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Does pandemic risk affect yield spreads in the EMU?

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ABSTRACT

Since 2020, the world is facing a huge pandemic crisis caused by an acute respiratory coronavirus syndrome. Beyond the impact on the population’s health or on normal social interaction, the virus led to a huge economic slowdown, requiring the prompt EMU’s authority’s reaction. The current paper explores how the sovereign yield spreads of EMU countries with respect to German bonds were affected during the pandemic period. To this end, I employ dynamic panel methods, the Pooled Mean Group estimator of Pesaran et al. (1999) and the Dynamic Common Correlated Effects estimator of Chudik and Pesaran (2015), which accounts for heterogeneous effects across countries and the non-stationarity of spreads and of their determinants. The model uncertainty is studied with a Bayesian VAR (BVAR) approach. The results reveal that, in addition to fundamentals (economic growth, large public debt, inflation, financial instability, country’s competitiveness and domestic investment), pandemic risk puts also substantial upward pressure on sovereign bond yields both, in the long-run and short-run on the selected period. Pandemic risk seems to raise yield spreads in the 14 EMU countries in the short-run, while disease mitigation measures reduce them in the long-run. Same negative effect of disease mitigation measures on yield spreads are also found with BVAR model. Results are relatively robust across different empirical methods and considered scenarios.

1. Introduction

Beginning spreading in the Chinese province of Wuhan, in December 2019, the coronavirus has proliferated fast around the entire world. Compared to previous pandemic episodes (Fig. 1), this health crisis has surprised by its unpredictability and aggressivity because it led to more than 3 million deaths, 160 million confirmed covid cases in more than 188 countries (World Health Organization -WHO, 2020).

Reached almost one month later, Europe has been and likely remain one of the most Covid-infected regions in the world (after Americas), with a death toll exceeding 800,000 (WHO, 2020). France, Spain, Italy, Germany and Poland have been among the most affected countries when looking to the total number of cumulative deaths and cases in 2020 (Figs. 2 and 3 of Appendix).

Beyond the impact on the population’s health or on normal social interaction, the COVID19 outbreak has led to an unprecedented economic slowdown, more important than that of 2008 financial crisis (OECD, 2020), mainly resulting from various government strategies combining social distancing, testing/quarantining, and lockdowns. Huge falls in GDP growth of Euro area countries (EMU) such that of Spain (−10.8%), Italy (−8.9%), Greece (−8.2%), France (−8.1%) and Portugal (−7.6%) involved large increases in budget deficit and public debt putting sizeable upward pressures on financial markets in Europe (Figs. 4, 5 and 6 of Appendix). All these patterns added to an already difficult context of euro area in which debt levels were already at high levels when pandemic hit. Today, the public debt is reaching more than 100% of GDP in several EMU such as Greece (205.6%), Italy (155.8%), Portugal (133.6%), Spain (120%),

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Cyprus (118%), France (116%) and Belgium (114%) which may suggest a real danger of failing into a debt trap for some of them (Table 1 of Appendix).

This unexpected health crisis led not only to unprecedented health and economic challenges, but also to financial threats. Emerging market economies experienced the sharpest reversal of portfolio flows which has really tightened financial conditions. The euro area has been also hit by financial stress. In the EMU countries, the prices of risk assets have decreased sharply, and market volatility has spiked in March 2020 while expectations of defaults have involved a rise in borrowing costs (Delatte and Guillaume, 2020; Ortmans and Tripier, 2020). The government bond spread to Germany rose sharply from 1.6% to 2.5% for Greece and from 1.4% to 2.5% for Italy, the latter country being the most affected by the pandemic crisis (Fig. 7). To reduce the risks of recurrence of a new global financial crisis due to an inadequacy of the capital, liquidity, and transparency of banks and other big financial firms, macroprudential policies have been embraced in Europe and around the world. During March 2021, the European Central Bank (ECB) announced a set of monetary policy measures to support the economy and ensure the euro area financial stability, during the pandemic outspread. After a crash on March 12 in the stock and bond markets, the ECB conducted an exceptional long-term refinancing operation (LTRO) for providing enough liquidity to markets and for preventing substantial disruptions in credit. The macroprudential policies were followed by a launch of a massive intervention program named the Pandemic Emergency Purchase Program (PEPP) to reduce the financial system's sensitivity to shocks. Thus, by limiting the buildup of financial vulnerabilities inside eurozone, the sovereign bond spreads have turnaround at the beginning at the second quarter 2020 as shown in Fig. 7.

The remarkable policy support and progress on vaccination helped the global economy out from the worst phases of the pandemic, although with expectations diverging across countries (Fig. 8 of Appendix). However, financial vulnerabilities still exist, especially for emerging EU markets (with large external financing needs). These countries may already face financial challenges (repricing of risk and/or tighter financial conditions) if US interest rates raise. But, has there been an incidence of the COVID outbreak on the EMU yield spreads? If yes, how pandemic crisis affected the dynamics of the yield spreads?

To answer these questions, the current paper assesses not only how government bond yields spread in the euro area were affected by their traditional determinants, but also if the current COVID outbreak could be an additional factor in explaining the yield spreads dynamics. A panel of fourteen-euro area countries (Austria, Belgium, Finland, France, Greece, Ireland, Italy, Latvia, Lithuania, Netherlands, Portugal, Slovakia, Slovenia and Spain) over the quarterly period 2011: Q1-2020: Q4 is used to explore the role of an extended set of potential spreads drivers, namely macroeconomic and expected fiscal fundamentals, international risk, liquidity conditions, and pandemic risk.

There is a wide economic literature on the determinants of yields on government bonds and of their spreads against a benchmark country. A key issue investigated by this literature is how markets assess the sovereign default risk. This question was first addressed in the context of emerging countries, which experienced episodes of country default (e.g. Edwards, 1984; Mody, 2009) and afterward, the analysis was extended to European sovereign bonds (Haugh et al. (2009); Cordogno et al., 2003; Bernoth et al., 2012; Manganelli and Wolswijk, 2009; Schuknecht et al., 2009; Haugh et al. (2009), Von Hagen et al., 2011; Barbosa and Costa, 2010; Oliveira et al., 2011; Maltritz, 2012, Aristei and Martelli, 2014, Delatte et Guillaume, 2020) to better quantify and understand the effects of European monetary union (EMU), in particular, in the context of the 2008–2009 global financial crisis. Although there is not a common pattern on the drivers of yields and spreads, the empirical evidence produced by these studies suggests some regularity and uniformity in results. Three main common drivers of bond yields and yield spreads were already identified during the global financial crisis: credit risk factors, market liquidity, and global risk aversion.

In addition to traditional, fundamental determinants of spread yields (GDP growth, inflation, government debt, liquidity), the
The current paper considers the role of Covid19 pandemic risk. To quantify both the epidemic risk and the recent measures to fight the Covid19 pandemic, the paper uses various indicators. The pandemic risk is measured by the recently formulated index conceptualized by Baker et al. (2020) and proposed by Ahir et al. (2018a, 2018b, 2020). It also includes information on several common policy responses that governments have taken to respond to the pandemic such as the stringency index, the containment health index, the government response index and the government support index with data coming from the Oxford Covid-19 Government Response Tracker. To capture the influence of epidemic risk on the yield spreads dynamics, the paper applies a set of dynamic panel estimators. First, the pooled mean group (PMG) estimator developed by Pesaran et al. (1999), which accounts for possible non-stationarity in the data and combines the advantage of heterogeneous effects across countries with that of stable and economically plausible estimates. The model was built to avoid endogeneity, omitted variable issues, and the use of time-invariant country characteristics (fixed effects). The main advantage of this approach is that it discriminates between long-run and short-run effects of different drivers on sovereign yield spreads. To my best knowledge, only few papers studied the spread determinants by using the PMG estimator (Ferrucci, 2003; Bellas et al., 2010 or Aristei and Martelli, 2014). Second, for robustness checks, the paper introduces a recent estimator, the Dynamic Common Correlated Effects estimator (DCCEMG) by Chudik and Pesaran (2015) that was not yet applied to the topic of sovereign bond spreads dynamics. The model is an extension of the Common Correlated Effects estimator (CCE) by Pesaran (2006) as it includes a lagged dependent variable and/or weakly exogenous variables as regressor in the panel.

In line with the literature, the paper assumes that bonds issued by Germany (the European country with the most stable economy over the last half of the century) are risk-free and compute spreads as the gap between the yields on ten-year government bonds of EMU countries and the remuneration of similar-maturity German bonds. The paper uses quarterly data for the post-crisis period: 2011Q1 to 2020 Q4. The large number of time periods (40 quarters) and countries (14) justifies the use of the PMG estimator of Pesaran et al. (1999) and DCCEMG estimator of Chudik and Pesaran (2015).

The results show that public debts, global financial instability, trade competitiveness, GDP growth, investments, as well as pandemic risk, put considerable pressures on sovereign bond yields in many Euro area countries, in the long-run and short-run. In the short-run, epidemic risk seems to have raised spreads in the EMU-14 countries while disease mitigation measures seem to close them.

The rest of the paper is structured as follows. The next section describes the empirical specification and reviews the data. Section 3 presents and interprets estimation results. The last section summarizes the main findings.

Note: Author’s computation by using gov. bond yield – 10 year maturity; ECB database.
2. Empiricomic specification and data

2.1. Econometric specification

The model explains the yield spreads by a function of variables related to the three risk dimensions drawn from the previous empirical literature (Maltriz, 2012; Cheptea and Matei, 2018), to which it adds the pandemic risk:

\[ \text{spreads}_it = f(\text{credit}_it, \text{liquidity}_it, \text{global}_it, \text{pandemic}_it) \]  

(2)

Variables \( \text{credit}_it \), \( \text{liquidity}_it \), \( \text{global}_it \), and \( \text{pandemic}_it \) accounts for the credit, liquidity, global, and, respectively, pandemic risk.

To disentangle between long-run and short-run effects on sovereign yield spreads, the paper uses the Pooled Mean Group (PMG) model developed by Pesaran et al. (1999). The long-run relationship between spreads on government bond yields (\( \text{spreads}_it \)) and their determinants can be written as follows:

\[ \text{spreads}_it = \theta_i + \alpha_i \text{credit}_it + \beta_i \text{liquidity}_it + \gamma_i \text{global}_it + \delta_i \text{pandemic}_it + \epsilon_{it} \]  

(3)

\( \theta_i \) are country-specific intercepts and \( \epsilon_{it} \) is a zero-mean error term. Each type of risk can be measured by more than one variable. Therefore, equation (3) includes a vector of variables for each type of risk (credit, liquidity, and global risks): \( \text{credit}_it \), \( \text{liquidity}_it \), \( \text{global}_it \), \( \alpha_i \), \( \beta_i \), and \( \gamma_i \) are the transposed vectors of associated coefficients, which are allowed vary across countries. Vector \( \text{pandemic}_it \) integrates variables such as the aggregate World Pandemic Uncertainty Index (WPUI) and other covid measures provided by the Oxford COVID-19 Government Response Tracker (OxCGRT) which systematically collects information on several different common policy responses that governments have taken to respond to the pandemic such as school closures and travel restrictions. These variables affect spreads differently for each country in the panel, leading to country-specific estimates for each element of the coefficients vector \( \delta_i \).

In line with the literature, we use GDP growth, inflation rate, government debt, and public deficit as factors shaping country-specific credit risks. Market liquidity is measured by the country’s central government debt (% GDP) related to the entire public debt of all euro area countries. This measure relates the countries market size to the EMU market size in terms of public debt. To capture global market conditions and risks common to all EMU countries, the Cboe's stock market volatility index (VIX) is added (Aristei and Martelli, 2014; Yildirim, 2016). The VIX is viewed as a “fear index” for asset markets (Whaley, 2000) because it reflects both stock market uncertainty and a variance risk premium. However, Bloom (2009) emphasizes that VIX depends on other measures of economic activity (often quite exogenous even to U.S. economy) and considers that this variable should be exogenous in the estimates. To reconcile these different views, the paper considers both hypothesis by estimating a PMG model where the VIX is inside the vector of explanatory variables (Xi), and a second one, where VIX is viewed as an exogenous variable. The paper also uses some additional country-specific controls - the trade balance to capture the country’s competitiveness, and the capital formation to GDP to assess whether the use of funds for domestic investment impacts default risk.

The autoregressive distributed lags (ARDL\((p,q))\) specification can be written as follows:

\[ \text{spreads}_it = \theta_i + \sum_{j=1}^{p} \lambda_{ij} \text{spreads}_{i,t-j} + \sum_{j=0}^{q} \alpha_{ij} \text{credit}_{i,t-j} + \sum_{j=0}^{q} \beta_{ij} \text{liquidity}_{i,t-j} + \sum_{j=0}^{q} \gamma_{ij} \text{global}_{i,t-j} + \sum_{j=0}^{q} \delta_{ij} \text{pandemic}_{i,t-j} + e_{it} \]  

(4)

where \( p \) is the number of lags of the dependent variable and \( q \) is the number of lags of the independent variables.

The corresponding error correction equilibrium model becomes:

\[ \Delta \text{spreads}_it = \phi_i \Delta \text{spreads}_{i,t-1} - \alpha_i \text{credit}_{i,t-1} - \beta_i \text{liquidity}_{i,t-1} - \gamma_i \text{global}_{i,t-1} - \delta_i \text{pandemic}_{i,t-1} + \sum_{j=1}^{q-1} \lambda_{ij} \Delta \text{spreads}_{i,t-j} + \sum_{j=0}^{q-1} \alpha_{ij} \text{credit}_{i,t-j} + \sum_{j=0}^{q-1} \beta_{ij} \text{liquidity}_{i,t-j} + \sum_{j=0}^{q-1} \gamma_{ij} \text{global}_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij} \text{pandemic}_{i,t-j} + \theta_i + e_{it} \]  

(5)

where \( \Delta x \) is the change in variable \( x \): \( \Delta x_{it} = x_{it} - x_{it-1} \); \( \Delta x_{it-q+1} = x_{it-q+1} - x_{it-q} \).

Terms between the brackets capture the long-term relationship. Parameter \( \phi_i \) represents the country-specific speed of adjustment to the long-run equilibrium. A statistically significant \( \phi_i \) indicates the existence of a long-run equilibrium for country \( i \), and a negative estimated value of \( \phi_i \) indicates that the system converges to its steady state after a shock. Bar superscripts define the response of spreads to changes in credit, liquidity, global, and pandemic risks on the long run, while tilde superscripts reflect the generated short-term changes in spreads. The PMG approach consists in estimating equation (5) under the assumption of identical long-term coefficients for all countries. Based on the Akaike criterion, the PMG models estimated in the next section includes 2 to 1 lags for each variable; \( p = 2 \) and \( q = 1 \).

Before studying the estimated long- and short-run coefficients, the paper tackles the validity of the PMG against its candidates - the heterogeneous Mean Group (MG) model and the dynamic fixed-effects specification (DFE) - with the Hausman test. Results of Hausman test are reported in Tables 7–9. When comparing the MG and the PMG estimates, the validity of the homogeneity of long-run effects...
cannot be rejected in each of the alternative models. The PMG estimator looks to be better as it is more efficient. Conversely, the DFE is strongly rejected in favor of the PMG for all the models, reflecting the cross-country heterogeneity in short-run dynamics and an adjustment to the long-run equilibrium for consistent estimates of the sovereign spread's drivers.

For robustness checks, the Dynamic Common Correlated Effects Estimator (DCCE) by Chudžik and Pesaran (2015) is used to assess the yield spread dynamics. By focusing on stationary heterogeneous panels with weakly exogenous regressors when the cross-sectional dimension and the time series dimension are sufficiently large, the model constitutes an extension of the Common Correlated Effects Estimator (CEE) by Pesaran (2006). The later was developed to nonstationary variables in Kapetanios et al. (2011) and Pesaran and Tosetti (2011). The model accounts for the unobserved common factors in the estimation by adding as covariates to the regression a linear combination of cross-sectional panel averages of both the dependent and the independent variables. These additional regressors cannot be explained in a meaningful way, but help to consistently estimate the model parameters in the presence of unobserved common factors and control for serially and spatially correlated error terms. When studying the impact of sovereign spread's drivers, the DCCE Estimator assesses internally the following equation:

\[
\Delta \text{spread}_i = \phi_i \text{spread}_{i,-1} + \gamma_i X_{it} + \delta_{i1} \Delta X_{it} + \sum_{j=0}^{PT} \delta_{ij} z_{it-j} + \epsilon_{it}
\]

where:

\[
z_t = (\text{spread}_{i,-1}, \text{spread}_{i,-2}, X_t, z_{it}) = (\text{credit}_{it}, \text{liquidity}_{it}, \text{global}_{it}, \text{pandemic}_{it})
\]

and

\[
X_{it} = (\text{credit}_{it}, \text{liquidity}_{it}, \text{global}_{it}, \text{pandemic}_{it})
\]

is the vector of explanatory variables.

The Mean Group (MG) Estimates are: \( \hat{\Pi}_{MG} = \frac{1}{N} \sum_{t=1}^{N} \hat{z}_t \) with \( \hat{z}_t = (\hat{\lambda}_i, \hat{\beta}_t) \).

The Pooled Mean Group (PMG) estimates (with common factors) are based on the next equation:

\[
\Delta \text{spread}_i = \phi_i \text{spread}_{i,-1} - \theta_{i1}X_{it} + \theta_{i1} \Delta X_{it} + \sum_{j=0}^{PT} \delta_{ij} z_{it-j} + \epsilon_{it}
\]

where \( \theta_{i1} = -\frac{\lambda_i}{C0} \) and \( \phi_i \) is the speed of adjustment coefficient. The variances are computed using Delta method. It is worth noting that under the null hypothesis, the errors terms are weakly cross-sectional dependent as follows:

\[
H_0 : E (u_{it}, u_{ij}) = 0, \ \forall i \text{ and } i \neq j
\]

Also, the cross-section dependence statistics (CD) can be written as follows:

\[
CD = \sqrt{\frac{2T}{N(N-1)}} \left( \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \right) \text{ and } \hat{\rho}_{ij} = \frac{\sum_{t=1}^{T} \hat{u}_{it} \hat{u}_{jt}}{(\sum_{t=1}^{T} \hat{u}_{it}^2)(\sum_{t=1}^{T} \hat{u}_{jt}^2)}
\]

3. Variables and data

The data sample covers 14 Eurozone countries in addition to Germany, which is used as reference, during the period Q1:2011 to Q1:2020. Monthly data on government bond yields are provided by the European Central Bank (ECB) to compute quarterly averages. The spreads on government bonds are thus computed as the difference between the quarterly yields on 10-year bonds issued by each country. Monthly data on government bond yields are provided by the European Central Bank (ECB) to compute quarterly averages. The later was developed to nonstationary variables in Kapetanios et al. (2011) and Pesaran and Tosetti (2011). The model accounts for the unobserved common factors in the estimation by adding as covariates to the regression a linear combination of cross-sectional panel averages of both the dependent and the independent variables. These additional regressors cannot be explained in a meaningful way, but help to consistently estimate the model parameters in the presence of unobserved common factors and control for serially and spatially correlated error terms. When studying the impact of sovereign spread's drivers, the DCCE Estimator assesses internally the following equation:

\[
\Delta \text{spread}_i = \phi_i \text{spread}_{i,-1} + \gamma_i X_{it} + \delta_{i1} \Delta X_{it} + \sum_{j=0}^{PT} \delta_{ij} z_{it-j} + \epsilon_{it}
\]

where:

\[
z_t = (\text{spread}_{i,-1}, \text{spread}_{i,-2}, X_t, z_{it}) = (\text{credit}_{it}, \text{liquidity}_{it}, \text{global}_{it}, \text{pandemic}_{it})
\]

and

\[
X_{it} = (\text{credit}_{it}, \text{liquidity}_{it}, \text{global}_{it}, \text{pandemic}_{it})
\]

is the vector of explanatory variables.

The Mean Group (MG) Estimates are: \( \hat{\Pi}_{MG} = \frac{1}{N} \sum_{t=1}^{N} \hat{z}_t \) with \( \hat{z}_t = (\hat{\lambda}_i, \hat{\beta}_t) \).

The Pooled Mean Group (PMG) estimates (with common factors) are based on the next equation:

\[
\Delta \text{spread}_i = \phi_i \text{spread}_{i,-1} - \theta_{i1}X_{it} + \theta_{i1} \Delta X_{it} + \sum_{j=0}^{PT} \delta_{ij} z_{it-j} + \epsilon_{it}
\]

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\[
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\]

Also, the cross-section dependence statistics (CD) can be written as follows:

\[
CD = \sqrt{\frac{2T}{N(N-1)}} \left( \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \right) \text{ and } \hat{\rho}_{ij} = \frac{\sum_{t=1}^{T} \hat{u}_{it} \hat{u}_{jt}}{(\sum_{t=1}^{T} \hat{u}_{it}^2)(\sum_{t=1}^{T} \hat{u}_{jt}^2)}
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3. Variables and data

The data sample covers 14 Eurozone countries in addition to Germany, which is used as reference, during the period Q1:2011 to Q1:2020. Monthly data on government bond yields are provided by the European Central Bank (ECB) to compute quarterly averages. The spreads on government bonds are thus computed as the difference between the quarterly yields on 10-year bonds issued by each country in the panel and yields on German bonds.

Quarterly data on GDP growth, inflation, government debt, and budget balance (deficit or surplus) comes from the Eurostat. I use the harmonized consumer price index (CPI) to measure inflation. Central government debt and budget balance are expressed in percentage of quarterly GDP. Similarly to Bernoth et al. (2012) and Maltritz (2012), the paper includes the central government debt as percentage of the entire EMU public debt (to link the country market size to that of EMU) as a complementary measure of market liquidity.

Trade balance is obtained from the Eurostat database. In line with traditional macroeconomic models, the trade balance reflects the country's competitiveness against foreign competitors. A surplus of trade balance may decrease default risk and thus, the yield spreads. As country exports more than imports goods and services, it increases the country's income and favours the economic growth. This makes easiest to collect funds to pay debt servicing.

I also employ the stock market volatility index of the Cboes Volatility Index (VIX) to measure the global financial risk. More precisely, the VIX measures the expected market-wide stock return volatility over the next 30 days as conveyed by a range of S&P500 stock index option prices (see more to http://www.cboe.com/products/vix-index-volatility/vix-options-and-futures/vix-index/vix-faq). This variable is a common proxy for the international financial instability in the recently emerged macroeconomic works (e.g., Campbell and Taksler (2003); Campello et al. (2008); Tang and Yan (2010)) also studying the causes and consequences of the 2008–2009 crisis. The

\[\text{Estonia, Luxembourg, Malta and Cyprus are not included in the panel because of the data unavailability regarding the WPUI index during the analyzed period. Also, the period excludes the 2008 global financial crisis and the EMU sovereign debt crisis to have more stable and economically plausible estimates on the pandemic impact on sovereign yield spreads.}\]
index is also viewed as a “fear index” for asset markets (Whaley, 2000) because it reflects both stock market uncertainty (the “physical” expected volatility), and a variance risk premium, which is also the expected premium from selling stock market variance in a swap contract. However, Bloom (2009) argues that VIX depends on other measures of economic activity (frequently quite exogenous, even to U.S. economy) suggesting that it should be rather included as an exogenous variable or as a fixed regressor in the model. To reconcile these two approaches, the paper estimates a PMG model where VIX is inside the vector of explanatory variables (\(X_t\)), and a second one, where VIX is taken as an exogenous variable.

The paper also uses some additional country-specific controls - the fixed brut capital formation to GDP to assess whether the use of funds for domestic investment impact default risk. Higher capital formation is expected to decrease the default risk because it involves higher productivity, higher economic growth and thus, a higher ability to respect the country's financial obligations.

To capture the pandemic risk, the paper uses the aggregate World Pandemic Uncertainty Index (WPUI) and other covid measures provided by the Oxford COVID-19 Government Response Tracker (OxCGRT). The later systematically collects information on several common policy responses that governments have taken to respond to the pandemic such as: the stringency index, the containment health index, the government response and the government support. These indices are between 1 and 100 and reflect the level of government action on the topics in question as follows:

- the government response index shows how the response of governments has varied on the period, becoming stronger or weaker over the course of the outbreak.
- the containment and health index combines ‘lockdown’ restrictions and closures with measures like testing policy and contact tracing, short term investment in healthcare, as well investments in vaccine;
- the economic support index records measures such as income support and debt relief
- the stringency index reflects the strictness of ‘lockdown style’ policies that primarily restrict people’s behavior.

It is worth noting that a higher position in an index does not necessarily mean that a country’s response is ‘better’ than others. The next pandemic measure, the WPUI index, is constructed by counting the number of times uncertainty is mentioned within a proximity to a word related to pandemics in the Economist Intelligence Unit (EIU) country reports. Accordingly, the index is the percent of the word “uncertain”, and its alternatives, that appear near the pandemic terms in EIU country reports, multiplied by 1000. A higher number means higher uncertainty related to pandemics and vice versa which increases the sovereign yield spreads. The WPUI index is also provided for each country of the panel and is computed in the same way. From Fig. 7 of Appendix, it can be observed that the uncertainty related to pandemics have decreased at the end of 2020 compared to its beginning. This positive trend may be explained by the government's policies of tracing the virus and progresses on vaccination of the population.

Since the multicollinearity negatively affects the precision of the estimator's coefficients and the statistical power of the empirical models, I compute the matrix correlation between the explanatory variables to avoid it and have smooth estimations. Table 2 of Appendix displays the matrix correlation and indicates that only covid variables are correlated with each other. Therefore, these variables will enter separately in the estimated models. Table 3 of Appendix displays main statistics of the explanatory variables used in the empirical specifications.

4. Results and discussions

4.1. Cross-sectional dependence, stationarity, and cointegration

Before turning to PMG estimations, I search for cross-section dependence between countries. Strong inter-dependencies between countries may arise because of the presence of common shocks (e.g., global financial crisis, pandemic crisis) that may impact differently EMU countries. To this end, I applied the Pesaran (2004) test which has best sample size properties when the number of periods exceeds the number of countries. The test results strongly reject the null hypothesis of no cross-sectional dependence for all variables (Table 4 of Appendix). After that, the paper checks for the stationarity and cointegration of variables, under cross-sectional dependence, using some panel unit root and cointegration tests. The Pesaran (2007) panel unit root test shows in Table 5 (appendix) that variables are stationary in level and first differences (except for the VIX index). For testing cointegration, the Westerlund (2007) cointegration test was performed (Table 6 of Appendix). The later test shows evidence of cointegration between the yield spreads and the main explanatory variables (\(G_t\) being statistically significant at 1%, and 5% levels, respectively). Since the panel combines both stationary and non-stationary data, an error correction framework can be confidently applied to evaluate the yield spreads dynamics.

4.2. Estimation results

The PMG models are estimated for the period 2011Q1-2020Q4 for 14 EMU countries and are displayed in Table 7 and Table 8. Two scenarios are proposed in estimations: the first one includes the VIX index in the vector of explanatory variables, while the second one takes it as an exogenous according to the Bloom (2009) view. The model selection procedure based on Akaike criterion indicates that an

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4 The WPUI index by country is constructed by counting the number of times a word related to pandemics is mentioned in the Economist Intelligence Unit country reports. Specifically, the index is the percent of the words related to pandemic episodes in EIU country reports, multiplied by 1000. A higher number means higher discussion about pandemics and vice versa.
ARDL (2,1,1,1,1,1,1,1) estimates better the yield spread's dynamics (Fig. 8 of Appendix). At a first view, the dynamic panel estimates yield similar qualitative results regarding the coefficients of explanatory variables in the long- and short-run dynamics.

The first key driver of the bond spread is the GDP growth per capita and reflects the state of the economy. This variable should have a negative impact on yield spreads. Theoretical studies on the sustainability of a country's debt (e.g. Domar, 1950) emphasizes the relationship between economic growth and debt growth and demonstrate that growing economies are more able to achieve their financial obligations than stagnating economies. In all estimations of the first scenario, the coefficient of the GDP growth is negative and significant in the long-run (only for the first two PMG). In the short-run, the coefficients of this variable are also negative, and sometimes, statistically significant at 1% and 5% levels (scenario 2). Overall, these results confirm that the state of the economy is a key indicator for financial markets, highly growing economies being more able to respect their financial obligations.

Inflation sets the pace for the country's economic activity and, therefore, may affect its bond yield spread. Higher price differentials lead to losses in competitiveness, mainly for countries that lack an independent monetary policy, such as the ones using pegged currencies, increasing their default risks. Furthermore, integrating a monetary union generates a stronger decrease in inflation in countries with a history of high inflation rates. Also, higher price differentials affect the real level of accumulated debt: high inflation expectations mean higher interest rates on government debt which makes the public borrowing more expensive. The positive estimates of short- and long-run effects of the inflation rate support this line of reasoning. The estimates are statistically significant both, in the long-run and short-run in PSTR models.

The liquidity indicator measures the access to credit and is proportional to the size of the country. Its effect on yield spreads is positive and statistically significant in the long-run (in both scenarios). This result is in line with findings by Manganelli and Wolswijk (2009) and Haugh et al. (2009). Higher levels of debt imply needs for higher resources to pay the debt service which increases yield spreads in the long-run. In the short-run, this liquidity measure is negative and statistically non-significant, in both scenarios.

At the same time, the estimates show that the stock market volatility index (VIX) raises the default risks faced by EMU countries, in the long-run, in all specifications (scenario 1). In the short-run, its effect is negative and statistically non-significant. In the Bloom (2009) scenario, the fear index increases the default risk, as expected.

A lower budget balance, i.e. a higher deficit, increases yield spreads. The government expenditure affects negatively economic growth and thus, increases the default risk. The estimated coefficients are positive and statistically non-significant for this variable in the long-run (both scenarios). In the short-run, fiscal spending raises the output and decreases the yield spreads which is in line with the Keynesian view.

Gross fixed capital formation is found to have a statistically significant effect in the short-run, in most specifications (first scenario). In the Bloom (2009) scenario, the domestic investments seem to positively affect the yield spreads which is counterfactual result. The higher capital formation (i.e., the use of funds), the lower the yield spreads. Thus, higher capital formation implies a higher productivity, higher economic growth in the future and a higher ability to pay debt services. Its positive effect decreases the default risk.

More competitive countries inspire higher confidence to investors (e.g. Malritz, 2012; Aristei and Martelli, 2014). This assertion is confirmed by the estimates of a negative effect of trade balance on yield spreads. A positive trade balance means that a country's goods and services became less expensive relative to its partners and implies a raise in competitiveness and in economic growth. This also reflects the willingness-to-pay debt service of the country.

Looking now at the pandemic indicators, the WPUI index has a negative and significant long-run effect on spreads (in both scenarios); in the short-run, the WPUI coefficient is positive, in the first scenario and negative, in the Bloom scenario. It is expected that the higher uncertainty related to pandemic, the higher are short-run spreads (which is the case of the first scenario where the VIX index is included in the vector of explanatory variables). In the long-run, the negative sign of WPUI index (it was expected rather a positive one) could be explained by the fact that this global health crisis is perceived to not be persistent and to not have economically devastating impacts in the long-run. This may suggest that markets anticipate smaller uncertainty and efficient social and economic actions from governments to contain the COVID outbreak.

Regarding the other variables of interest, it can be observed a negative and a significant effect of stringency index in the long-run, and a positive effect in the short-run (first scenario). The results suggest that lockdowns are associated with lower spreads in the long-run, highlighting the importance of strictness of ‘lockdown style’ policies that primarily restrict people's behavior. In the short run, the effect is positive and statistically significant which may assess the risk of non-containing the virus initially, which overwhelmed the hospital infrastructure and necessitate an economic lockdown. This could increase the debt burden, and thus, the default risk. In the Bloom scenario, lockdown measures seem to close spreads both, in the long-run and short-run.

Same long-run and short-run effects are perceived for the containment health index which combines ‘lockdown’ restrictions and closures with measures of testing policy and contact tracing, short term investment in healthcare, as well investments in vaccine. In other words, disease mitigation measures seem to close spreads only in the long-run while, in the short-run (first scenario), epidemic risk seems to lead to higher spreads. Again, in the Bloom scenario, the disease measures seem to tight yield spreads.

The government response and the economic support index have the same statistically significant behaviors both in the long- and short-run as previous indices. The fact that governments are providing direct cash to people who lose their jobs or are freezing financial obligations for households (e.g.; stopping loan repayments, preventing services like water from stopping, or banning evictions) or coordinate policies about testing/vaccine for current infection seems to decrease the default risk, in the long-run. In the short-run, there is still a fear to not contain the virus spreads and to put in place continuous lockdowns which may raise the debt levels or encourage flight to credit quality. In the Bloom (2009) scenario, it seems that all disease measures compact yield spreads and decrease the default risk (which is an optimistic scenario).
5. Robustness

I re-estimate the determinants of sovereign spreads along alternative estimation methods as follows:

- In the third scenario, the paper considers that the “anchor country” (i.e., Germany) is “not completely free of default risk”. Indeed, another point where the literature follows different paths is whether the “anchor country” is “completely free of default risk” or not. The difference consists in the fact that the “anchor country risky” scenario links the spreads and explanatory variables to the observation of the “anchor” country (Germany), while in the “anchor country no-risky scenario”, it uses the “original” data observed for the analyzed countries and compute the spread by subtracting the yield of the selected country by the yield of the anchor country. Considering “the anchor risky” scenario, it is rather unlikely because it implies that, in epidemic episodes, investors consider the occurrence of diseases in Germany to be less serious than in other countries which does not correspond to the reality. However, the testing and tracing covid measures, the social and economic responses to the Covid crisis show that Germany has a number of deaths and covid cases lower than Italy, France and Spain (which were the most affected countries by the covid disease). Although the choice of the German Bond as a risky reference is not the best one, because pandemic risk is a common shock (even if its degree of magnitude in terms of risk may vary from one country to another), I will estimate this unlikely scenario (see Table 9 of Appendix). Contrary to previous scenarios, the disease measures seem to close non-significantly the spreads in the long-run (except for economic support measures - as income support and debt relief – which seem to be appreciated by investors because they significantly compact yield spreads). In the short-run, there is still a panic to not contain the virus spreads and to put in place continuous lockdowns, which may develop the economic insecurity and therefore, raise the debt levels. Furthermore, the government response measures to pandemic risk seems to play a key role in closing spreads in the short-run horizon. Thus, applying a range of bold policy responses to limit disruption (even if there are varying degrees across countries) compacts yield spreads and lowers the default risk. Remember that the VIX index is taken here as an exogenous variable as suggested by Bloom (2009).

- In the fourth scenario, the paper proposes to account for the unobserved factors and weakly exogenous variables in the estimation process of heterogeneous panels, by assessing the Dynamic Common Correlated Effects estimator of Chudik and Pesaran (2015). The results are provided in Table 10 of Appendix. The disease measures reduce significantly the spreads in the long-run as coefficients are negative and statistically significant at 1%, 5% and 10% levels. In the short-run, findings are positive but, statistically non-significant (which brings them closer to the results of the first scenario).

- In the fifth scenario, instead to apply an ARDL panel specification, the paper proposes a brief Bayens Vector Autoregressive approach (BVAR) based on two types of priors (widely used in the related literature): the Litterman-Minessotta prior (see Litterman, 1986) and the Giannone, Lenza and Primiceri prior to assess the model uncertainty. The first prior can be thought of as a way of automatically choosing the prior mean $\bar{\pi}_{\text{MN}}$ and the prior variance $V_{\text{MN}}$ in a way in which they are sensible in many empirical contexts. In the Minnesota Prior, the explanatory variables in the VAR in any equation can be divided into the own lags of dependent variable, the lags of the other endogenous variables and exogenous variables. Because the BVAR model integrates growth rates data (like GDP growth, inflation) exhibiting little persistence, estimations simply set $\bar{\pi}_{\text{MN}} = 0$. However, as our sample also includes data in log-level (like deficit, debt and so on.), the Minnesota Prior uses a prior mean expressing a belief that such variables may follow a random walk behavior or a fair degree of persistence. Table 11 of Appendix shows only the results based on a prior mean equal to 0. The findings embodying a certain degree of persistence ($\pi_{\text{MN}} = 0.9$) of some explanatory variables are qualitatively similar to that pointing little persistence in data and are upon request from the author. As the previous specification, the second specification based on Giannone, Lenza and Primiceri prior has hyperparameters with prior variance described by a tightness parameter, a decay parameter and a parameter for lags of other variables. In this second case, parameters are optimally estimated (Table 12 of Appendix). Two scenarios are estimated using these priors. The first one considers the VIX index as an endogenous variable (model 1 noted M1) whilst the second one takes this variable as an exogenous one (model 2 noted M2 in Tables 11 and 12 of Appendix). Overall, these two alternative specifications of BVAR approach (used for robustness checks) do not affect the main paper’s finding about the importance of diseases measures on yield spread dynamics in the euro area countries. Estimates indicate that disease mitigation measures significantly reduce the yield spreads in euro area (as all coefficients are negative and statistically significant) which is in line with findings of previous scenarios.

6. Main conclusions

The global health crisis erupted in early 2020 led to the worst economic crisis since the Great Depression. It had dramatic effects on the economy and society, calling for greater government interventions and coordination around the entire world. The current paper focuses on whether the pandemic risk constitutes an additional driver of the yield spreads dynamics. In the paper, the spreads are computed with respect to German bonds using quarterly data over the 2011—2020 period. By applying recent dynamic panel methods, such as the Pooled Mean Group estimator of Pesaran et al. (1999) and the Dynamic Common Correlated Effects Estimator of Chudik and Pesaran (2015), the paper shows that, in addition to fundamentals (economic growth, large public debt, inflation, financial instability and country’s competitiveness), most part of the pandemic risk indicators clearly influence the market perception of default risk as well as the country’s borrowing costs, both in the long -and short-run. More precisely, pandemic risk seems to raise yield spreads in the 14 EMU countries, in the short-run, while government's disease mitigation measures reduce them, in the long-run. Results are relatively robust across different empirical methods and scenarios. Accordingly, the Bayesian approach (used to assess the model uncertainty) shows once again that disease mitigation measures significantly reduce the yield spreads in euro area countries.
These results are in line with those of Tripier and Ortmans (2020), and Delatte et Guillaume (2020) showing that the COVID outbreak was a key factor of the explosive increase in interest rate spreads on sovereign debt between January 2020 and March 12, 2020. In fact, in the absence of wise macroprudential policies of the ECB, a scenario of a sudden surge in yield spreads for three EMU countries (Italy, Spain and France) would have been a reality, from their point of view.

Therefore, the containment of the yield spreads in euro area countries is a big challenge facing the EMU, as interest rate spreads on sovereign debt also have repercussions in countries with strong fundamentals. Understanding the forces leading the spreads dynamics is essential for economists and policymakers. Thus, financial market authorities should take into consideration not only the fiscal, credit, liquidity or behavioral risks when compressing spread movements, but also pandemic risks (such as COVID outbreak) to manage investor’s risk aversion.

Due to remarkable policy support and progress on vaccination as well as to the ECB reactivity in March 2020 through wise macroprudential policies ensuring the stability of the financial system and stimulating economic activity, EMU countries are now beginning to emerge from the worst phases of the pandemic, although with expectations diverging across countries.

Declaration of competing interest

The author declares that she does not have any conflict of interests.

Appendix A. Figures

![Fig. 2. Total cumulative deaths (thousand) for EU countries: 2020](image1)

![Fig. 3. Total cumulative cases (millions) in EU countries: 2020.](image2)

Note: the author’s computation using WTO database

Economic and fiscal situation

Huge contractions in real GDP (Fig. 4) led to large increases in budget deficit and public debt (Figs. 5 and 6). In terms of budget deficit, the most affected countries were Malte (−10.2%), Greece (−10.1%), Italy (−9.3%), Slovenia (−8.6%), Spain (−8.4%) and
Lithuania (−8.0%). Today, the public debt is reaching more than 100% of GDP in several EU countries such as in Greece (205.6%), Italy (155.8%), Portugal (133.6%), Spain (120%), Cyprus (118%) and Belgium (114%). This may suggest a real danger for some countries of failing into a debt trap.

![Real GDP growth: 2019 and 2020](image1.png)

**Note:** Data comes from Eurostat database.

**Fig. 4.** Real GDP growth evolution in EU countries, 2019–2020. Note:

![Central Gov. Deficit (% of GDP) for EU countries, 2019–2020](image2.png)

**Note:** Data comes from Eurostat database.

**Fig. 5.** Central Gov. Deficit (% of GDP) for EU countries, 2019–2020.

![Government consolidated gross debt (% of GDP) for EU countries, 2019–2020](image3.png)

**Note:** Data comes from Eurostat database.

**Fig. 6.** Government consolidated gross debt (% of GDP) for EU countries, 2019–2020.
Pandemic situation in 2020

![Graph showing the evolution of the WPUIC in 2020](image)

**Note:** WPUIG - the Global World Pandemic Uncertainty Index; WPUIC – the Country Pandemic Uncertainty Index

**Fig. 7.** The World and the Country Pandemic Uncertainty Index in EMU countries in 2020.

![Graph showing ARDL (p, q) selection based on Akaike criterion](image)

**Fig. 8.** ARDL (p, q) selection based on Akaike criterion: different scenarios.
### Appendix B. Tables

#### Table 1
The dynamic of public debt (% of GDP) and of budget deficit (% GDP) during the pandemic crisis

| Country/Area | Public Debt dynamic | Budget deficit dynamic |
|--------------|---------------------|------------------------|
|              | 2019 | 2020 | 2019 | 2020 |
| EU27         | 77,5 | 90,7 | -0,8 | -5,9 |
| ZE19         | 83,9 | 98   | -1   | -6   |
| Belgium      | 98,1 | 114,1| -1,9 | -7,2 |
| Greece       | 180,5| 205,6| 0,4  | -10,1|
| Spain        | 95,5 | 120  | -1,3 | -8,4 |
| France       | 97,6 | 115,7| -3,6 | -6,9 |
| Italy        | 134,6| 155,8| -1,8 | -9,3 |
| Cyprus       | 94   | 118,2| -1,6 | -7,3 |
| Portugal     | 116,8| 133,6| -1,8 | -6,6 |
| Malta        | 42   | 54,3 | 0,3  | -10,2|
| Austria      | 70,5 | 83,9 | 0,4  | -7,8 |
| Slovenia     | 65,6 | 80,8 | 0,5  | -8,6 |
| Slovakia     | 48,2 | 60,6 | -1,7 | -6,7 |

Note: i) Data are provided by Eurostat database.

#### Table 2
Matrix correlation of the explanatory variables

| GDP growth | Inflation | Trade Balance | Investment | VIX | C.Gov. Debt | C.Gov. Deficit |
|------------|-----------|---------------|------------|-----|-------------|---------------|
| GDP growth | 1         |               |            |     |             |               |
| Inflation  | -0,11     | 1             |            |     |             |               |
| Trade Balance | 0,10     | -0,09         | 1          |     |             |               |
| Domestic Investment | 0,12 | 0,18      | -0,01     | 1   | 0,04        | 1             |
| VIX        | 0,17      | 0,06          | -0,12      | 0,04| 1           |               |
| C. Gov. Debt | -0,17  | -0,04        | 0,01       | -0,09| -0,01      | 1             |
| C. Gov. Deficit | 0,24  | 0,07          | 0,12       | 0,10| -0,33       | -0,15         |
| Containment health index | -0,22 | -0,10            | 0,03       | -0,04| 0,47        | 0,017         |
| Gov. Response Index | -0,21 | -0,09   | 0,03 | -0,04| 0,48        | 0,016         |
| Economic Support Index | -0,18 | -0,09      | 0,04       | -0,04| 0,49        | 0,012         |
| Stringency Index | -0,23 | -0,10 | 0,03 | -0,03| 0,47        | 0,017         |
| WPUIC | -0,26     | -0,08         | 0,01       | -0,04| 0,36        | 0,032         |

Note: WPUIC -

#### Table 3
Main descriptive statistics

| Variables    | Obs  | Mean  | Std. Dev. | Min  | Max  |
|--------------|------|-------|-----------|------|------|
| Spread       | 1064 | 1,31  | 2,33      | -0,24| 23,98|
| GDP Growth   | 1064 | 0,35  | 0,98      | -10,80| 3,81 |
| Inflation    | 1064 | 1,22  | 0,83      | -1,65| 3,44 |
| Dom. Investment | 1064 | 21,82 | 4,64      | 9,30 | 74,00|
| Trade Balance | 1064 | 1,25  | 4,48      | -18,80| 15,20|
| Central Gov. Debt-19 | 1064 | 5,94  | 8,27      | 0,03 | 32,52|
| Central Gov. Debt | 1064 | 94,73 | 7,42      | 81,30| 205,60|
| Central Gov. Deficit | 1064 | -1,21 | 1,66      | -9,10| 3,09 |
| VIX          | 1064 | 19,30 | 8,09      | 10,30| 58,32|
| WPUIC        | 1064 | 0,93  | 4,86      | 0,00 | 43,32|
| Stringency Index | 1064 | 2,62  | 12,07     | 0,00 | 81,85|
| Containment Health Index | 1064 | 2,50  | 11,45     | 0,00 | 71,90|
| Economic Support Index | 1064 | 3,15  | 15,15     | 0,00 | 100,00|
| Gov. Response Index | 1064 | 2,63  | 12,13     | 0,00 | 73,98|

### Stationarity and cointegration analysis
### Table 4
Cross-sectional dependence test of Pesaran (CD)

| Variables                      | Pesaran (CD) test |
|--------------------------------|-------------------|
|                                | CD               | p-value |
| GDP growth                     | 41.514***        | 0.000   |
| Inflation                      | 41.205***        | 0.000   |
| Trade balance                  | 7.831***         | 0.000   |
| Domestic investment            | 12.604***        | 0.000   |
| Central govt. debt (relative to Euro Area_19 debt) | 1.887***        | 0.000   |
| Central govt. debt (% GDP)     | 21.010***        | 0.000   |
| Budget Deficit                | 21.141***        | 0.000   |
| VIX                            | 63.277***        | 0.000   |
| Stringency Index              | 63.174***        | 0.000   |
| World Pandemic Uncertainty Index | 51.361***      | 0.000   |
| Containment health index       | 63.185***        | 0.000   |
| Economic support index         | 63.044***        | 0.000   |
| Government response index      | 63.021***        | 0.000   |

Note: i) all variables are in natural log; ii) *p < 0.10, **p < 0.05, ***p < 0.01; iii) H0: cross-section independence CD ~ N(0,1); iv) The Pesaran (2004) CD test is distributed as a standard normal under the null hypothesis of cross-sectional independence and is based on mean pair-wise correlation coefficients. It is applied in efficient way for N and T going to infinity in any order and it is robust to possible structural breaks; (v) Eviews procedures.

### Table 5
Panel unit root test by Pesaran (2007): 2011 Q1-2020Q4 period

| Variables/CIPS stats | CIPS stats (var. in levels) | CIPS stats (var. in first differences) |
|----------------------|-----------------------------|----------------------------------------|
| Spread               | -4.581***                   | -6.190***                              |
| GDP growth           | -5.177***                   | -6.190***                              |
| Inflation            | -2.232**                    | -2.501***                              |
| Trade balance        | -3.997***                   | -6.071***                              |
| Domestic investment  | -4.060***                   | -5.568***                              |
| Central govt. debt (Euro Area 19) | -3.446***      | -6.190***                              |
| Budget Deficit       | -4.853***                   | -5.964***                              |
| VIX                  | 2.610                       | 2.610                                  |
| Stringency Index     | -4.933***                   | -6.190***                              |
| World Pandemic Uncertainty Index | -5.536***      | -5.804***                              |
| Containment health index | -4.933***         | -5.561***                              |
| Economic support index | -3.012**            | -4.933***                              |
| Government response index | -4.933***         | -5.561***                              |

H0 (homogeneous non-stationary): bi = 0 for all i

Note: i) estimates considers max(lags) equal to 3; ii) results include constant only; ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively; iv) H0: Homogenous non-stationarity.

### Table 6
Westerlund (2007) Cointegration test: 2011q1-2020q4. Benchmark Model with spread GDP growth, inflation, trade balance, domestic investment, central govt debt related to ZE19, budget deficit.

| Model with         | Statistics | Value | Z-value | P-value |
|--------------------|------------|-------|---------|---------|
| Constant only      | Gt         | -3.758| -3.592  | 0.000   |
|                    | Ga         | -9.632| 3.128   | 0.999   |
|                    | Pt         | -8.985| 0.609   | 0.729   |
|                    | Pa         | -7.408| 2.457   | 0.993   |
| Trend and Constant | Gt         | -3.667| -2.001  | 0.023   |
|                    | Ga         | -10.476| 4.150   | 1.000   |
|                    | Pt         | -7.154| 3.917   | 1.000   |
|                    | Pa         | -9.425| 3.222   | 0.999   |

Note: i) H0: no cointegration; ii) With 14 series and 6 covariates; iii) Average AIC selected lag length: 1 and Average AIC selected lead length: 0.64 for model with constant only; iv) Average AIC selected lag length: 1 and Average AIC selected lead length 0.57 for model with trend & constant.

PMG and DCCE estimates
### Table 7
PMG estimates of EMU14 yield spreads drivers with Germany as “free anchor”: 2011q1-2020q4

| Explanatory variables | (1) Benchmark | (2) World Pandemic Uncertainty Index | (3) Stringency Index | (4) Containment health index | (5) Economic support index | (6) Gov. response index |
|-----------------------|---------------|--------------------------------------|----------------------|----------------------------|--------------------------|------------------------|
| **Long-run coefficients** |               |                                      |                      |                           |                          |                        |
| Real GDP growth       | –0.092***     | –0.145***                           | 0.040                | 0.045*                   | 0.068**                  | 0.049*                 |
|                       | (0.035)       | (0.045)                              | (0.025)              | (0.026)                  | (0.136)                  | (0.026)                |
| Inflation             | 0.371***      | 0.324                                | 0.152***             | 0.153***                 | 0.161***                 | 0.156***               |
|                       | (0.042)       | (0.043)                              | (0.025)              | (0.025)                  | (0.026)                  | (0.025)                |
| Trade balance         | –0.099**      | –0.071***                           | –0.047**             | –0.048**                 | –0.054**                 | –0.049***              |
|                       | (0.051)       | (0.050)                              | (0.023)              | (0.023)                  | (0.024)                  | (0.023)                |
| Domestic Investment   | –1.330***     | –1.220*                             | 0.011                | 0.014                    | 0.069                    | 0.023                  |
| Central gov. debt     | 2.650***      | 1.945***                            | 1.302***             | 1.286***                 | 1.265***                 | 1.298***               |
|                       | (0.654)       | (0.674)                              | (0.288)              | (0.291)                  | (0.295)                  | (0.292)                |
| Budget deficit        | 0.037         | 0.012                               | 0.023                | 0.022                    | 0.024                    | 0.022                  |
|                       | (0.025)       | (0.030)                              | (0.018)              | (0.018)                  | (0.018)                  | (0.018)                |
| Pandemic risk         | –            | –0.153***                            | –0.088***            | –0.093**                 | –0.087***                | –0.092***              |
|                       | (0.056)       | (0.023)                              | (0.013)              | (0.024)                  | (0.022)                  | (0.023)                |
| Error correction term | –0.296***     | –0.299***                           | –0.321***            | –0.320***                | –0.319***                | –0.321***              |
| (ECT)                 | (0.055)       | (0.047)                              | (0.043)              | (0.043)                  | (0.043)                  | (0.043)                |
| Hausman test          |               |                                      |                      |                           |                          |                        |
| PMG vs. MG            | 14.85         | 7.45* (0.383)                        | 177.30(0.000)        | 3.79* (0.804)            | 21.59 (0.003)           | 590.65 (0.000)         |
|                       | (0.021)       | (0.78)                               |                      |                          |                          |                        |
| PMG vs. DFE           | 0.63 (0.999)  | 41.68 (0.000)                        | 42.88 (0.000)        | 40.31 (0.000)            | 60.76 (0.000)           | 45.41 (0.000)          |
|                       | (0.000)       | (0.78)                               |                      |                          |                          |                        |
| **Short-run coefficients** |            |                                      |                      |                           |                          |                        |
| Δ Spread (−1)         | 0.280***      | 0.273***                            | 0.279***             | 0.277***                 | 0.274***                 | 0.278***               |
|                       | (0.066)       | (0.064)                             | (0.055)              | (0.055)                  | (0.055)                  | (0.055)                |
| Δ Real GDP growth     | –0.009        | 0.008                               | –0.018               | –0.021                   | –0.027***                | –0.023***              |
|                       | (0.011)       | (0.013)                              | (0.011)              | (0.011)                  | (0.011)                  | (0.011)                |
| Δ Inflation           | 0.177         | 0.192*                               | 0.220***             | 0.219**                  | 0.199*                   | 0.211*                 |
|                       | (0.119)       | (0.116)                              | (0.113)              | (0.112)                  | (0.108)                  | (0.114)                |
| Δ Trade balance       | 0.077**       | 0.072**                             | 0.069***             | 0.069***                 | 0.071***                 | 0.070***               |
|                       | (0.024)       | (0.024)                             | (0.024)              | (0.024)                  | (0.023)                  | (0.024)                |
| Δ Domestic Inv.       | 0.747**       | 0.709**                             | 0.519* (0.364)       | 0.531**                  | 0.534*                   | 0.533*                 |
|                       | (0.318)       | (0.024)                             | (0.271)              | (0.364)                  | (0.364)                  | (0.364)                |
| Δ Central gov. debt   | –1.174        | –1.210                              | –1.454               | –1.476                   | –1.266                   | –1.494                 |
|                       | (1.662)       | (1.627)                             | (1.764)              | (1.766)                  | (1.793)                  | (1.769)                |
| Δ Budget deficit      | –0.054*       | –0.048**                            | –0.050*              | –0.051                  | –0.053*                  | –0.051*                |
|                       | (0.023)       | (0.024)                             | (0.028)              | (0.029)                  | (0.030)                  | (0.029)                |
| Δ Pandemic Risk       | –            | –0.062***                           | –0.089**             | –0.083*                 | –0.062                   | –0.079                 |
|                       | (0.017)       | (0.043)                             | (0.050)              | (0.072)                  | (0.053)                  | (0.053)                |
| VIX                   | 0.438***      | 0.494***                            | 0.495***             | 0.501***                 | 0.518***                 | 0.501***               |
|                       | (0.097)       | (0.099)                             | (0.097)              | (0.099)                  | (0.119)                  | (0.101)                |
| Constant              | 0.460         | 0.309***                            | –0.682***            | –0.699***                | –0.807***                | –0.710***              |
| Tre                   | (0.559)       | (0.411)                             | (0.249)              | (0.243)                  | (0.239)                  | (0.245)                |
| Trend                 | –0.023**      | –0.022***                           | –0.023***            | –0.022***                | –0.022***                | –0.022***              |
| Tre                   | (0.008)       | (0.008)                             | (0.008)              | (0.007)                  | (0.007)                  | (0.007)                |
| No. of obs. (N × T)   | 560           | 560                                 | 560                  | 560                      | 560                      | 560                    |
| Log likelihood        | 67.059        | 74.516                               | 85.802               | 86.121                   | 86.659                   | 86.131                 |

Note: i) MG – Mean Group Estimator; PMG – Pooled Mean Group Estimator; DFE - Fixed Differenced Estimator; ii) Standard error in parenthesis. ***, **, * - statistical significance at the 1%, 5%, and 10% level; iii) ARDL(2,1,1,1,1,1,1,1,1,1) based on Akaike criterion; iv) * MG vs PMG. Note: Standard error in parenthesis. ***, **, * - statistical significance at the 1%, 5%, and 10% level; ARDL(2,1,1,1,1,1,1,1,1,1) with Akaike criterion.
Table 8
PMG estimates of EMU_14 yield spreads with Germany as “free anchor”: 2011q1-2020q4

| Explanatory variables | (1) Benchmark | (2) World Pandemic Uncertainty Index | (3) Stringency Index | (4) Containment health index | (5) Economic support index | (6) Gov. response index |
|-----------------------|---------------|-------------------------------------|----------------------|----------------------------|--------------------------|------------------------|
| **Long-run coefficients** |               |                                     |                      |                            |                          |                        |
| Real GDP growth       | −0.105***     | −0.104**                            | −0.022               | −0.014                     | −0.004                   | −0.010                 |
|                        | (0.042)       | (0.049)                             | (0.052)              | (0.053)                    | (0.055)                  | (0.054)                |
| Inflation              | 0.349***      | 0.335**                             | 0.313***             | 0.312***                   | 0.314***                 | 0.308***               |
|                        | (0.043)       | (0.045)                             | (0.043)              | (0.044)                    | (0.043)                  | (0.043)                |
| Trade balance          | −0.110**      | −0.105**                            | −0.098**             | −0.099**                   | −0.103**                 | −0.096**               |
|                        | (0.048)       | (0.049)                             | (0.049)              | (0.049)                    | (0.049)                  | (0.049)                |
| Domestic Investment    | −0.937*       | −1.115*                             | −0.834               | −0.824                     | −0.853                   | −0.790                 |
|                        | (0.582)       | (0.596)                             | (0.557)              | (0.557)                    | (0.550)                  | (0.549)                |
| Central gov. debt      | 4.037***      | 4.085***                            | 3.967***             | 3.935***                   | 3.861***                 | 4.002***               |
|                        | (0.702)       | (0.698)                             | (0.653)              | (0.654)                    | (0.645)                  | (0.645)                |
| Budget deficit         | 0.029         | 0.006                               | 0.020                | 0.019                      | 0.018                    | 0.021                  |
|                        | (0.034)       | (0.039)                             | (0.038)              | (0.038)                    | (0.037)                  | (0.038)                |
| VIX                    | 1.032***      | 1.160***                            | 1.251***             | 1.250***                   | 1.244***                 | 1.259***               |
|                        | (0.132)       | (0.157)                             | (0.161)              | (0.161)                    | (0.158)                  | (0.159)                |
| Pandemic risk          | −0.279***     | −0.283***                           | −0.285***            | −0.285***                  | −0.286***                | −0.287***              |
|                        | (0.063)       | (0.064)                             | (0.059)              | (0.059)                    | (0.059)                  | (0.059)                |
| **Error correction term (ECT)** |            |                                     |                      |                            |                          |                        |
| Haushan test           |               |                                     |                      |                            |                          |                        |
| MG vs. PMG             | 6.79 (0.459)  | 21.45 (0.003)                       | 157.18 (0.00)        | 23.68 (0.003)              | 4.83 (0.776)             | 10.04 (0.262)          |
| PMG vs. DFR            | 2.04*         | 24.72* (0.002)                      | 7.35 (0.499)         | 10.24 (0.249)              | 1.20 (0.997)             | 7.19 (0.516)           |

| **Short-run coefficients** | (1)              | (2)               | (3)                | (4)              | (5)            | (6)            |
|---------------------------|------------------|-------------------|--------------------|-----------------|----------------|----------------|
| Δ Spread (−1)             | 0.304***         | 0.302***          | 0.289***           | 0.288***        | 0.289***       | 0.289***       |
|                           | (0.064)          | (0.064)           | (0.065)            | (0.065)         | (0.064)        | (0.065)        |
| Δ Real GDP growth         | −0.012           | −0.004            | −0.011             | −0.014          | −0.016         | −0.016         |
|                           | (0.013)          | (0.015)           | (0.014)            | (0.013)         | (0.013)        | (0.013)        |
| Δ Inflation               | 0.131*           | 0.137*            | 0.140              | 0.138*          | 0.122*         | 0.129***       |
|                           | (0.081)          | (0.082)           | (0.077)            | (0.075)         | (0.072)        | (0.078)        |
| Δ Trade Balance           | 0.087***         | 0.086***          | 0.085              | 0.085***        | 0.086***       | 0.085***       |
|                           | (0.025)          | (0.025)           | (0.023)            | (0.023)         | (0.023)        | (0.023)        |
| Δ Domestic Inv.           | 0.660***         | 0.643**           | 0.603***           | 0.612**         | 0.620**        | 0.610**        |
|                           | (0.295)          | (0.271)           | (0.254)            | (0.364)         | (0.364)        | (0.364)        |
| Δ Central gov. debt19     | −1.105           | −1.250            | −1.337             | −1.365          | −1.269         | −1.410         |
|                           | (1.542)          | (1.512)           | (1.596)            | (1.598)         | (1.647)        | (1.602)        |
| Δ Budget deficit          | −0.052**         | −0.050**          | −0.052**           | −0.052**        | −0.052*        | −0.053**       |
|                           | (0.023)          | (0.025)           | (0.027)            | (0.027)         | (0.026)        | (0.027)        |
| Δ VIX                     | 0.015            | −0.020            | −0.024             | −0.018          | −0.010         | −0.025         |
|                           | (0.09)           | (0.094)           | (0.088)            | (0.087)         | (0.083)        | (0.089)        |
| Δ Pandemic Risk           | −0.050**         | 0.096**           | 0.094              | 0.093*          | 0.095**        | 0.095**        |
|                           | (0.025)          | (0.045)           | (0.048)            | (0.053)         | (0.049)        | (0.049)        |
| Constant                  | 0.561            | 0.617             | 0.360              | 0.352           | 0.377          | 0.340          |
|                           | (0.869)          | (0.887)           | (0.842)            | (0.833)         | (0.825)        | (0.850)        |
| Trend                     | −0.025***        | −0.025***         | −0.025***          | −0.025***       | −0.025***      | −0.025***      |
|                           | (0.008)          | (0.008)           | (0.008)            | (0.008)         | (0.008)        | (0.008)        |
| No. of obs. (N × T)       | 560              | 560               | 560                | 560             | 560            | 560            |
| Log likelihood            | 64.222           | 68.790            | 75.712             | 75.812          | 76.90          | 76.328         |

Note: i) Standard error in parenthesis. ***, **, * - statistical significance at the 1%, 5%, and 10% level; ii) ARDL(2,1,1,1,1,1,1) is based on Akaike criterion; iii) PMG estimates are made in Eviews; iv) Hausman test results are made in Stata; v) * DFE vs PMG; * - PMG vs MG.

Note: Standard error in parenthesis. ***, **, * - statistical significance at the 1%, 5%, and 10% level; ARDL(4,1,1,1,1,1,1,1,1,1) with Akaike criterion.
Table 9
PMG estimates of EMU_14 yield spreads drivers with Germany as “no free anchor”: 2011q1-2020q4

| Explanatory variables | (1) Benchmark | World Pandemic Uncertainty Index | Stringency Index | Containment health index | Economic support index | Gov. response index |
|-----------------------|---------------|----------------------------------|------------------|--------------------------|-----------------------|---------------------|
| Long-run coefficients |               |                                  |                  |                          |                       |                     |
| Real GDP growth       | -0.072        | -0.014                           | -0.062           | -0.046                   | -0.019                | -0.098              |
| Inflation             | 0.230***       | 0.405***                         | 0.139***         | 0.167**                  | 0.454***              | 0.204***            |
| Trade balance         | -0.129***      | -0.099**                         | -0.141***        | -0.153**                 | -0.019***             | -0.134***           |
| Domestic Investment   | -0.029         | 1.197**                          | -0.422           | -0.557                   | -0.417                | -0.190              |
| Central gov. debt     | 6.448***       | 0.35                             | 8.322***         | 4.762***                 | 7.275**               |                     |
| Pandemic risk         | -              | 0.204                            | -0.080           | -0.649                   | -2.133***             | 0.196               |
| Error correction term | -0.247***      | -0.252***                        | -0.228***        | -0.234***                | -0.271***             | -0.236***           |
| Short-run coefficients|               |                                  |                  |                          |                       |                     |
| Δ Spread (−1)         | 0.301***       | 0.294***                         | 0.311***         | 0.312***                 | 0.321***              | 0.269***            |
| Δ Spread (−2)         | -0.065         | -0.051                           | -0.080           | -0.074                   | -0.017                | -0.058              |
| Δ Spread (−3)         | 0.083          | 0.081                            | 0.082            | 0.084                    | 0.117*                | 0.089               |
| Δ Real GDP growth     | 0.014          | 0.002                            | 0.017            | 0.017                    | 0.017                 | 0.019               |
| Δ Inflation           | 0.023          | -0.032                           | -0.087           | -0.099                   | -0.145                | -0.074              |
| Δ Trade Balance       | 0.065***       | 0.027                            | 0.067***         | 0.070***                 | 0.052**               | 0.061***            |
| Δ Domestic Inv.       | 0.486*         | 0.422                            | 0.551***         | 0.584***                 | 0.621*                | 0.473*              |
| Δ Central gov. debt19 | -0.633         | 0.968                            | -1.424           | -1.217                   | -1.016                | -1.956              |
| Δ Budget deficit      | -0.038         | -0.024                           | -0.041           | -0.040                   | -0.050                | -0.040**            |
| Δ VIX                 | 0.569***       | 0.503***                         | 0.516***         | 0.518***                 | 0.550***              | 0.582***            |
| Δ Pandemic Risk       | -0.013         | -0.013                           | 0.565***         | 0.677***                 | 0.317***              | -0.443**            |
| Constant              | 0.130          | 0.206                            | 0.255            | 0.291                    | 0.438                 | 0.090               |
| TRE                   | 0.530          | 0.373                            | 0.660            | 0.690                    | 0.511                 | 0.590               |
| Trend                 | -0.036***      | -0.021***                        | -0.038***        | -0.038***                | -0.036***             | -0.036***           |
| No. of obs. (N × T)   | 560            | 560                              | 560              | 560                      | 560                   | 560                 |
| Log likelihood        | 85.290         | 99.662                           | 97.167           | 96.584                   | 111.897               | 101.717             |

Note: i) Standard error in parenthesis. ***, **, * - statistical significance at the 1%, 5%, and 10% level; ii) ARDL(2,1,1,1,1,1,1,1,1) is based on Akaike criterion; iii) PMG estimates are made in Eviews; iv) Hausman test results are made in Stata. Note: Standard error in parenthesis. ***, **, * - statistical significance at the 1%, 5%, and 10% level; ARDL(4,1,1,1,1,1,1,1,1,1) with Akaike criterion.
Table 10
Dynamic Common Correlated Effects Estimator - Pooled Mean Group (with Germany as “free anchor”): 2011q1-2020q4

| Explanatory variables | (1) Benchmark | (2) World Pandemic Uncertainty Index | (3) Stringency Index | (4) Containment health index | (5) Economic support index | (6) Gov. response index |
|-----------------------|--------------|------------------------------------|----------------------|-----------------------------|---------------------------|------------------------|
| **Long-run coefficients** | | | | | | |
| Real GDP growth | −0.082** | −0.152** | −0.145** | −0.143** | −0.140** | −0.145** |
| Inflation | 0.014 | 0.011 | 0.006 | 0.006 | −0.001 | 0.005 |
| Trade balance | −0.033 | −0.007 | −0.018 | −0.018 | −0.018 | −0.017 |
| Domestic Investment | 0.772 | 0.837 | −0.749 | −0.759 | 0.824 | 0.769 |
| Central gov. debt | −0.159 | 0.027 | 0.024 | 0.028 | 0.050 | 0.035 |
| Budget deficit | 0.031 | −0.021 | −0.016 | −0.016 | −0.012 | −0.017 |
| VIX | 0.591*** | 0.832*** | 0.862** | 0.866** | 0.874** | 0.867** |
| Pandemic risk | −0.175** | −0.146* | −0.147* | −0.137** | −0.144** |
| Error correction term (ECT) | −0.022 | −0.072* | −0.070* | −0.071* | −0.062* | −0.069 |

**Panel A: Long-run dynamics**

| **Short-run coefficients** | (1) | (2) | (3) | (4) | (5) | (6) |
|---------------------------|----|----|----|----|----|----|
| Δ Spread (−1) | 0.521*** | 0.463*** | 0.462*** | 0.464*** | 0.469*** | 0.465*** |
| Δ Real GDP growth | 0.025 | −0.066*** | −0.054*** | −0.054*** | −0.055*** | −0.055*** |
| Δ Inflation | 0.306*** | 0.379*** | 0.311** | 0.308** | 0.283** | 0.306** |
| Δ Trade Balance | −0.022 | −0.032 | −0.023 | −0.024 | −0.024 | −0.025 |
| Δ Domestic Inv. | −0.501*** | −0.511*** | −0.182 | −0.194 (0.364) | −0.221** (0.364) | −0.196 (0.364) |

**Panel B: Short-run dynamics**

| Δ Central gov. debt19 | −0.743 | −1.521 | −1.545 | −1.534 | −1.294 | −1.523 |
| Δ Budget deficit | 0.008 | 0.005 | 0.001 | 0.002 | 0.003 | −0.003 |
| Δ VIX | −0.207* | −0.257*** | −0.258** | −0.260** | −0.254** | −0.260** |
| Δ Pandemic Risk | −0.067 | 0.010 | 0.008 | 0.005 | 0.003 |

| No. Of obs. (N × T) | 560 | 560 | 560 | 560 | 560 | 560 |
| RMSE | 0.58 | 0.58 | 0.58 | 0.58 | 0.58 | 0.58 |
| CD stat (p-value) | 15.36 | 12.53 (0.00) | 13.61 (0.00) | 13.59 (0.00) | 13.85 (0.00) | 13.63 (0.00) |

Note: i) Standard error in parenthesis. ***, **, * - statistical significance at the 1%, 5%, and 10% level; ii) ARDL(2,1,1,1,1,1,1,1,1,1) is based on Akaike criterion; iii) PMG estimates are made in Eviews; iv) Hausman test results are made in Stata.

Note: Standard error in parenthesis. ***, **, * - statistical significance at the 1%, 5%, and 10% level; ARDL(4,1,1,1,1,1,1,1,1,1) with Akaike criterion.
### Table 11
BVAR results with Litterman-Minesotta Prior: 2011q1-2020q4

| Pandemic variable | No. Countries | R2adj | Fisher-Stat |
|-------------------|---------------|-------|-------------|
| Spread (-1)       | 560           | 0.911 | 980,336     |
| GDP growth (-1)   | 560           | 0.911 | 980,336     |
| Inflation (-1)    | 560           | 0.911 | 980,336     |
| Domestic Investment (-1) | 560 | 0.911 | 980,336     |
| Central Gov. Debt (-1) | 560 | 0.911 | 980,336     |
| Budget deficit (-1) | 560 | 0.911 | 980,336     |
| VIX (-1)          | 560           | 0.911 | 980,336     |
| Pandemic risk (-1) | 560         | 0.911 | 980,336     |

Note: Standard error in parenthesis. ***, **, * - statistical significance at the 1%, 5%, and 10% level. M1 = BVAR with VIX endogenous, M2 = BVAR with VIX exogenous. When the prior mean for the coefficient on the first own lag is 0.9 (Mu = 0.9, a fair degree of persistence) or Mu = 1, results are qualitatively similar, Findings are upon request.
Table 12
BVAR results with GiannoneLenzaPrimiceri Prior: 2011q1-2020q4

| Pandemic variable | None | WPULx | Stringency.x | Containment Health.x | Economic Support.x | Gov. Response.x |
|-------------------|------|-------|---------------|----------------------|--------------------|-----------------|
| Prior type        |      |       |               |                      |                    |                 |
| HP: Mu = 0, L1 = 0.51 |      |       |               |                      |                    |                 |
|                   | M1   | M2   | M1           | M2           | M1               | M2               | M1               | M2               | M1               | M2               |
| Spread (-1)       | 0.939*** | 0.941*** | 0.927*** | 0.927*** | 0.928*** | 0.922*** | 0.928*** | 0.928*** | 0.925*** | 0.929*** | 0.923*** |
| GDP growth        | 0.027 | 0.019 | 0.041 | 0.048 | 0.045 | 0.050* | 0.042 | 0.047 | 0.039 | 0.038 | 0.042 | 0.044 |
| Inflation         | 0.029 | 0.031 | 0.021 | 0.011 | 0.014 | 0.004 | 0.015 | 0.005 | 0.014 | 0.008 | 0.015 | 0.006 |
| Domestic Investment | 0.017 | 0.017 | 0.017 | 0.016 | 0.0157 | 0.016 | 0.015 | 0.016 | 0.016 | 0.016 | 0.016 |
| Central Gov. Debt | 0.074 | 0.079 | 0.085 | 0.108 | 0.092 | 0.117 | 0.097 | 0.117 | 0.097 | 0.117 | 0.097 |
| Budget deficit    | 0.002 | 0.011 | 0.003 | 0.004 | 0.006 | 0.000 | 0.006 | 0.000 | 0.006 | 0.000 | 0.006 |
| VIX               | 0.293*** | 0.482*** | 0.885*** | 0.752*** | 0.435*** | 0.870*** | 0.435*** | 0.860*** | 0.455*** | 0.854*** | 0.441*** | 0.862*** |
| Pandemic risk     | - | - | -0.066*** | (0.037) | -0.162*** | (0.040) | -0.092*** | (0.036) | -0.193*** | (0.039) | -0.091*** | (0.036) | -0.194*** | (0.040) | -0.097*** | (0.035) | -0.183*** | (0.037) | -0.092*** | (0.035) | -0.190*** | (0.038) |
| Constant          | -1.094*** | -1.614*** | -2.9306*** | -2.250*** | -2.830*** | -2.639*** | -2.830*** | -2.647*** | -2.830*** | -2.647*** | -2.830*** | -2.647*** |
| No. Obs           | 560 | 560 | 560 | 560 | 560 | 560 | 560 | 560 | 560 | 560 | 560 |
| R2adj             | 0.937 | 0.938 | 0.936 | 0.936 | 0.937 | 0.941 | 0.937 | 0.941 | 0.937 | 0.941 | 0.937 |
| SSR               | 262.038 | 255.797 | 256.429 | 248.243 | 258.814 | 244.65 | 258.869 | 244.764 | 258.286 | 244.822 | 258.787 |
| Fisher-Stat       | 1048.145 | 1075.426 | 937.668 | 937.668 | 927.206 | 984.423 | 926.998 | 983.937 | 929.293 | 983.688 | 927.31 |
| Marginal Log-Likeliho | -2265.22 | -2311.645 | -2261.199 | -2300.747 | -2527.531 | -2675.476 | -2511.023 | -2652.951 | -2459.315 | -2597.28 | -2489.732 | -2648.071 |

Note: i) Standard error in parenthesis. ****, ***, * - statistical significance at the 1%, 5%, and 10% levels. ii) M1 = BVAR with VIX endogenous, M2 = BVAR with VIX exogenous. When the prior mean for the coeff. on the first own lag is 0.9 (Mu = 0.9, a fair degree of persistence) or Mu = 1, results are qualitatively similar and are upon request from the author; iii) HP - hyperparameters.
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