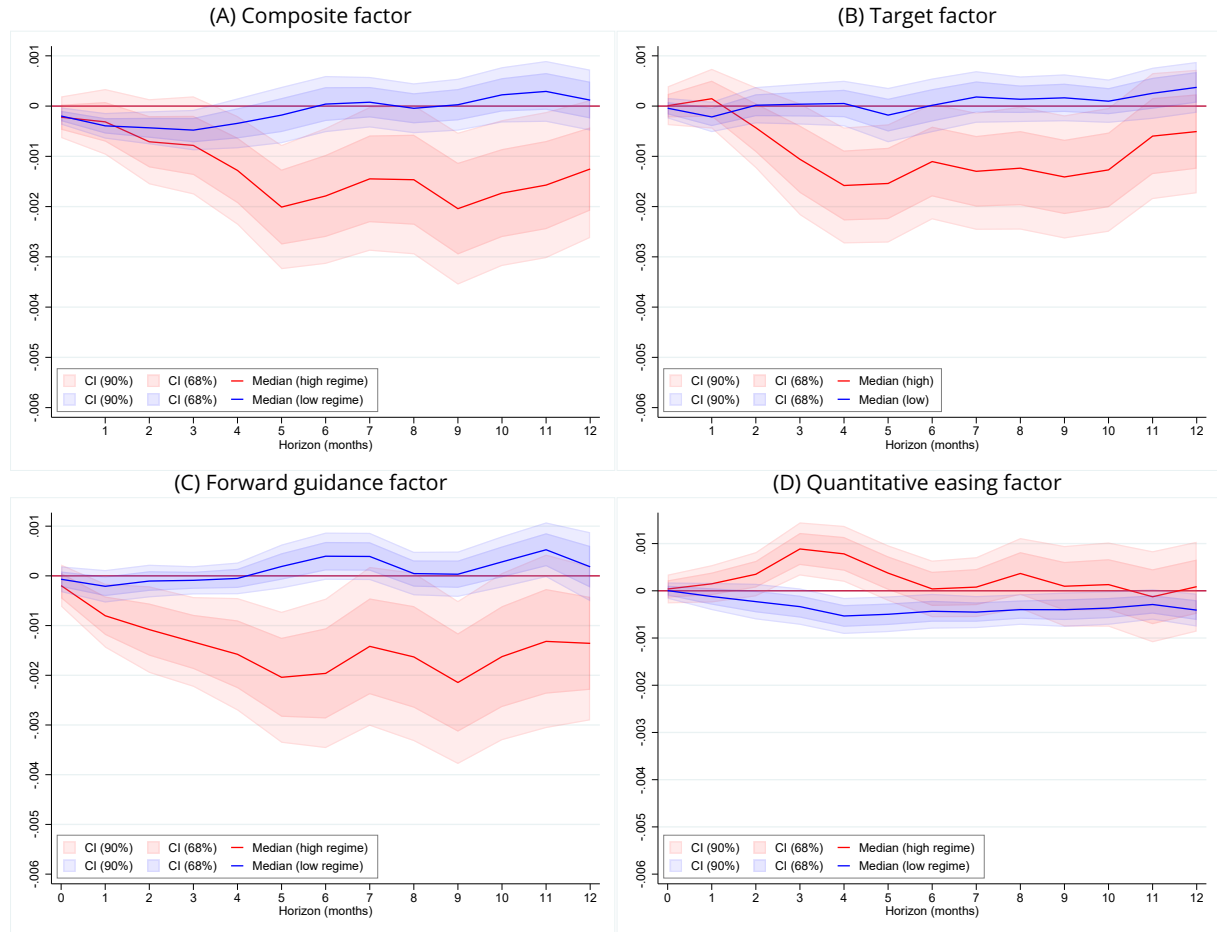
The factor loadings from the vector of EA-MPD policy shocks are depicted in Figure 8. Following the approach by Ricco et al. (2024), we identify three surprises during ECB Governing Council meeting days - the monetary event window. These three pure monetary policy surprises contain the signals sent by central bank about: (1) the current setting of policy rates (Target), (2) the bank's future stance (Forward Guidance - FG, path factor), and (3) quantitative easing (QE) policy decisions. Consistent with previous studies (Almerud et al., 2024), the Target surprises primarily affect the short end of the OIS yield curve (highest loading at OIS-1M), the FG surprises have stronger effects on the mid- and long-term horizons (highest loading at OIS-2Y), and the QE surprises affect mid- and long-term horizons (peak at OIS-3Y) in addition to movements in nominal exchange rates (highest loading at EURUSD). The QE surprises load into the behavior of EUROSTOXX50 negatively, which helps to further extract the pure information shock (Jarocinski and Karadi, 2020) from the pure Target shock contained by the first factor. In addition, the shortest horizons (OIS-SW, OIS-1M) have close to zero loadings for FG and QE factor, giving the Target factor the interpretation of a pure immediate key policy rate change. The one single composite factor is an amalgam of all three factors as it loads primarily on short and medium-term shocks as well as stock market prices and exchange rates.

Three monetary policy shocks are depicted in the B panel of the Figure 8. Due to data availability the time series start in October 2002. The Target shock is most prominent during the Great

⁸The literature identified four distinct factors for the Euro Area (Motto and Ozen, 2022; Ricco et al., 2024); however, the last factor - the asymmetric country-risk factor from the 10-year bond yields of Germany, France, Italy and Spain (Akkaya et al., 2024) - is purposefully excluded from our set of monetary policy shocks. In reality, it is the effect of the other three shocks on the asymmetric reaction in sovereign bond yields which is the subject of our analysis.

Financial Crisis in 2008 and at the peak of euro area debt crisis in 2012. The QE shock gains on prominence during the 2012-2018 period⁹ All three types of shocks are active during the COVID-induced easing monetary policy phase as well as the post-COVID inflationary period of restrictive monetary policy. The composite shock is the most dominant during the Great Financial Crisis, euro area debt crisis and COVID pandemic.

Figure 9: State-dependent impulse response functions w.r. to a monetary policy shocks (threshold 105%)



Note: Synchronization index calculated by eq. 1. Impulse response function for specification eq. 5. High regime indicates countries (observations) with debt-to-GDP ratio larger than the pre-determined threshold, i.e., $DD_{it-j-13} = 1$. Low regime indicates countries (observations) with debt-to-GDP ratio smaller than the pre-determined threshold, i.e., $DD_{it-j-13} = 0$. Greece is excluded.

The response functions associated with the identified four distinct monetary policy shocks are depicted in Figure 9.¹⁰ There are a number of observations which are worthy of discussion.

The negative effect of monetary policy restrictive shock on bond yields synchronization in high fiscal regimes is confirmed for three out of four distinct MP shocks (Figure 9). The composite factor (Panel A), the pure target shock (Panel B), and the forward guidance shock (Panel C) produce

⁹These shock captures the period of the ECB balance sheet policies which include both, the credit easing as well as pure quantitative easing measures.

¹⁰We exclude other measures of unconventional monetary policy (asset purchases and loans to banks) from the list of control variables. Instead, we add all the identified factors into the list of control variables. For the estimates with one composite indicator, the unconventional monetary policy measures are kept in the list of other covariates.

responses similar in shape and progression across time. Overall, they correspond to our baseline findings reported in Figure 4. In terms of the magnitude, the strongest responses reported for the forward guidance shock account for approximately three fourths of the the median effect in Figure 4. This suggests that while the de-synchronization tendencies may be triggered by pure standard and unconventional monetary policies, the role of unexplained residuals (removed by the PCA procedure) potentially attributed to the information shock may still be of importance.

In contrast, we observe a short-lived positive response peaking at the third month for the quantitative tightening shock (Panel D). This intriguing finding contradicts the hypothesized reaction about the calming effect of the ECB's sovereign bond purchases. The initial distribution of the volume of ECB's quantitative easing was based on the ECB's capital key with the aim of maintaining market neutrality across the bond maturity spectrum (Andrade et al., 2016). The ECB's capital key weights equally the respective country's share in the total population and gross domestic product of the EU, which implies that the quantitative easing policy was not specifically targeting economies experiencing elevated pressure on their sovereign bond yields. Consequently, the increased fragmentation of high-debt regime economies following the announcement of quantitative easing policies may signal a perceived lack of funds required to mitigate rising credit risk for the most affected economies.

3.4 Implications for common monetary policy

Grauwe and Ji (2012) argue that, during the European debt crisis, only Greece experienced a solvency crisis; the other heavily indebted countries were instead hit by self-fulfilling liquidity crises. Callegari et al. (2023) propose a redefinition of the role of the lender of last resort in the context of economic union. If sovereign debt markets are the focus, the key market failure is the inability to roll over sustainable sovereign debts when belief-driven, self-fulfilling crises emerge. Consequently, a central bank may be incentivized to stabilize sovereign debt markets if: i) existing market fragmentation impairs the effective transmission of monetary policy shocks, and ii) there is a clear distinction between liquidity and solvency issues.

Our findings demonstrate that, in the presence of underlying structural heterogeneity, monetary policy can contribute to and magnify the (de-)fragmentation of sovereign bond markets. In our analysis, the non-linearity of the response is linked to a certain debt-to-GDP threshold, which market participants may consider as the demarcation line between low- and high-debt regimes. As the debt-to-GDP ratio is associated with default risk (i.e. solvency criteria), our findings may present a potential conundrum for the conduct of common monetary policy. On the one hand, increasing debt levels raise concerns about fiscal sustainability triggered by the accumulation of idiosyncratic factors, which common monetary policy may deliberately overlook in order to avoid the 'fiscal dominance' trap. On the other hand, the elevated risk of de-stabilisation of the sovereign bond market triggered by common monetary policy actions may prompt a call for a corrective response.

In this context, the ECB introduced a new monetary policy tool in 2022 – the Transmission Protection Instrument (TPI). This measure is part of the ECB's efforts to address specific challenges regarding the effective transmission of monetary policy by purchasing securities from jurisdictions where financing conditions deteriorate without justification based on country-specific fundamentals (Assenmacher, 2023; Arnold, 2023). As such, the monetary policy's role is envisioned in preventing the belief-driven self-fulfilling crisis (Callegari et al., 2023).

In our sample of EA economies, the country-specific critical thresholds derived in-sample from historical distribution do not serve as the strict delimiting line inducing the non-linear response to an ECB's monetary policy shock. The backward-looking investors who pay heightened attention to critical increase in debt levels compared to its historical realization instigate overall neg-

ative response in bond market synchronization, but without the presence of the state-dependent effects. This may indicate that financial market participants may be more inclined to anchor their risk assessment to a set of well-known critical points, such as the Maastricht debt criteria.

Alternatively, during periods of elevated stress, any critical point may be deliberately selected, for example at ratio 105% of GDP, by self-fulfilling market coordination in order to provide a guidance to distinguish between high- and low-debt regimes. Yet, the use of the maximum sustainable debt concept with involuntary default (Collard et al., 2022, 2023) for the critical turning points also triggers the non-linear response in yields of high-debt regime economies, thereby playing part in the (de-)synchronisation process. Non-linearities manifest even when sustainable levels of sovereign debt are determined with the pre-GFC information set. As a consequence, the common monetary policy, while not specifically targeting the bond yields of affected economies, might be compelled to take the state-dependent increasing risk of (de-)fragmentation into account.

Rojas and Thaler (2024) demonstrate in their three-period model of strategic sovereign default that monetary policy, and the TPI tool in particular, may be successful in preventing the panic-induced sovereign and financial sector insolvency if the upper bound on sovereign spreads is not set too close to the fundamentals. Otherwise, a new self-fulfilling panic may arise due to increased incentives to default as bonds are subject to purchases by the ECB. Since we show that the reaction of financial markets to a single monetary policy decisions may be more pronounced in the most vulnerable economies, a sufficiently large maneuvering space could help to absorb the secondary effects stemming from the observed nonlinearities.

The accommodative monetary policy shock may reduce de-synchronisation tendencies in economies with high debt, as reported by Corradin and Schwaab (2023) or van der Zwan et al. (2024). In contrast, the risk of elevated market fragmentation alongside tightened monetary policy may signal the onset of a fiscal dominance trap. In this scenario, the distinction to be drawn in the conduct and communication of common monetary policy is along the lines of the materialised effect of nonlinearities resulting in fragmentation risk. In this context, Mario Draghi's famous Whatever it takes speech may be interpreted as targeting the problem of desynchronisation and redenomination risks rather than focusing on the underlying structural heterogeneity. However, when non-linearities tend to appear alongside structurally unsound debt positions, potentially at the maximum sustainable (Collard et al., 2023) public debt at risk (Furceri et al., 2025) set around 105% of GDP, the distinction becomes rather blurred.

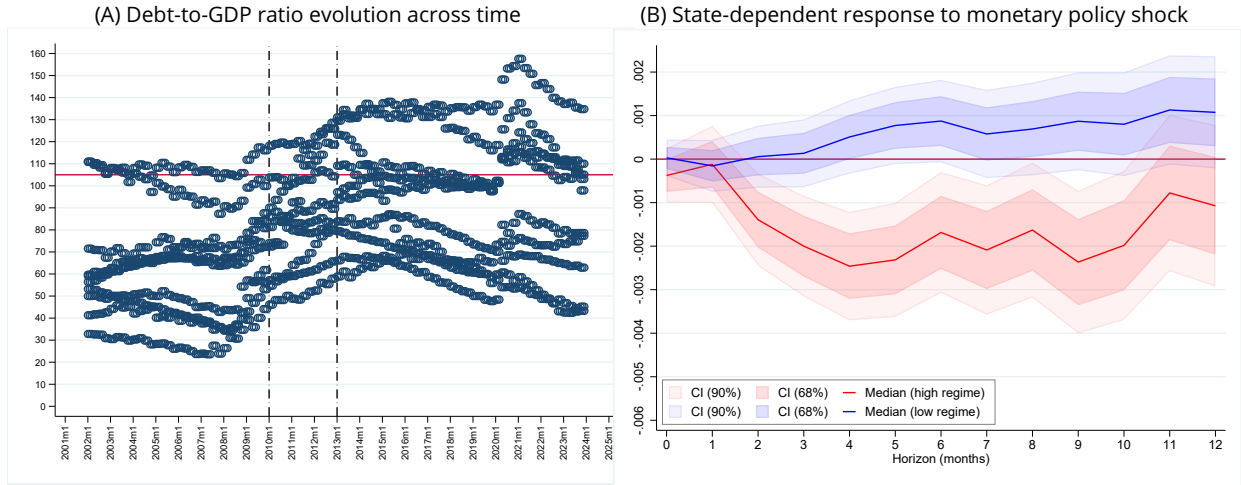
3.5 Sensitivity analysis

We employ a battery of sensitivity checks to ensure the robustness of our findings.

First, few studies identify de-synchronisation tendencies around moments of heightened financial stress (Candelon et al., 2022). As illustrated in Figure 10 (Panel A), few economies breached the critical threshold of 105% GDP for the first time during the unwinding of the European debt crisis in 2011. For this reason, our state-dependent outcomes may indirectly respond to the accumulation of non-fundamentally driven speculative panic rather than to critical thresholds determined by specific debt-to-GDP levels. To test this possibility, we excluded the years 2010-2012, which were identified as the period of euro area debt crisis (Hobelsberger et al., 2022; Canofari et al., 2025), from our sample and re-estimated our findings with robust standard errors. The impulse response functions (Figure 10, Panel B) are indistinguishable, both quantitatively and qualitatively, from the baseline findings — due to the narrower confidence intervals, the difference in response between high- and low-debt regimes becomes more pronounced and statistically significant at 10% significance levels.

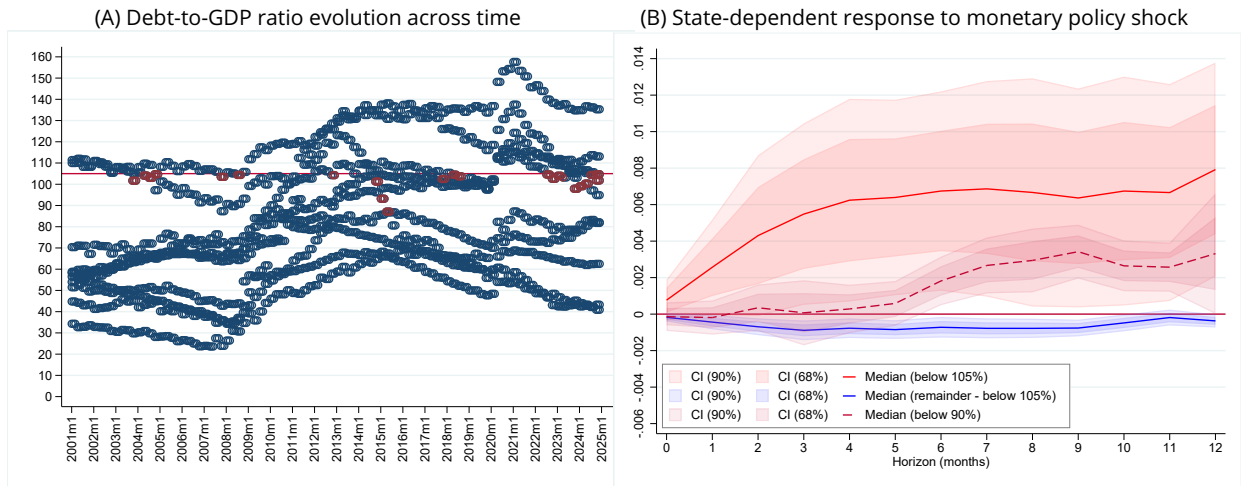
Second, we zoom in to those country-time observations which materialize immediately after

Figure 10: Model with the exclusion of the EA debt crisis period



Note: The red reference line is set at 105% of GDP. Synchronization index calculated by eq. 1. Impulse response function for specification eq. 5. High regime indicates countries (observations) with debt-to-GDP ratio larger than the pre-determined threshold, i.e., $DD_{it-j-13} = 1$. Low regime indicates countries (observations) with debt-to-GDP ratio smaller than the pre-determined threshold, i.e., $DD_{it-j-13} = 0$. Threshold is set at 105% GDP. Greece is excluded. Years 2010-2012 are excluded.

Figure 11: Model with the reverse regime-switching observations



Note: The red reference line is set at 105% of GDP. Synchronization index calculated by eq. 1. Impulse response function for specification eq. 5. Median (below 105%) indicates countries (observations) with debt-to-GDP ratio smaller than threshold 105% if the median of the previous 12 months was higher than 105% GDP, i.e., $DD_{it-j-13} = 1$. Median (remainder - below 105%) indicates all other countries (observations), i.e., $DD_{it-j-13} = 0$. Median (below 90%) indicates countries (observations) with debt-to-GDP ratio smaller than threshold 90% if the median of the previous 12 months was higher than 90% GDP, i.e., $DD_{it-j-13} = 1$. Greece is excluded.

the decline of debt levels below the indicative threshold of 105%. We identify these observations as months during which the debt-to-GDP ratio was smaller than the critical threshold of 105% GDP and the median of debt-to-GDP ratio over the previous 12 months was higher than 105% GDP, at the same time. As can be seen in Figure 11 (Panel A), there are several such instances distributed across time and EA member states, which makes this exercise plausible. The associated impulse response functions are depicted in Figure 11 (Panel B). The tightening monetary policy shock triggers a strong positive response in the dependent variable resulting in an increase in the bond market synchronization index. In contrast to our baseline findings, once a country has managed to reduce its level of indebtedness below a certain threshold, restrictive monetary policy tends to improve the level of synchronization in the affected countries. In addition, lowering the critical threshold from 105% GDP to 90% GDP substantially reduces the magnitude of the estimated responses, along with worsening statistical significance, up to a sixth month. This further corroborates our findings regarding the regime-switching properties at higher critical thresholds.

Third, Brennan et al. (2024) find that heterogeneity in monetary shock series attributed to difference in data or methods may affect the magnitudes of point estimates but only affect the sign in certain specifications. We therefore examine the shorter end of the yield curve by using the 1 month OIS rates instead of the baseline 3 month OIS rates. The results, available upon request, show no distinct difference between bond synchronization response to tightening monetary policy shock in both cases. We also replace the shocks extracted from monetary policy window by those from the press conference (Motto and Ozen, 2022) and press release (Altavilla et al., 2019) in order to test the stability of the IRFs reported in Section 3.3. While the responses generated for the press conference broadly correspond to our baseline findings, the reactions to the shocks extracted for the press release differ substantially in terms of direction, magnitude and significance. Consequently, verbal communication by ECB representatives plays a pivotal role in shaping market perceptions of monetary policy decisions. In this sense, communication may be considered a distinct policy tool in itself, as acknowledged by the ECB (ECB, 2025).

Fourth, we follow the procedure by Buda et al. (2025), who adopt the approach by Schorfheide and Song (2024), and drop observations between March and October 2020 when estimating our local projection responses. The exclusion of certain months from the time dimension limits the calculation of the Driscoll-Kraay standard errors – the While heteroskedasticity-robust standard errors are computed instead. The results, available upon request, are practically indistinguishable from our baseline findings in terms of shape and magnitude. The difference between responses for high and low-regime countries becomes even more pronounced and statistically significant at the 10% confidence level.

Fifth, we substitute the central bank's asset purchases and loans to commercial banks with the M3 monetary aggregate as an alternative measure of quantitative easing policy, similar to Sulikova et al. (2024). We also add Target2 balances as in Kakes and van den End (2023), which have been discussed in light of an important empirical manifestation of common monetary policy within intra-EA bank balances. The response functions, available upon request, are practically undistinguishable from the baseline findings. As an alternative, we exclude all of these measures altogether – the findings remain robust to for the reduced list of covariates.

Last, we transform our data into quarterly frequency used by, e.g., Afonso et al. (2025). For the baseline specifications, the difference in impulse response functions between high- and low-debt regimes is statistically significant at the third quarter with the high-debt regimes reporting the negative response peaking at the -0.002 change - similar to Figure 4 (Panel B). Once the critical debt threshold is set at around 110% GDP, the shape of the response remains consistent with our baseline findings.

4 Conclusions

We study conditionally of sovereign bond yield synchronization in EA countries under the assumption that transmission of monetary policy shocks is state-dependent on sovereign debt levels. We differentiate among two fiscal stances – the high-debt and low-debt regimes – which are delimited by a historically observed turning points in the debt-to-GDP ratios. We use a panel of monthly data, spanning the period 2001–2014, for the 11 Euro-Area countries and estimate three local projection models: (1) a linear model, (2) a threshold model conditional on empirically observed fiscal regimes, and (3) a threshold model conditional on cross-country maximum sustainable debt levels.

Our findings can be summarized as follows. The unconditional effect of restrictive monetary policy shocks has a negative impact on the level of cross-country bond market synchronization. In addition, when we use government debt as a measure of fiscal regime (with the empirically observed cut-off point of 105% ratio to GDP serving as a threshold), we report presence of non-linearity in response. For the low-debt regimes we find no evidence of change in their level of synchronization while the high-debt regimes are negatively affected by the restrictive monetary policy shock. Moreover, we document the presence of existing non-linearities also for the estimates of theoretically-derived individual maximum sustainable debt levels by (Collard et al., 2022) when used as critical turning points.

From a policy perspective, while the common monetary policy does not specifically target the bond yields of affected economies, it may be compelled to take the increasing risk of fragmentation into account. In this scenario, the distinction to be drawn in the conduct and communication of the common monetary policy lies in the materialized effect of nonlinearities resulting in fragmentation risk. However, when nonlinearities tend to appear alongside structurally unsustainable debt positions, it becomes more difficult to delineate this distinction.

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Appendix

Table A.1: Description of variables

Variable	Measure	Economic justification	Source
Government Debt	% GDP, first difference, interpolated to monthly frequency by cubic spline	To control for the fiscal position of the country	Eurostat
Current Account Balance	% GDP, first difference	To control for the external position of the country	Eurostat
HICP Index	MoM % growth rate	To account for nominal price development	Eurostat
Industrial Production Index	MoM % growth rate	To account for the overall business cycle dynamics	Eurostat
World Economic Uncertainty Index (WUI)	MoM % growth rate	To account for the global economic uncertainty	WUI website
Euro Stoxx 50 Volatility EUR Price Index	MoM % growth rate	To account for the global financial uncertainty	FRED
General Government Debt Securities held by CB	MoM % growth rate	To account for the ECB's quantitative easing policy	ECB Data Portal
Loans to Monetary Financial Institutions extended by CB	MoM % growth rate	To account for the ECB's credit easing policy	ECB Data Portal
M3 aggregate	volumes, domestic currency, MoM % growth rate	To account for the ECB's quantitative easing policy (Sulikova et al., 2024)	Eulerpool
Target2 balances	volumes, domestic currency, MoM % growth rate	To account for the ECB's unconventional monetary policy (Kakes and van den End, 2023)	ECB
Standard MP shock	3 months OIS, monetary policy window	Mermelas and Tagkalakis (2024); Canofari et al. (2025)	Altavilla et al. (2019)

Table A.2: Country-specific turning points based on government debt-to-GDP ratio

Country	90th prct	Individual critical thresholds		Pre-crisis D	Pre-crisis S
		MSD D k=0.3	MSD S k=0.3		
Austria	85.2	131.94	85.66	189.1	143.4
Belgium	109.8	163.21	95.33	183.9	141.0
Finland	74.8	76.46	62.26	200.9	155.5
France	112.8	145.77	89.74	180.5	137.8
Germany	78.7	96.78	71.61	108.1	94.8
Greece	187.9	49.49	45.12	196.7	155.2
Ireland	109.4	54.37	50.33	554.6	200.7
Italy	138.1	88.04	66.64	133.9	110.2
Netherlands	66.0	113.64	79.00	121.5	105.8
Portugal	132.6	89.81	68.07	111.9	97.8
Spain	109.0	93.35	70.8	692.8	200.8
Average	109.5	100.26	71.4	243.1	140.3
Average (w/o Greece)	105.34	104.5	74.0	247.7	138.8

Notes: Individual critical thresholds are calculated as the 90th percentile of country-specific yields. The MSD denotes maximum sustainable debt with deterministic ('D') or stochastic ('S') risk-free rate and 30% ('k=0.3') recovery rates reported by Collard et al. (2023). The pre-crisis denotes maximum sustainable debt with deterministic ('D') or stochastic ('S') risk-free rate evaluated at the pre-GFC sample (1999-2007) calculated by Collard et al. (2022).

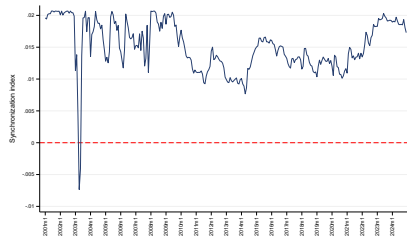


Figure A.1: Synch. index - AT

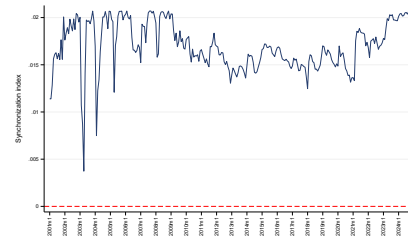


Figure A.2: Synch. index - BE

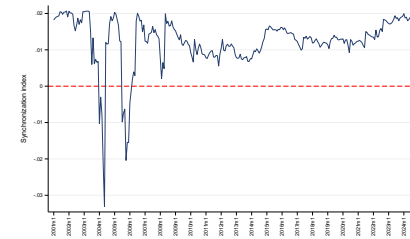


Figure A.3: Synch. index - FI

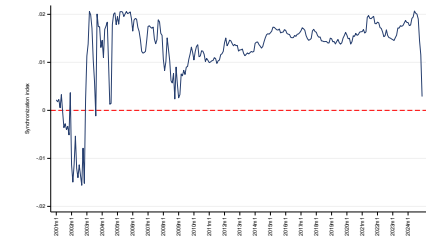


Figure A.4: Synch. index - FR

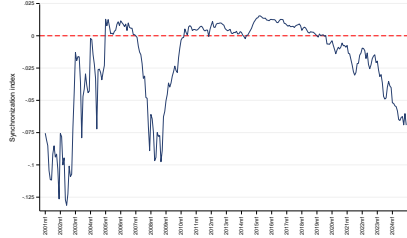


Figure A.5: Synch. index - DE

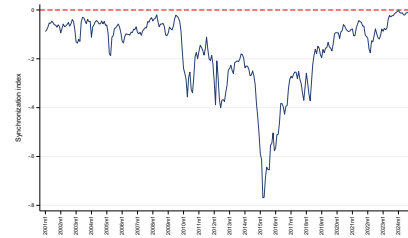


Figure A.6: Synch. index - EL

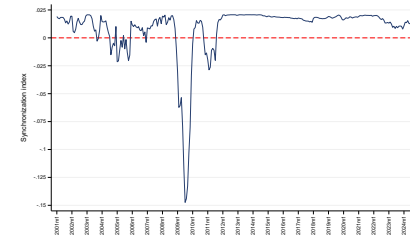


Figure A.7: Synch. index - IE

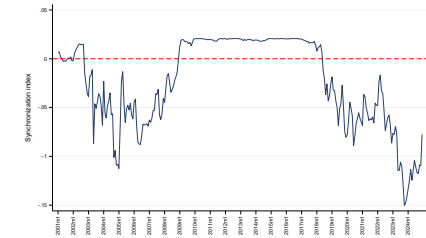


Figure A.8: Synch. index - IT

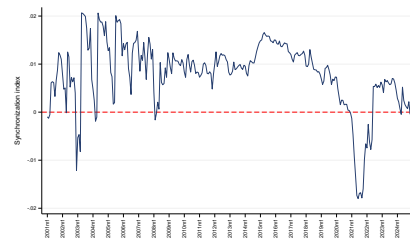


Figure A.9: Synch. index - NL

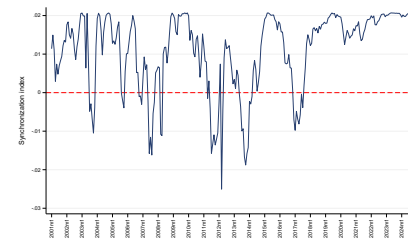


Figure A.10: Synch. index - PT

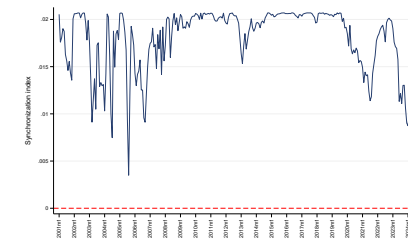


Figure A.11: Synch. index - ES

Note: Synchronization index calculated by eq. 1.

Source: Own compilation based on data from the Eurostat.