Explaining Long-Term Bond Yields Synchronization Dynamics in Europe

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Abstract

We examine the empirical determinants of sovereign yield synchronization dynamics in the European Monetary Union. Using a time-varying measure of (long-term) government bond yields synchronization and Bayesian Model Averaging methods, we show that the persistence of synchronization measures differs significantly between GIIPS countries (Portugal, Italy, Ireland, Greece, and Spain) and the rest of the monetary union, as well as across periods characterized by whether the zero lower bound of interest rates was binding or not and the post-Draghi *whatever it takes* era. The degree of synchronization in inflation rates with the rest of the currency area is a robust predictor of the synchronization of sovereign yields, as opposed to economic fundamentals describing the fiscal positions of individual countries. An out-of-sample forecasting exercise reveals that accounting for the most relevant economic fundamentals within the monetary union can lead to improvements in the directional accuracy of the forecasts of yield synchronization rates only for GIIPS countries.

Keywords: Long-term government bond yields, European Monetary Union, Synchronization measures, Bayesian Model Averaging

JEL classification: C11; C33; C52; F45; H63

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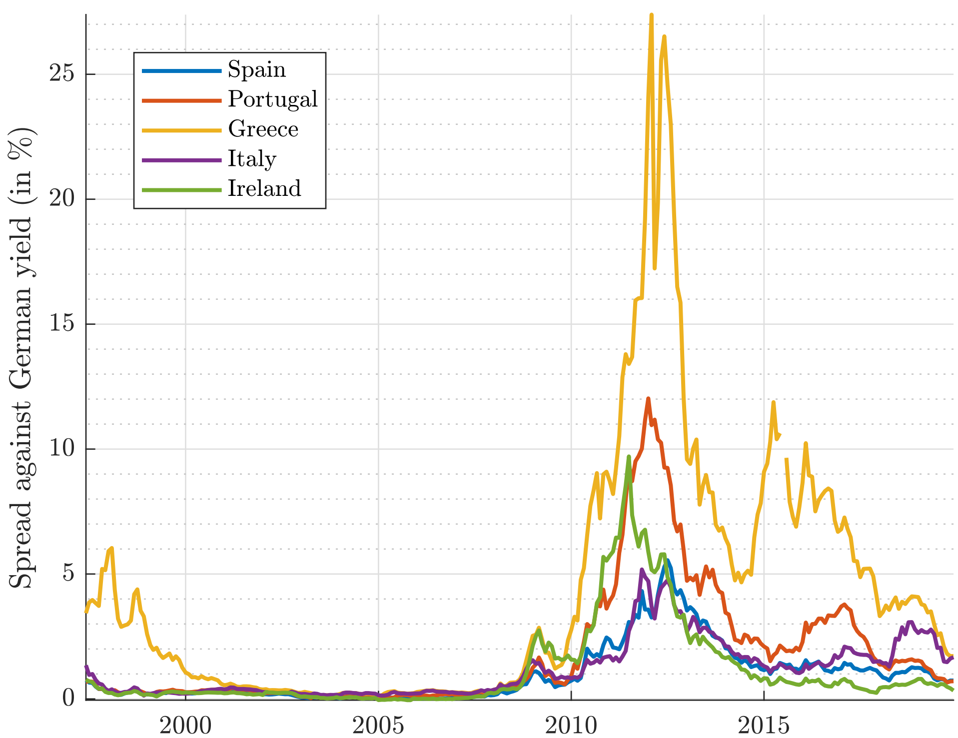
1 Introduction

The 2012 European sovereign debt crisis emerges as one of the most dramatic episodes in the recent economic history of the European Union. After the Great Recession, the dynamics of budget deficits in the European economies ignited a lack of confidence in the ability of these countries to repay their debt. This was particularly true for the so-called GIIPS countries (Greece, Italy, Ireland, Portugal, and Spain), which experienced large increases in their long-term government bond yields and sovereign spreads, reflecting a loss of confidence of investors in these economies. Consequently, after the first phase of growing differentials in long-term interest rates that started in 2010, from 2012 the long-term interest rates of European countries diverged substantially. Such a development is depicted in Figure 1, which shows the long-term government bond yield (10-year) spreads of GIIPS economies against the German bond for 1999-2019.

Figure 1: **Long-Term Government Bond Yield (10-Year) Spreads**. The spread is computed as the difference between the yield of each country and the German yield. Source: FRED Dataset.



The objective of this paper is to unveil the robust determinants of synchronization dynamics in long-term government bond yields in the European Monetary Union (EMU) over the last two decades in the presence of specification uncertainty. In particular, we take into account that the relationships between synchronization measures for sovereign bond yields and their determinants may be subject to parameter heterogeneity across individual economies and over time due to structural breaks and country-specific institutional settings. The driving factors of relative dynamics in government bond yields across European economies have not been rigorously addressed in the existing empirical literature hitherto, and the macroeconomic developments in the euro area over the last decade indicate that the lack of synchronization of government bond yields may hamper the sustainability of EMU as a currency area.

The literature that examines the main empirical predictors of sovereign bond yields is extensive.[1] Kilponen et al. (2015) provide an excellent review of the literature devoted to studying the factors that determine sovereign yields and their change over time. Variables describing the fiscal position of countries, such as the debt-to-GDP ratio, and the current account balance tend to be used as proxies for the creditworthiness and default risk of a country and are often identified as robust determinants of sovereign yields. Arghyrou & Kontonikas (2012); Aßmann & Boysen-Hogrefe (2011); Attinasi et al. (2009); Barrios et al. (2009); Haugh et al. (2009) are important contributions that highlight the role of sovereign credit risk (as proxied by fiscal fundamentals) on government bond spreads in Europe. In an application using US data, Laubach (2009) finds that (projected) deficit and debt-to-GDP ratios are positively correlated with long-term interest rates. Poghosyan (2014) shows that increases in government debt-to-GDP ratios have positive impacts on government bond yields both in the long and short run. Real money market rates and inflation rates are also found to have significant effects on the deviation of yields from their long-run equilibrium. Poghosyan (2014) proposes two main mechanisms: the effect of higher debt levels on the default risk premium (see e.g. Manasse et al., 2003 for a theoretical underpinning of this mechanism) and the potential effect of fiscal expansions on the crowding out of private investment, which may imply higher real interest rates given the reduction in the capital stock (see e.g. the theoretical framework proposed by Engen & Hubbard 2004).

Beyond the impact of macroeconomic fundamentals, much of the existing empirical literature emphasizes the role that contagion effects have on sovereign yields. Some of the countries in the European periphery (such as Portugal, Ireland, and Spain) have been found to suffer from economic spillovers from the crisis in Greece (Arghyrou & Tsoukalas, 2011; Claeys & Vasicek, 2012; Claeys & Vašíček, 2014). Previous work also argues that the effect of different sovereign risk factors on sovereign yields may be subject to time variation and regime changes (Kilponen et al., 2015), which justifies explicitly addressing parameter heterogeneity in econometric modeling exercises related to the

[1] For theoretical contributions, see e.g. Arghyrou & Tsoukalas (2011); Gapen et al. (2008) among others.

assessment of the drivers of government bond yields. Arghyrou & Tsoukalas (2011) and Bernoth et al. (2012) find that the market penalizes adverse fiscal positions relatively more during crisis periods as compared to tranquil periods. In addition, Costantini et al. (2014) show that the effects of certain macroeconomic variables on the bond yield spread depend on whether the economies analyzed align with the standard optimum currency criteria, and report that gaps in competitiveness modulate the effect of fiscal variables on bond yield spreads.

Overall, these contributions identify specific sets of factors that might act as potential predictors of sovereign bond yield synchronization across countries. These can be broadly classified into four different categories: (i) variables describing the fiscal position of countries, which act as indicators of their specific creditworthiness; (ii) covariates accounting for changes in the general aggregate sovereign risk; (iii) country-specific institutional characteristics that may affect the overall level of sovereign risk, and (iv) the business cycle characteristics of the particular economic period in consideration, since the effect of some factors may vary depending on whether the economy is in a recessionary or an expansionary phase.

While the literature has mostly focused on examining the determinants of bond yield spreads, understanding the factors that drive bond yield synchronization levels within a monetary union emerges as a relevant question with important policy implications. If the cross-country synchronization of bond yield rates is weak within the union, supranational policy authorities may need to implement policies targeted only to those countries whose economies are detached from the other countries in the union. Moreover, to the extent that long-term government bond yields are a measure of how investors perceive sovereign risk in a given country, our exercise allows us to isolate the factors that robustly explain synchronization levels in sovereign risk as perceived by the financial sector.

Our results indicate that the level of the short-term interest rate shapes the persistence dynamics of synchronization measures of sovereign yields, with robust differences in periods dominated by the zero lower bound of interest rates and those periods following the famous Draghi's *whatever it takes* speech. This result also holds when comparing GIIPS countries to the rest of the monetary union. We find that economic fundamentals describing fiscal positions cannot systematically explain yield synchronization changes. Inflation synchronization dynamics appear robustly associated with the synchronization of long-term yields, and this association is, in turn, dependent on whether the economy is at the zero lower bound of interest rates, and differs for GIIPS countries as compared to the rest of EMU. We show that the associations uncovered making use of historical data lead to limited improvements in the directional accuracy of out-of-sample predictions of government bond yield synchronization measures.

The remainder of the paper is organized as follows. Section 2 describes the econometric framework used and gives an overview of the data employed. Section 3 shows the main results of the model averaging exercise. Section 4 reports the results of a pseudo-out-of-sample forecasting exercise aimed at evaluating the predictive accuracy of the models used, and Section 5 concludes.

2 Data and Methodology

2.1 Bond Yield Synchronization in Europe

Our analysis assesses the empirical determinants of cross-country co-movement in government bond yields. For the purpose of measuring the level of synchronization in bond yields, we consider a time-varying measure based on sigma-convergence analysis (see Crespo-Cuaresma & Fernández-Amador, 2013a,b). The synchronization measure for country i (out of N countries that compose the monetary union)[2] in period t is given by

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

where

$$s_t = \sqrt{\frac{\sum_j (r_{jt} - \bar{r}_t)^2}{N}}, \tag{2}$$

and

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

The variable r_{it} denotes the long-term (10-year) government bond yield (in percentage points, sourced from the Federal Reserve Economic Dataset, FRED) of country i at time t. The variable s_{it} defined in Equation (3) denotes the cross-country standard deviation in period t of the long-term government bond yield value (in percentage) excluding country i. In a similar way, the variable s_t defined in Equation (2) denotes the standard deviation of long-term government bond yields including all the countries in the monetary union. The index builds upon the comparison of the variation in long-term bond yields across all countries of the monetary union with the variation in a counterfactual monetary union that does not include country i. If the index $synch_{it}$ is negative (positive), the cross-country yield volatility is lower (higher) when excluding country i from the sample. In other words, negative (positive) values of this index imply that excluding country i results in a less (more) heterogeneous group of countries in terms of the dispersion of long-term government bond yields. This measure is relevant for our exercise because it allows us to construct country-specific, time-varying measures of

[2] Throughout all our empirical analysis, the countries included are: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Netherlands, Portugal, Slovakia, Slovenia, and Spain.

synchronization that are more suitable than other measures found in the literature[3] because they allow taking into account the structure of the monetary union in a more rigorous manner.

Figure 2 depicts the cross-country standard deviation of the long-term government bond yields (i.e., the variable s_t in Equation (2)) for the countries in EMU, along with the dates at which countries joined the currency area. The period with the highest levels of heterogeneity in bond yields corresponds to the government debt crisis that started in 2012. After this phase, the variation in the yields significantly decreases but does not return to the level observed prior to the crisis. The synchronization measure appears to present changes in its autocorrelation structure over the period considered, but is characterized by overall high persistence in the indicator during the last two decades.

Figure 2: **Cross-country standard deviation of long-term government bond yields**. Vertical lines indicate the date of adhesion to the EMU. Source: FRED Dataset

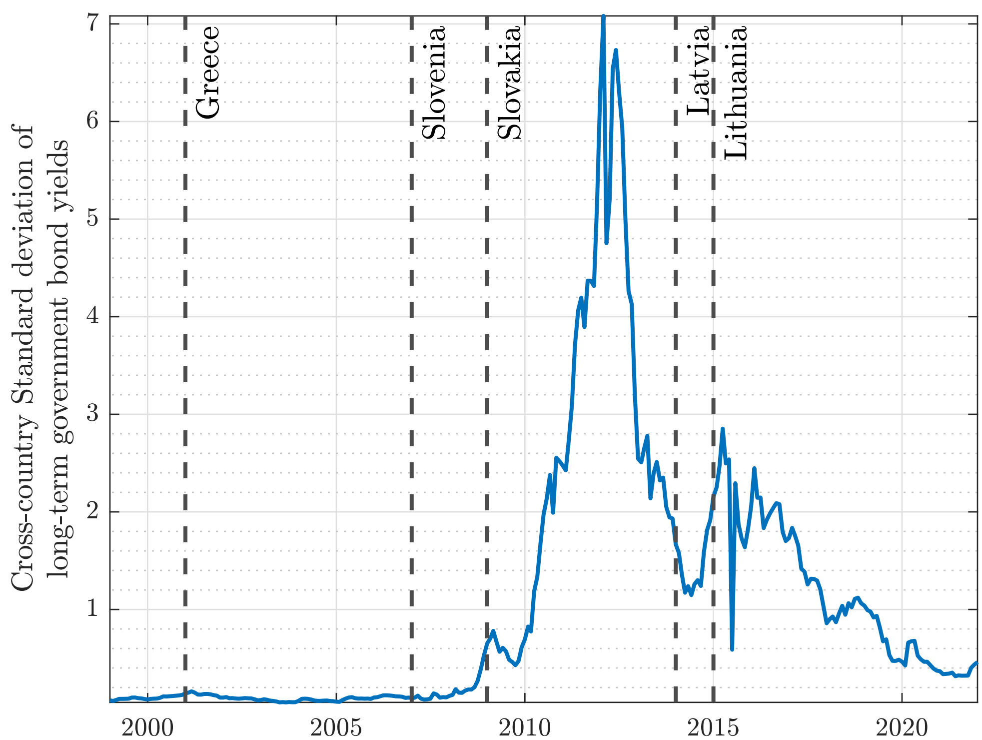
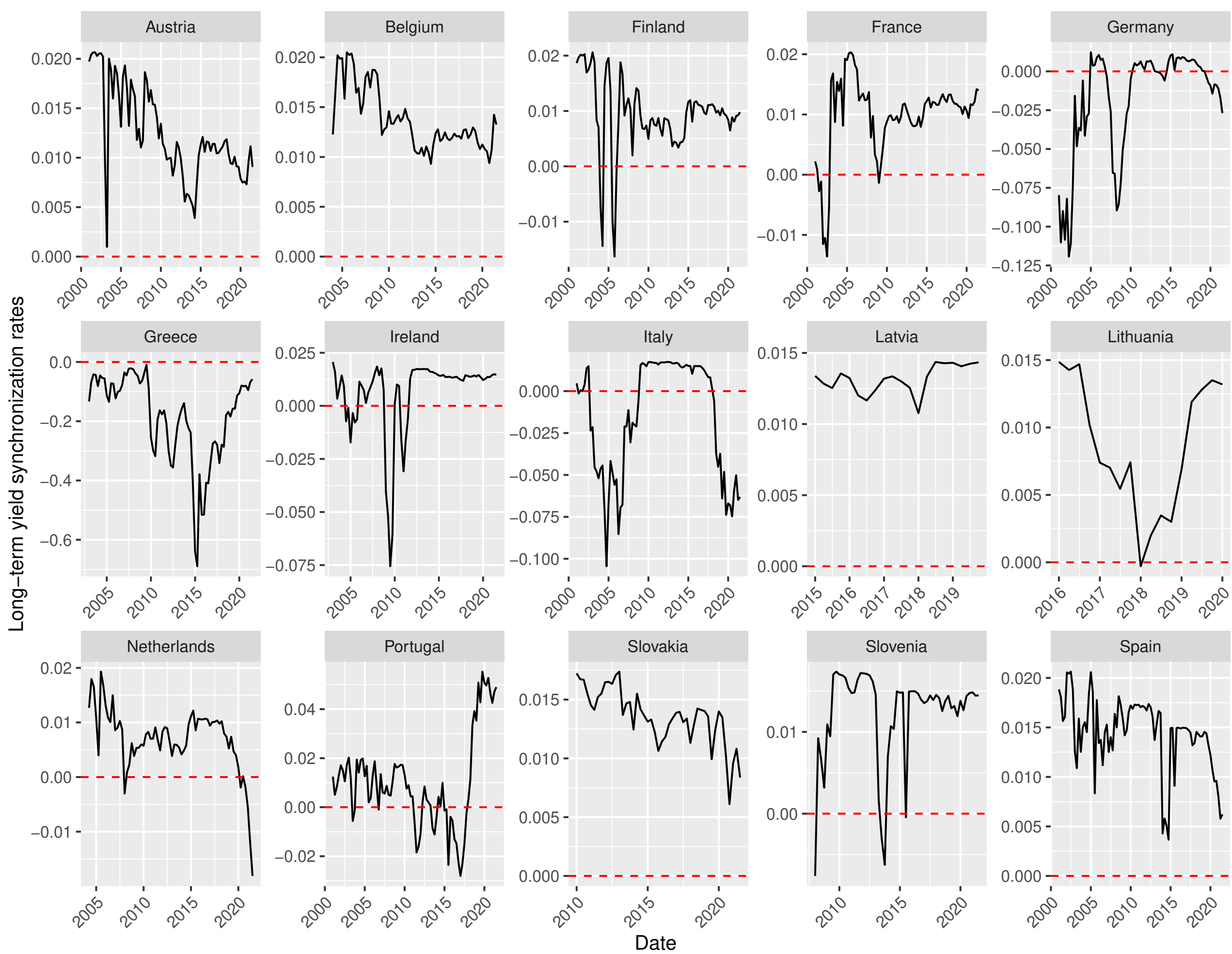


Figure 3 offers a visual representation of the synchronization variable (i.e., the variable $synch_{it}$ in Equation (1)) for each country in the sample. As in the case of the overall synchronization measure presented in Figure 2, the 2008 financial and the 2012 debt crises and their subsequent periods are

[3]See e.g. Antonakakis (2012); C. Barbieri et al. (2021) and Martins (2022) for contributions on the construction of bond yield synchronization rates for European and G7 economies, respectively.

characterized by systematic decreases in yield synchronization for a large majority of the economies in the EMU. Certain countries (notably Greece and Italy) present negative values of the synchronization variable for a large number of periods. The decline in the synchronization variable after 2008 for Germany is related to German bonds being deemed a safe haven during this period, hence bringing long-term yields down. Excluding Germany from the EMU would thus result in a less heterogeneous union, since many of the remaining countries experienced large increases in their long-term yields, inducing higher levels of yield heterogeneity within the Union.

Figure 3: **Long-term government bond yield synchronization dynamics by country.**



2.2 The Determinants of Bond Yield Synchronization: Assessing Uncertainty

In order to assess empirically the robustness of the association between the covariates and the synchronization rate, we entertain regression models embedded in the specification given by

$$synch_{it} = \sum_{j=1}^{4} \gamma_j synch_{i,t-j} + \sum_{k=1}^{K} \sum_{j=1}^{4} \theta_{kj} x_{kit-j} + \alpha_i + \lambda_t + \epsilon_{it}, \qquad \epsilon_{it} \sim N(0, \sigma^2), \tag{4}$$

where, in addition to the lagged dependent variable, other controls $\{x_{kt}\}$, $k = 1, ..., K$ are used, potentially including lags of a macroeconomic uncertainty measure (Ahir et al. 2022), real GDP (in growth rates) to account for the overall business cycle dynamics, the current account balance of payments and debt over GDP to control for the fiscal position of the country with respect to the rest of the world, the annual rate of inflation (annual rate of change) to account for cross-country price differentials,[4] as well as their interaction with (a) a dummy variable that identifies observations that belong to any of the GIIPS countries, (b) a (country-specific) dummy variable that identifies observations corresponding to recession periods,[5] (c) a dummy variable that identifies observations for which the Euribor[6] was below zero, so as to address the potential effects of zero lower bound effects on the determinants of bond yield synchronization, and (d) a dummy variable that identifies observations corresponding to those periods after the famous *"whatever it takes"* speech by Mario Draghi that took place on the 26th of July 2012.[7]

For all variables, up to four lags are allowed in the most general specification given that they are all sampled at a quarterly frequency. For our choice of covariates, this leads to a total of $K = 124$ potential (non-fixed effects) variables. Assuming that the country and time-fixed effects are always included in a model, the combination of those 124 variables leads to 2^{124} possible specifications nested in the general model in Equation (4). The use of Bayesian Model Averaging (BMA) techniques allows us to account for specification uncertainty, thus evaluating the support that the data provides to the inclusion of particular variables as controls in the regression model in a rigorous and statistically founded manner.

The main purpose of the analysis is to compute the posterior distributions of an object of interest

[4] The data on real GDP, debt over GDP, and the annual inflation rate were obtained from Eurostat, while the data for the current account balance of payments were sourced from the OECD data.

[5] Recession periods are sourced from the Federal Reserve Economic Data (FRED), which identifies these based on the "trough method". We compute the values for Lithuania and Latvia making use of data from the OECD Composite Leading Indicators.

[6] Data on the Euribor is sourced from the European Central Bank Statistical Data Warehouse.

[7] For a comprehensive description of the data, including summary statistics and the time range of the main variables for each country, see Tables 4 and 5 in the Appendix.

Θ, which will typically be a parameter of the model while integrating away the uncertainty about specification choice,

$$P(\Theta|y) = \sum_{f=1}^{M} P(\Theta|y, M_f)P(M_f|y), \tag{5}$$

where $P(\Theta|y)$ denotes the posterior distribution of Θ, and $P(\Theta|y, M_f)$ denotes the posterior distribution of Θ conditional on the model specification M_f (out of all specifications $M = 2^{124}$). $P(M_f|y)$ denotes the posterior model probability, which is proportional to the product of the marginal likelihood, $P(y|M_f)$ and the prior probability of specification M_f,

$$P(M_f|y) \propto P(y|M_f)P(M_f). \tag{6}$$

Collecting all the parameters associated with the explanatory variables in the specification given in equation Equation (4) into the vector ψ_f and after the choice of priors for this vector, the marginal likelihood of the model can be obtained as

$$P(y|M_f) = \int_{\psi_f} \int_{\sigma} l(y|\psi_f, \sigma, M_f)P(\psi_f, \sigma)d\psi_f d\sigma, \tag{7}$$

where $l(y|\beta_f, \sigma)$ denotes the likelihood function of model M_f and $P(\psi_f, \sigma)$ is the prior density over the parameters of the specification. Following the standard choice of priors over model-specific parameters employed in the BMA literature (see for example Fernández et al., 2001a,b), we impose an uninformative prior on the relative scale (that is, on $\ln \sigma$), and the g-prior by Zellner (1986) on the parameters associated to the covariates of the model,

$$p(\sigma) \propto \frac{1}{\sigma}, \tag{8}$$

$$p(\psi_f|\sigma) \sim \mathcal{N}\left(0, g\sigma^2(X_f^{\intercal} X_f)^{-1}\right), \tag{9}$$

where X_f is the matrix of observations of the explanatory variables in the specification, and g is a scalar that needs to be elicited.

For our empirical application, we employ three different setups. In the first space of models considered, we include year and country fixed effects in all specifications. In the second one, we omit fixed effects, so as to exploit between-country variation in the estimates of our effects, and in the third one, we explicitly account for the particular nature of specifications including interaction terms, following Chipman (1996) and Crespo-Cuaresma (2011). In order to ensure the interpretability of the parameter estimates in models including interaction terms, Chipman (1996) proposes to assign a lower prior probability to specifications that contain the interacted variables without including the covariates that form it (the parent variables). We use a strong heredity prior that assigns a zero prior model probability to those specifications that include the interaction, but where the parent variables are not included as additional covariates in the model.[8]

3 Empirical Results: What Drives Synchronization in Government Bond Yields?

3.1 BMA Results

Table 1 presents the results of the BMA exercise based on specifications of the type given by Equation (4). For all three different settings (including country and year fixed effects, omitting them, and including heredity priors), we use the first 10,000 draws of the Markov Chain as burn-ins and base our inference on 10,000,000 draws.[9] The selected hyperparameter on Zellner's g-prior for the regression coefficients is based on the BRIC prior, and the prior over the model space corresponds to the beta-binomial prior on inclusion probabilities by Ley & Steel (2009b), elicited so as to imply an uninformative distribution a priori over the size of the model. We include three posterior statistics of interest in Table 1: the posterior inclusion probability (PIP) of each covariate, which summarizes its relevance by presenting the sum of posterior inclusion probabilities of specifications including that particular variable, and the corresponding mean and standard deviation of the posterior distribution of the parameter attached to the variable.

Table 1: **Bayesian Model Averaging results (covariates in levels)**

	Time and country fixed effects			Standard BMA			Strong heredity prior		
	PIP	Post. Mean	Post. SD	PIP	Post. Mean	Post. SD	PIP	Post. Mean	Post. SD
$synch_{t-1}$	1	0,7941	0,084	1	0,9078	0,1123	1	1,1521	0,0464
$synch_{t-2}$	0,1281	-0,0284	0,0767	0,1814	-0,0436	0,0966	1	-0,3101	0,0596
$synch_{t-3}$	0,0029	-0,0002	0,0103	0,0159	-0,0019	0,027	0,2728	0,0438	0,0776
$synch_{t-4}$	0,0054	0,0006	0,0098	0,0685	0,0086	0,0367	0,7388	0,0908	0,0577
$uncert_{t-1}$	0,0008	0	0,0003	0,0009	0	0,0003	0,0005	0	0,0003
$uncert_{t-2}$	0,0008	0	0,0004	0,0013	0	0,0005	0,001	0	0,0004
$uncert_{t-3}$	0,0006	0	0,0003	0,0007	0	0,0003	0,0007	0	0,0003
$uncert_{t-4}$	0,0005	0	0,0002	0,0005	0	0,0002	0,0005	0	0,0002
gdp_{t-1}	0,0005	0	0,0003	0,0007	0	0,0003	0,0005	0	0,0002

[8] See also Papageorgiou (2011) and Moser & Hofmarcher (2014) for a discussion on prior distributions over the model space for specifications with related regressors.

[9] Standard checks for convergence of the Markov chain, such as the correlation between the relative frequency of models sampled and their analytical posterior model probability, indicate convergence.

Table 1 continued from previous page

	Time and country fixed effects			Standard BMA			Strong heredity prior		
	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD
gdp_{t-2}	0,0007	0	0,0003	0,0006	0	0,0003	0,0004	0	0,0002
gdp_{t-3}	0,0005	0	0,0002	0,0007	0	0,0003	0,0007	0	0,0003
gdp_{t-4}	0,0015	0	0,0013	0,0009	0	0,0007	0,0011	0	0,0006
bop_{t-1}	0,0007	0	0,0003	0,0008	0	0,0003	0,0006	0	0,0002
bop_{t-2}	0,0006	0	0,0003	0,0011	0	0,0004	0,0007	0	0,0003
bop_{t-3}	0,0006	0	0,0004	0,0008	0	0,0003	0,0007	0	0,0003
bop_{t-4}	0,0003	0	0,0002	0,0008	0	0,0003	0,0006	0	0,0003
$debt_{t-1}$	0,0005	0	0,0008	0,0131	-0,0004	0,0036	0,0067	-0,0002	0,0023
$debt_{t-2}$	0,0007	0	0,0014	0,0185	-0,0007	0,0074	0,0107	-0,0003	0,0039
$debt_{t-3}$	0,0004	0	0,0005	0,0118	-0,0003	0,0039	0,0059	-0,0001	0,0026
$debt_{t-4}$	0,0005	0	0,0012	0,0092	-0,0001	0,0057	0,0041	-0,0001	0,0021
inf_{t-1}	0,0004	0	0,0003	0,0005	0	0,0003	0,0004	0	0,0002
inf_{t-2}	0,0004	0	0,0003	0,0007	0	0,0003	0,0008	0	0,0004
inf_{t-3}	0,0004	0	0,0003	0,0008	0	0,0004	0,0006	0	0,0003
inf_{t-4}	0,0008	0	0,0006	0,0009	0	0,0006	0,001	0	0,0005
$I(rec_{it} = 1)$	0,0063	-0,0001	0,002	0,0033	0	0,0013	0,0082	-0,0001	0,0013
$I(rec_{it} = 1)\times\ synch_{t-1}$	0,97	0,2345	0,0834	0,6424	0,1226	0,1157	0,0059	0,0004	0,0057
$I(rec_{it} = 1)\times\ synch_{t-2}$	0,8282	-0,1438	0,0749	0,4606	-0,0863	0,1006	0,0003	0	0,0022
$I(rec_{it} = 1)\times\ synch_{t-3}$	0,0113	0,0013	0,0128	0,0221	0,0016	0,014	0	0	0,0003
$I(rec_{it} = 1)\times\ synch_{t-4}$	0,0541	0,0032	0,0142	0,4081	0,0239	0,0312	0,0003	0	0,0007
$I(rec_{it} = 1)\times\ uncert_{t-1}$	0,001	0	0,0004	0,0008	0	0,0004	0	0	0
$I(rec_{it} = 1)\times\ uncert_{t-2}$	0,0008	0	0,0003	0,0011	0	0,0005	0	0	0
$I(rec_{it} = 1)\times\ uncert_{t-3}$	0,0007	0	0,0003	0,0008	0	0,0005	0	0	0
$I(rec_{it} = 1)\times\ uncert_{t-4}$	0,0008	0	0,0003	0,0006	0	0,0003	0	0	0
$I(rec_{it} = 1)\times\ gdp_{t-1}$	0,0007	0	0,0003	0,0006	0	0,0002	0	0	0
$I(rec_{it} = 1)\times\ gdp_{t-2}$	0,001	0	0,0004	0,0008	0	0,0003	0	0	0
$I(rec_{it} = 1)\times\ gdp_{t-3}$	0,0009	0	0,0003	0,0011	0	0,0004	0	0	0
$I(rec_{it} = 1)\times\ gdp_{t-4}$	0,0344	0,0008	0,0047	0,0239	0,0006	0,0039	0	0	0
$I(rec_{it} = 1)\times\ bop_{t-1}$	0,0031	0,0001	0,0011	0,0036	0,0001	0,0011	0	0	0
$I(rec_{it} = 1)\times\ bop_{t-2}$	0,0159	0,0004	0,0032	0,0164	0,0004	0,003	0	0	0
$I(rec_{it} = 1)\times\ bop_{t-3}$	0,0032	0,0001	0,0011	0,0037	0,0001	0,0011	0	0	0
$I(rec_{it} = 1)\times\ bop_{t-4}$	0,0104	0,0002	0,0025	0,0116	0,0002	0,0024	0	0	0
$I(rec_{it} = 1)\times\ debt_{t-1}$	0,0111	-0,0003	0,0044	0,0265	-0,0008	0,0068	0	0	0
$I(rec_{it} = 1)\times\ debt_{t-2}$	0,0234	-0,0084	0,0841	0,0407	-0,005	0,0551	0	0	0
$I(rec_{it} = 1)\times\ debt_{t-3}$	0,0175	0,007	0,0796	0,0275	0,0025	0,0506	0	0	0
$I(rec_{it} = 1)\times\ debt_{t-4}$	0,0088	0,0004	0,0175	0,0226	-0,0002	0,0148	0	0	0
$I(rec_{it} = 1)\times\ inf_{t-1}$	0,0011	0	0,0005	0,0009	0	0,0006	0	0	0
$I(rec_{it} = 1)\times\ inf_{t-2}$	0,001	0	0,0009	0,001	0	0,0011	0	0	0
$I(rec_{it} = 1)\times\ inf_{t-3}$	0,0031	-0,0001	0,0015	0,0017	0	0,0013	0	0	0
$I(rec_{it} = 1)\times\ inf_{t-4}$	0,0042	-0,0001	0,0017	0,0031	-0,0001	0,0014	0	0	0
$I(GIIPS_i = 1)$	-	-	-	0,0039	-0,0001	0,0014	0,0013	0	0,0005
$I(GIIPS_i = 1)\times\ synch_{t-1}$	0,0345	0,011	0,0604	0,3455	0,1204	0,1713	0	0	0,0005

Table 1 continued from previous page

	Time and country fixed effects			Standard BMA			Strong heredity prior		
	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD
$I(GIIPS_i = 1)\times$ $synch_{t-2}$	0,0433	-0,0144	0,0737	0,3719	-0,1548	0,2112	0	0	0
$I(GIIPS_i = 1)\times$ $synch_{t-3}$	0,0182	0,0033	0,0254	0,3313	0,0602	0,1011	0	0	0
$I(GIIPS_i = 1)\times$ $synch_{t-4}$	0,0023	0,0002	0,005	0,143	0,0207	0,059	0	0	0
$I(GIIPS_i = 1)\times$ $uncert_{t-1}$	0,0008	0	0,0005	0,0015	0	0,0008	0	0	0
$I(GIIPS_i = 1)\times$ $uncert_{t-2}$	0,0005	0	0,0003	0,0009	0	0,0006	0	0	0
$I(GIIPS_i = 1)\times$ $uncert_{t-3}$	0,0008	0	0,0004	0,0018	0	0,0007	0	0	0
$I(GIIPS_i = 1)\times$ $uncert_{t-4}$	0,0004	0	0,0002	0,0008	0	0,0004	0	0	0
$I(GIIPS_i = 1)\times$ gdp_{t-1}	0,0011	0	0,0004	0,0008	0	0,0003	0	0	0
$I(GIIPS_i = 1)\times$ gdp_{t-2}	0,0007	0	0,0003	0,0006	0	0,0002	0	0	0
$I(GIIPS_i = 1)\times$ gdp_{t-3}	0,0008	0	0,0003	0,0012	0	0,0004	0	0	0
$I(GIIPS_i = 1)\times$ gdp_{t-4}	0,0036	0,0001	0,0011	0,0023	0	0,0008	0	0	0
$I(GIIPS_i = 1)\times$ bop_{t-1}	0,0005	0	0,0002	0,0014	0	0,0005	0	0	0
$I(GIIPS_i = 1)\times$ bop_{t-2}	0,0006	0	0,0003	0,0014	0	0,0005	0	0	0
$I(GIIPS_i = 1)\times$ bop_{t-3}	0,0007	0	0,0004	0,0007	0	0,0003	0	0	0
$I(GIIPS_i = 1)\times$ bop_{t-4}	0,0006	0	0,0003	0,001	0	0,0004	0	0	0
$I(GIIPS_i = 1)\times$ $debt_{t-1}$	0,0005	0	0,0009	0,0333	-0,0009	0,0075	0	0	0
$I(GIIPS_i = 1)\times$ $debt_{t-2}$	0,001	-0,0002	0,0101	0,046	-0,0045	0,0447	0	0	0
$I(GIIPS_i = 1)\times$ $debt_{t-3}$	0,0007	0	0,0031	0,0305	-0,0007	0,0168	0	0	0
$I(GIIPS_i = 1)\times$ $debt_{t-4}$	0,0007	0,0001	0,0094	0,0281	0,0025	0,0412	0	0	0
$I(GIIPS_i = 1)\times$ inf_{t-1}	0,0007	0	0,0005	0,0006	0	0,0003	0	0	0
$I(GIIPS_i = 1)\times$ inf_{t-2}	0,0013	0	0,0008	0,0006	0	0,0003	0	0	0
$I(GIIPS_i = 1)\times$ inf_{t-3}	0,0006	0	0,0004	0,001	0	0,0005	0	0	0
$I(GIIPS_i = 1)\times$ inf_{t-4}	0,0016	0	0,001	0,0007	0	0,0003	0	0	0
$I(ZLB_t = 1)$	0,0006	0	0,001	0,0006	0	0,0011	0,9568	0,0093	0,0124
$I(ZLB_t = 1)\times$ $synch_{t-1}$	1	-1,0803	0,0722	1	-1,0906	0,0728	1	-1,0936	0,07
$I(ZLB_t = 1)\times$ $synch_{t-2}$	1	0,9435	0,1183	1	0,977	0,089	1	1,0111	0,0747
$I(ZLB_t = 1)\times$ $synch_{t-3}$	0,1944	0,0354	0,0735	0,0568	0,0088	0,0384	0,0002	0	0,003
$I(ZLB_t = 1)\times$ $synch_{t-4}$	0,003	-0,0003	0,0053	0,0201	-0,0024	0,0177	0,0031	-0,0002	0,0051
$I(ZLB_t = 1)\times$ $uncert_{t-1}$	0,0008	0	0,0006	0,0007	0	0,0004	0	0	0
$I(ZLB_t = 1)\times$ $uncert_{t-2}$	0,0006	0	0,0004	0,0009	0	0,0004	0	0	0
$I(ZLB_t = 1)\times$ $uncert_{t-3}$	0,0005	0	0,0004	0,0007	0	0,0005	0	0	0
$I(ZLB_t = 1)\times$ $uncert_{t-4}$	0,0007	0	0,0004	0,0007	0	0,0004	0	0	0
$I(ZLB_t = 1)\times$ gdp_{t-1}	0,0006	0	0,0002	0,0004	0	0,0002	0	0	0
$I(ZLB_t = 1)\times$ gdp_{t-2}	0,0013	0	0,0005	0,0013	0	0,0005	0	0	0
$I(ZLB_t = 1)\times$ gdp_{t-3}	0,0006	0	0,0002	0,0005	0	0,0002	0	0	0
$I(ZLB_t = 1)\times$ gdp_{t-4}	0,0006	0	0,0004	0,0005	0	0,0002	0	0	0
$I(ZLB_t = 1)\times$ bop_{t-1}	0,0006	0	0,0003	0,0006	0	0,0002	0	0	0
$I(ZLB_t = 1)\times$ bop_{t-2}	0,0006	0	0,0002	0,0007	0	0,0003	0	0	0
$I(ZLB_t = 1)\times$ bop_{t-3}	0,0007	0	0,0003	0,0009	0	0,0003	0	0	0
$I(ZLB_t = 1)\times$ bop_{t-4}	0,0006	0	0,0003	0,0008	0	0,0003	0	0	0
$I(ZLB_t = 1)\times$ $debt_{t-1}$	0,0012	0	0,0014	0,0011	0	0,0013	0	0	0,0003
$I(ZLB_t = 1)\times$ $debt_{t-2}$	0,0012	0	0,004	0,001	0	0,0019	0	0	0,0005

Table 1 continued from previous page

	Time and country fixed effects			Standard BMA			Strong heredity prior		
	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD
$I(ZLB_t = 1)\times\ debt_{t-3}$	0,0017	0,0001	0,0081	0,0011	0,0001	0,0098	0	0	0,0002
$I(ZLB_t = 1)\times\ debt_{t-4}$	0,0013	0	0,0058	0,0012	-0,0001	0,0094	0	0	0,0001
$I(ZLB_t = 1)\times\ inf_{t-1}$	0,0007	0	0,0005	0,0007	0	0,0004	0	0	0
$I(ZLB_t = 1)\times\ inf_{t-2}$	0,0024	-0,0001	0,0014	0,0009	0	0,0006	0	0	0
$I(ZLB_t = 1)\times\ inf_{t-3}$	0,0075	-0,0003	0,004	0,0032	-0,0001	0,0026	0	0	0
$I(ZLB_t = 1)\times\ inf_{t-4}$	0,0007	0	0,001	0,0009	0	0,0007	0	0	0
$I(Draghi_t = 1)$	0,0011	0	0,0017	0,0009	0	0,0017	1	-0,0039	0,0126
$I(Draghi_t = 1) \times synch_{t-1}$	1	0,8569	0,0852	1	0,7924	0,1011	1	0,8196	0,0813
$I(Draghi_t = 1) \times synch_{t-2}$	1	-0,8641	0,1432	0,9999	-0,8032	0,1617	1	-0,7654	0,0876
$I(Draghi_t = 1) \times synch_{t-3}$	0,7775	0,1549	0,0885	0,5808	0,1189	0,1127	0,0065	0,0021	0,0279
$I(Draghi_t = 1) \times synch_{t-4}$	0,006	-0,0008	0,0124	0,0841	-0,017	0,0603	0,0065	-0,0013	0,0184
$I(Draghi_t = 1) \times uncert_{t-1}$	0,0021	0	0,0011	0,0012	0	0,0007	0	0	0
$I(Draghi_t = 1) \times uncert_{t-2}$	0,0015	0	0,0008	0,0013	0	0,0007	0	0	0
$I(Draghi_t = 1) \times uncert_{t-3}$	0,0006	0	0,0004	0,0006	0	0,0003	0	0	0
$I(Draghi_t = 1) \times uncert_{t-4}$	0,0005	0	0,0003	0,0006	0	0,0003	0	0	0
$I(Draghi_t = 1) \times gdp_{t-1}$	0,0004	0	0,0002	0,0006	0	0,0002	0	0	0
$I(Draghi_t = 1) \times gdp_{t-2}$	0,0008	0	0,0004	0,0009	0	0,0005	0	0	0
$I(Draghi_t = 1) \times gdp_{t-3}$	0,0005	0	0,0002	0,0006	0	0,0002	0	0	0
$I(Draghi_t = 1) \times gdp_{t-4}$	0,0006	0	0,0011	0,0007	0	0,0006	0	0	0,0004
$I(Draghi_t = 1) \times bop_{t-1}$	0,0007	0	0,0003	0,0006	0	0,0002	0	0	0
$I(Draghi_t = 1) \times bop_{t-2}$	0,0005	0	0,0002	0,0007	0	0,0003	0	0	0
$I(Draghi_t = 1) \times bop_{t-3}$	0,0009	0	0,0004	0,001	0	0,0004	0	0	0
$I(Draghi_t = 1) \times bop_{t-4}$	0,0008	0	0,0003	0,0009	0	0,0003	0	0	0
$I(Draghi_t = 1) \times debt_{t-1}$	0,0011	0	0,0034	0,0011	0	0,0013	0	0	0
$I(Draghi_t = 1) \times debt_{t-2}$	0,001	0	0,0035	0,001	0	0,0019	0	0	0,0001
$I(Draghi_t = 1) \times debt_{t-3}$	0,0014	0	0,0017	0,0013	0	0,0014	0	0	0,0001
$I(Draghi_t = 1) \times debt_{t-4}$	0,0011	0	0,0017	0,001	0	0,002	0	0	0,0002
$I(Draghi_t = 1) \times inf_{t-1}$	0,0004	0	0,0003	0,001	0	0,0005	0	0	0
$I(Draghi_t = 1) \times inf_{t-2}$	0,0005	0	0,0004	0,0011	0	0,0007	0	0	0
$I(Draghi_t = 1) \times inf_{t-3}$	0,0076	-0,0007	0,009	0,0114	-0,001	0,0099	0	0	0
$I(Draghi_t = 1) \times inf_{t-4}$	0,0129	0,0011	0,0108	0,0316	0,0021	0,0139	0	0	0,0001

Note: The table depicts the results for specifications where the yield synchronization variable is regressed against the *synchronization levels* of the independent variables. PIP stands for Posterior Inclusion Probability, Post. Mean is the mean of the posterior distribution of the corresponding effect, and Post SD is the standard deviation of the posterior distribution

The results of the BMA exercise reveal the importance of persistence dynamics to explain sovereign bond yield synchronization. For all prior settings, only autoregressive terms of the synchronization measure achieve high PIPs, and depending on the prior setting, robust differences in persistence and in the long-run mean of the synchronization variable are identified in different periods, as identified by the emergence of the zero lower bound and Mario Draghi's speech. The results in settings where no heredity prior is employed show that in recessions and periods for which the Euribor was below zero, as well as in the post-Draghi period, robust changes in the partial correlation between lagged values of the synchronization variable and current ones are observed. On the other hand, the setting which imposes a strong heredity prior only indicates different dynamics for the synchronization variable in the zero lower bound and post-Draghi periods as compared to the rest of the sample.

Concentrating on the results based on a strong heredity prior, which is a more conservative setting in terms of finding robust structural breaks, the results indicate a different level and volatility of the synchronization indicator in periods that are characterized by the zero lower bound of interest rates being a binding constraint. The estimated coefficients indicate dynamics of the synchronization measure that tend to be much less volatile and less persistent during the zero lower bound period as compared to the rest of the sample. This result is in line with the view that the ECB's unconventional monetary policy was able to increase the connectedness of long-term interest rate returns across countries of the euro area (see for example Akovali et al., 2021; Malliaropulos & Migiakis, 2018).

Our results show that economic fundamentals are not able to robustly predict the synchronization level of government bond yields in the EMU. This conclusion is in conflict with the results often found in the sovereign yield spreads literature, which suggests that variables describing the fiscal position of countries are strong predictors of government bond yield spreads and thus would affect the synchronization of yields within the monetary union. The results of our model averaging exercise, on the other hand, show that modeling structural breaks in the dynamics of synchronization for particular periods related to the economic environment in which bond markets operate is capable of explaining the joint dynamics of long-term government bond yields better than specifications based on macroeconomic indicators.

The fact that macroeconomic fundamentals are found not to predict long-term yield synchronization rates relates to the nature of the synchronization measure employed. As stated previously, this measure is driven by a direct comparison between the yield volatility in the union and a counterfactual union in which a particular country is not included. This means that the inclusion of a particular country in the Union might induce higher yield volatility, irrespective of whether this is due to the country experiencing higher or lower yield levels relative to other countries in the Union.

With this in mind, the nature of our synchronization exercise would call for the use of similar synchronization measures as explanatory variables in the model. By including covariates based on synchronization indices instead of levels of the potential covariates, we are able to address whether desynchronization in particular macroeconomic variables acts as robust predictors of bond yield desynchronization in EMU. For that purpose, we repeat our BMA analysis but replace the controls with synchronization indices for that particular variable, making use of Equation (3). Using these indices as potential covariates, the results of applying BMA with the same settings as those for the case in Table 1 are presented in Table 2.[10]

Similarly to the results based on covariates in levels, we find that government bond yield synchronization is a persistent process whose dynamics changed in the zero lower bound and the post-Draghi periods and appear different in the group of GIIPS countries. In addition, the results suggest that inflation synchronization indices are robust predictors of long-term government bond yields and that such an effect also differs quantitatively for the zero lower bound period and GIIPS countries. The overall effect of inflation differentials, as measured by the sum of the coefficients of the lagged inflation synchronization variables, appears larger in these subsamples, indicating a larger sensitivity of government bond yield synchronization to inflation synchronization. This result indicates that monitoring inflation differentials can be of particular importance as a leading indicator of asymmetric shocks to government bond yields in the euro area.

Table 2: **Bayesian Model Averaging results (covariates as synchronization indices)**

	Time and country fixed effects			Standard BMA			Strong heredity prior		
	PIP	Post. Mean	Post. SD	PIP	Post. Mean	Post. SD	PIP	Post. Mean	Post. SD
$synch_{t-1}$	1	0,7685	0,0539	1	0,8029	0,0669	1	1,1141	0,051
$synch_{t-2}$	0,0173	-0,0034	0,0278	0,0286	-0,0059	0,0376	1	-0,2705	0,0713
$synch_{t-3}$	0,0683	-0,0105	0,0411	0,0713	-0,0105	0,0401	0,994	0,0084	0,1499
$synch_{t-4}$	0,3764	0,0518	0,0728	0,6654	0,0947	0,0753	0,4416	0,1021	0,119
$uncert_{t-1}$	0,0015	0	0,0003	0,0015	0	0,0003	0,001	0	0,0002
$uncert_{t-2}$	0,0014	0	0,0003	0,0021	0	0,0004	0,0019	0	0,0005
$uncert_{t-3}$	0,0016	0	0,0004	0,0019	0	0,0004	0,0018	0	0,0004
$uncert_{t-4}$	0,0011	0	0,0003	0,0012	0	0,0003	0,001	0	0,0002
gdp_{t-1}	0,0012	0	0,0004	0,0018	0	0,0004	0,001	0	0,0003
gdp_{t-2}	0,0011	0	0,0004	0,0014	0	0,0003	0,0009	0	0,0003
gdp_{t-3}	0,0081	0,0002	0,002	0,0051	0,0001	0,0011	0,0031	0	0,0013
gdp_{t-4}	0,0015	0	0,0004	0,0013	0	0,0003	0,0023	0	0,0006
bop_{t-1}	0,0013	0	0,0003	0,0059	0,0001	0,0012	0,0019	0	0,0005

[10]For the sake of completeness, we also conducted a similar analysis for a setting where the government bond yield spreads (and not the synchronization measures) are used as the dependent variable and the potential independent variables enter the model in levels. The results are presented in the Appendix and confirm the conclusion that public debt and inflation dynamics are robust drivers of yield differentials (especially when interacted with the GIIPS variable), although they do not appear to predict differences in synchronization measures based on government bond yields.

Table 2 continued from previous page

	Time and country fixed effects			Standard BMA			Strong heredity prior		
	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD
bop_{t-2}	0,0013	0	0,0004	0,002	0	0,0004	0,0013	0	0,0003
bop_{t-3}	0,002	0	0,0006	0,0015	0	0,0003	0,0012	0	0,0003
bop_{t-4}	0,001	0	0,0003	0,0028	0	0,0006	0,0012	0	0,0003
$debt_{t-1}$	0,0055	0,0002	0,0033	0,006	0,0002	0,0033	0,2038	0,0084	0,0179
$debt_{t-2}$	0,0172	0,0016	0,0167	0,007	0,0003	0,004	0,3634	0,0168	0,0287
$debt_{t-3}$	0,0056	0,0002	0,0032	0,0053	0,0002	0,0028	0,0534	0,0007	0,0134
$debt_{t-4}$	0,0087	-0,0007	0,0129	0,0049	0,0001	0,0029	0,0368	-0,0004	0,0137
inf_{t-1}	0,0014	0	0,0004	0,0012	0	0,0004	0,0011	0	0,0005
inf_{t-2}	0,0022	0	0,0008	0,0017	0	0,0005	0,0013	0	0,0006
inf_{t-3}	0,0021	0	0,0012	0,002	0	0,0009	1	0,0498	0,0212
inf_{t-4}	0,0016	0	0,0009	0,0028	0	0,0012	1	-0,0722	0,0216
$I(rec_{it}=1)$	0,0126	-0,0002	0,0024	0,0135	-0,0003	0,0024	0,0276	-0,0003	0,002
$I(rec_{it}=1)\times\ synch_{t-1}$	0,9925	0,2653	0,0531	0,9755	0,2606	0,0622	0,0241	0,0023	0,0174
$I(rec_{it}=1)\times\ synch_{t-2}$	0,9791	-0,2039	0,0516	0,9704	-0,2109	0,0555	0,0052	-0,0007	0,0102
$I(rec_{it}=1)\times\ synch_{t-3}$	0,0104	0,0008	0,0107	0,0086	0,0006	0,0096	0,0005	0	0,0012
$I(rec_{it}=1)\times\ synch_{t-4}$	0,0665	0,0049	0,0192	0,0558	0,0044	0,019	0,0002	0	0,0005
$I(rec_{it}=1)\times\ uncert_{t-1}$	0,0014	0	0,0003	0,0018	0	0,0004	0	0	0
$I(rec_{it}=1)\times\ uncert_{t-2}$	0,0025	0	0,0006	0,0033	0	0,0007	0	0	0
$I(rec_{it}=1)\times\ uncert_{t-3}$	0,0012	0	0,0003	0,001	0	0,0002	0	0	0
$I(rec_{it}=1)\times\ uncert_{t-4}$	0,0011	0	0,0002	0,0011	0	0,0002	0	0	0
$I(rec_{it}=1)\times\ gdp_{t-1}$	0,0021	0	0,0006	0,0022	0	0,0005	0	0	0
$I(rec_{it}=1)\times\ gdp_{t-2}$	0,0012	0	0,0003	0,0012	0	0,0003	0	0	0
$I(rec_{it}=1)\times\ gdp_{t-3}$	0,0019	0	0,0005	0,0018	0	0,0004	0	0	0
$I(rec_{it}=1)\times\ gdp_{t-4}$	0,0037	0	0,0009	0,0023	0	0,0005	0	0	0
$I(rec_{it}=1)\times\ bop_{t-1}$	0,0015	0	0,0004	0,0034	0	0,0008	0	0	0
$I(rec_{it}=1)\times\ bop_{t-2}$	0,0015	0	0,0004	0,0037	0	0,0008	0	0	0
$I(rec_{it}=1)\times\ bop_{t-3}$	0,0013	0	0,0003	0,0015	0	0,0003	0	0	0
$I(rec_{it}=1)\times\ bop_{t-4}$	0,0015	0	0,0004	0,0044	0	0,0009	0	0	0
$I(rec_{it}=1)\times\ debt_{t-1}$	0,0076	0,0002	0,0024	0,0127	0,0004	0,0039	0,0001	0	0,0002
$I(rec_{it}=1)\times\ debt_{t-2}$	0,0185	0,0006	0,0046	0,028	0,001	0,0067	0,0003	0	0,0006
$I(rec_{it}=1)\times\ debt_{t-3}$	0,0076	0,0002	0,0025	0,0102	0,0003	0,0037	0,0001	0	0,0002
$I(rec_{it}=1)\times\ debt_{t-4}$	0,0116	0,0003	0,0032	0,0172	0,0005	0,0045	0,0001	0	0,0003
$I(rec_{it}=1)\times\ inf_{t-1}$	0,0024	0	0,0009	0,0042	0,0001	0,0015	0	0	0
$I(rec_{it}=1)\times\ inf_{t-2}$	0,0052	0,0002	0,0026	0,0126	0,0004	0,0043	0	0	0
$I(rec_{it}=1)\times\ inf_{t-3}$	0,0451	-0,0021	0,0112	0,1684	-0,0073	0,019	0,0059	-0,0003	0,0036
$I(rec_{it}=1)\times\ inf_{t-4}$	0,0187	0,001	0,008	0,0436	0,0023	0,0115	0,0008	0	0,0015
$I(GIIPS_i=1)$	-	-	-	0,0027	0	0,0006	1	-0,0049	0,0091
$I(GIIPS_i=1)\times\ synch_{t-1}$	0,0218	0,0055	0,04	0,0232	0,0046	0,0334	0,0185	0,0021	0,017
$I(GIIPS_i=1)\times\ synch_{t-2}$	0,0649	-0,0129	0,0558	0,1111	-0,0197	0,0612	0,0025	-0,0001	0,0086
$I(GIIPS_i=1)\times\ synch_{t-3}$	0,024	-0,0003	0,0243	0,0192	-0,0014	0,0209	0,0172	0,0017	0,0148
$I(GIIPS_i=1)\times\ synch_{t-4}$	0,2467	0,0367	0,0678	0,2391	0,042	0,0789	0,0071	0,0007	0,0085
$I(GIIPS_i=1)\times\ uncert_{t-1}$	0,001	0	0,0002	0,0013	0	0,0003	0	0	0

Table 2 continued from previous page

	Time and country fixed effects			Standard BMA			Strong heredity prior		
	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD
$I(GIIPS_i = 1)\times$ $uncert_{t-2}$	0,0013	0	0,0004	0,0018	0	0,0004	0	0	0
$I(GIIPS_i = 1)\times$ $uncert_{t-3}$	0,0022	0	0,0006	0,0019	0	0,0004	0	0	0
$I(GIIPS_i = 1)\times$ $uncert_{t-4}$	0,0014	0	0,0003	0,0012	0	0,0003	0	0	0
$I(GIIPS_i = 1)\times$ gdp_{t-1}	0,0024	0	0,0006	0,0018	0	0,0005	0	0	0,0001
$I(GIIPS_i = 1)\times$ gdp_{t-2}	0,0012	0	0,0004	0,0014	0	0,0003	0	0	0
$I(GIIPS_i = 1)\times$ gdp_{t-3}	0,0089	0,0002	0,0021	0,005	0,0001	0,001	0,0001	0	0,0003
$I(GIIPS_i = 1)\times$ gdp_{t-4}	0,0012	0	0,0003	0,0013	0	0,0003	0	0	0
$I(GIIPS_i = 1)\times$ bop_{t-1}	0,0015	0	0,0004	0,0066	0,0001	0,0013	0	0	0
$I(GIIPS_i = 1)\times$ bop_{t-2}	0,0013	0	0,0003	0,0019	0	0,0004	0	0	0
$I(GIIPS_i = 1)\times$ bop_{t-3}	0,0019	0	0,0005	0,0015	0	0,0003	0	0	0
$I(GIIPS_i = 1)\times$ bop_{t-4}	0,001	0	0,0003	0,0031	0	0,0007	0	0	0
$I(GIIPS_i = 1)\times$ $debt_{t-1}$	0,0206	0,0011	0,008	0,1757	0,0112	0,0253	0,0033	0,0002	0,0037
$I(GIIPS_i = 1)\times$ $debt_{t-2}$	0,1209	0,0135	0,0465	0,4205	0,0323	0,0485	0,0082	0,0005	0,0059
$I(GIIPS_i = 1)\times$ $debt_{t-3}$	0,0172	0,0008	0,007	0,1189	0,007	0,0202	0,0004	0	0,0011
$I(GIIPS_i = 1)\times$ $debt_{t-4}$	0,0449	-0,0054	0,0337	0,1041	0,0007	0,0321	0,0005	0	0,0012
$I(GIIPS_i = 1)\times$ inf_{t-1}	0,0009	0	0,0004	0,0013	0	0,0005	0	0	0
$I(GIIPS_i = 1)\times$ inf_{t-2}	0,0025	0	0,0011	0,0029	0	0,0012	0	0	0,0001
$I(GIIPS_i = 1)\times$ inf_{t-3}	1	-0,1299	0,0222	1	-0,1331	0,0205	1	-0,1364	0,0188
$I(GIIPS_i = 1)\times$ inf_{t-4}	1	0,1327	0,0224	1	0,1382	0,0221	1	0,1604	0,0186
$I(ZLB_t = 1)$	0,0016	0	0,0018	0,0019	0,0001	0,002	1	0,0064	0,0112
$I(ZLB_t = 1)\times$ $synch_{t-1}$	1	-1,0912	0,0743	1	-1,0989	0,0776	1	-1,0883	0,0652
$I(ZLB_t = 1)\times$ $synch_{t-2}$	0,9996	0,8017	0,1462	0,9999	0,7767	0,138	1	1,0481	0,0709
$I(ZLB_t = 1)\times$ $synch_{t-3}$	0,8679	0,2049	0,1097	0,8954	0,2229	0,1027	0,0066	0,0011	0,0175
$I(ZLB_t = 1)\times$ $synch_{t-4}$	0,0752	0,0168	0,0636	0,0797	0,0175	0,0636	0,001	0,0001	0,0041
$I(ZLB_t = 1)\times$ $uncert_{t-1}$	0,0013	0	0,0003	0,0014	0	0,0003	0	0	0
$I(ZLB_t = 1)\times$ $uncert_{t-2}$	0,0012	0	0,0003	0,0017	0	0,0003	0	0	0
$I(ZLB_t = 1)\times$ $uncert_{t-3}$	0,0011	0	0,0003	0,0013	0	0,0003	0	0	0
$I(ZLB_t = 1)\times$ $uncert_{t-4}$	0,0012	0	0,0003	0,0014	0	0,0003	0	0	0
$I(ZLB_t = 1)\times$ gdp_{t-1}	0,0013	0	0,0003	0,0016	0	0,0004	0	0	0
$I(ZLB_t = 1)\times$ gdp_{t-2}	0,0014	0	0,0003	0,0018	0	0,0004	0	0	0
$I(ZLB_t = 1)\times$ gdp_{t-3}	0,0016	0	0,0006	0,0009	0	0,0002	0	0	0,0002
$I(ZLB_t = 1)\times$ gdp_{t-4}	0,0011	0	0,0003	0,001	0	0,0002	0	0	0
$I(ZLB_t = 1)\times$ bop_{t-1}	0,0011	0	0,0003	0,0014	0	0,0004	0	0	0
$I(ZLB_t = 1)\times$ bop_{t-2}	0,0011	0	0,0003	0,0013	0	0,0003	0	0	0
$I(ZLB_t = 1)\times$ bop_{t-3}	0,0014	0	0,0003	0,0013	0	0,0003	0	0	0
$I(ZLB_t = 1)\times$ bop_{t-4}	0,0013	0	0,0003	0,0019	0	0,0004	0	0	0
$I(ZLB_t = 1)\times$ $debt_{t-1}$	0,0053	-0,0007	0,0127	0,0046	-0,0007	0,012	0,0005	0	0,0006
$I(ZLB_t = 1)\times$ $debt_{t-2}$	0,0039	0,0007	0,0153	0,0035	0,0006	0,0148	0,0009	0	0,0009
$I(ZLB_t = 1)\times$ $debt_{t-3}$	0,8797	-0,5924	0,2497	0,9795	-0,6966	0,1494	0,0002	0	0,0032
$I(ZLB_t = 1)\times$ $debt_{t-4}$	0,878	0,559	0,2396	0,9791	0,6649	0,1454	0,0001	0	0,0031
$I(ZLB_t = 1)\times$ inf_{t-1}	0,0062	0,0001	0,0016	0,0041	0,0001	0,0012	0	0	0,0002
$I(ZLB_t = 1)\times$ inf_{t-2}	0,0407	0,0014	0,0074	0,0164	0,0005	0,0041	0,0002	0	0,0006

Table 2 continued from previous page

	Time and country fixed effects			Standard BMA			Strong heredity prior		
	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD
$I(ZLB_t = 1) \times inf_{t-3}$	0,6088	-0,0307	0,0269	0,4636	-0,0222	0,0253	0,9969	-0,0631	0,0138
$I(ZLB_t = 1) \times inf_{t-4}$	0,0256	0,0012	0,0079	0,0463	0,0022	0,0108	0,0149	0,0008	0,0072
$I(Draghi_t = 1)$	0,0016	0	0,0016	0,0014	0	0,0015	1	-0,0027	0,0112
$I(Draghi_t = 1) \times synch_{t-1}$	1	0,8772	0,0915	1	0,8806	0,0943	1	0,8036	0,0749
$I(Draghi_t = 1) \times synch_{t-2}$	0,9785	-0,6488	0,1629	0,9735	-0,6087	0,1556	1	-0,8493	0,1009
$I(Draghi_t = 1) \times synch_{t-3}$	0,134	0,0198	0,0981	0,117	0,0157	0,0965	0,4332	0,1595	0,1881
$I(Draghi_t = 1) \times synch_{t-4}$	0,748	-0,1872	0,1374	0,9614	-0,2561	0,0983	0,4367	-0,1319	0,1534
$I(Draghi_t = 1) \times uncert_{t-1}$	0,0018	0	0,0004	0,0013	0	0,0003	0	0	0
$I(Draghi_t = 1) \times uncert_{t-2}$	0,0019	0	0,0005	0,0021	0	0,0004	0	0	0
$I(Draghi_t = 1) \times uncert_{t-3}$	0,0013	0	0,0003	0,0012	0	0,0003	0	0	0
$I(Draghi_t = 1) \times uncert_{t-4}$	0,0012	0	0,0003	0,0015	0	0,0003	0	0	0
$I(Draghi_t = 1) \times gdp_{t-1}$	0,001	0	0,0003	0,0012	0	0,0003	0	0	0
$I(Draghi_t = 1) \times gdp_{t-2}$	0,001	0	0,0003	0,0015	0	0,0004	0	0	0
$I(Draghi_t = 1) \times gdp_{t-3}$	0,0018	0	0,0009	0,0013	0	0,0003	0,0004	0	0,0009
$I(Draghi_t = 1) \times gdp_{t-4}$	0,001	0	0,0003	0,0014	0	0,0003	0	0	0
$I(Draghi_t = 1) \times bop_{t-1}$	0,0013	0	0,0003	0,0016	0	0,0005	0	0	0
$I(Draghi_t = 1) \times bop_{t-2}$	0,0014	0	0,0004	0,0013	0	0,0003	0	0	0,0001
$I(Draghi_t = 1) \times bop_{t-3}$	0,002	0	0,0005	0,0015	0	0,0003	0	0	0,0001
$I(Draghi_t = 1) \times bop_{t-4}$	0,0012	0	0,0003	0,0015	0	0,0003	0	0	0
$I(Draghi_t = 1) \times debt_{t-1}$	0,0413	-0,0103	0,053	0,0345	-0,008	0,0459	0,0011	0	0,0012
$I(Draghi_t = 1) \times debt_{t-2}$	0,7343	0,2771	0,1819	0,9342	0,3554	0,1214	0,0009	0	0,0009
$I(Draghi_t = 1) \times debt_{t-3}$	0,0018	0	0,003	0,0021	0,0001	0,0039	0,0003	0	0,0006
$I(Draghi_t = 1) \times debt_{t-4}$	0,7337	-0,2393	0,1538	0,9341	-0,3184	0,1041	0,0003	0	0,0007
$I(Draghi_t = 1) \times inf_{t-1}$	0,0034	0,0001	0,0012	0,0024	0	0,0008	0	0	0,0002
$I(Draghi_t = 1) \times inf_{t-2}$	0,0119	0,0004	0,0037	0,0033	0,0001	0,0014	0	0	0
$I(Draghi_t = 1) \times inf_{t-3}$	0,005	0	0,003	0,0058	-0,0001	0,0032	0,0055	0,0003	0,0053
$I(Draghi_t = 1) \times inf_{t-4}$	0,6239	0,0401	0,0334	0,485	0,0287	0,0317	0,9951	0,0996	0,0167

Note: The table depicts the results for specifications where the yield synchronization variable is regressed against the *synchronization levels* of the independent variables. PIP stands for Posterior Inclusion Probability, Post. Mean is the mean of the posterior distribution of the corresponding effect, and Post SD is the standard deviation of the posterior distribution

3.2 Exploring the Jointness of Yield Synchronization Determinants

In order to explore the nature of the models that perform particularly well in terms of explaining the synchronization of yields in EMU, we analyze the posterior results of the BMA analysis by assessing the joint posterior inclusion probability of pairs of variables. In particular, such an analysis can help us assess the importance of explicitly modeling parameter heterogeneity through the inclusion of interaction terms in specifications aimed at explaining yield synchronization. For this purpose, we compute jointness measures that quantify the likelihood that pairs of variables tend to appear together in specifications with high posterior model probability. We employ jointness measures of based on the work of Doppelhofer & Weeks (2009); Ley & Steel (2009a), Ley & Steel (2007) and Hofmarcher et al. (2018).[11] For all of the measures considered here, positive values for the jointness measure indicate that the two specific covariates at hand act as complements in the sense that they tend to appear jointly in specifications with high posterior model probability. Larger values of the jointness variables indicate that the posterior model probabilities of models which include (and/or exclude) these two covariates are larger than those which only include one of the variables (see Amini & Parmeter, 2020, for a comprehensive review of jointness measures).

We start by analyzing the jointness between covariates for the space of models in which the bond yield synchronization indicators are explained by the levels of the independent variables and we include country and period fixed effects. In Figure 4, we show a heatmap of the jointness measure proposed by Hofmarcher et al. (2018) for this case, while the corresponding heatmaps for the other jointness indicators can be found in the Appendix. The covariate pairs with the highest level of jointness include the variables that are found to have the highest individual posterior inclusion probabilities: lags of the yield synchronization variable and their interactions with the post-Draghi and zero lower bound dummies. These results point to the need of addressing structural breaks in the specification of the dynamics of yield synchronization in the period under study.[12]

We also compute jointness measures for the space of models in which we regress the bond yield synchronization variables on the synchronization indices of the independent variables. The results are presented in Figure 5 for the jointness measure by Hofmarcher et al. (2018) and in the Appendix for the rest of the jointness indicators. As in the previous case, the measures by Ley & Steel (2007) and Hofmarcher et al. (2018) indicate the same group of variables as those with the highest pairwise jointness. The covariates that have high jointness values are similar to those found for the case where the levels of the variables are used as covariates, expanded with inflation synchronization and its

[11] See the Appendix for a detailed description of the measures employed, as well as the visualization of all of the jointness measures employed.

[12] For the measure proposed in Doppelhofer & Weeks (2009), some lags of the synchronization variable interacted with the post-Draghi and recession dummies appear as strong complements with lags of the balance of payments, the zero lower bound dummy, and certain lags of GDP growth interacted with the recession variable.

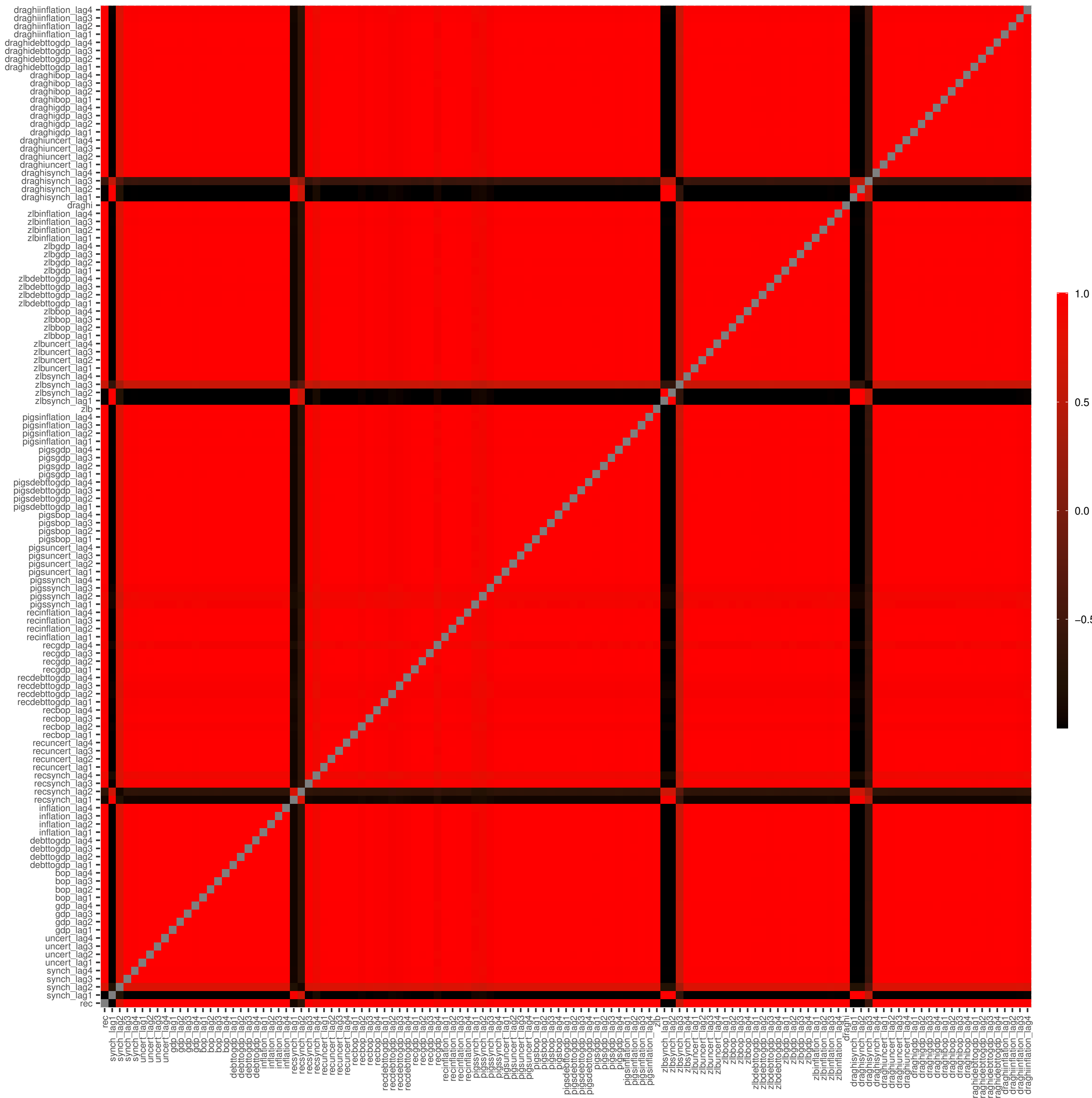


Figure 4: **Jointness results**. The heatmap depicts the jointness between the variables in the model where we regress the yield synchronization rates against the *levels* of the independent variables. The measure used is the one by Hofmarcher et al. (2018)

interactions with the PIIGS dummy.[13]

[13] When computing the measure by Doppelhofer & Weeks (2009), we find a substantially higher number of covariates that are strong complements. These include synchronization in inflation, uncertainty, the balance of payments, and GDP, both as parent variables and interacted with the PIIGS and zero lower bound dummies.

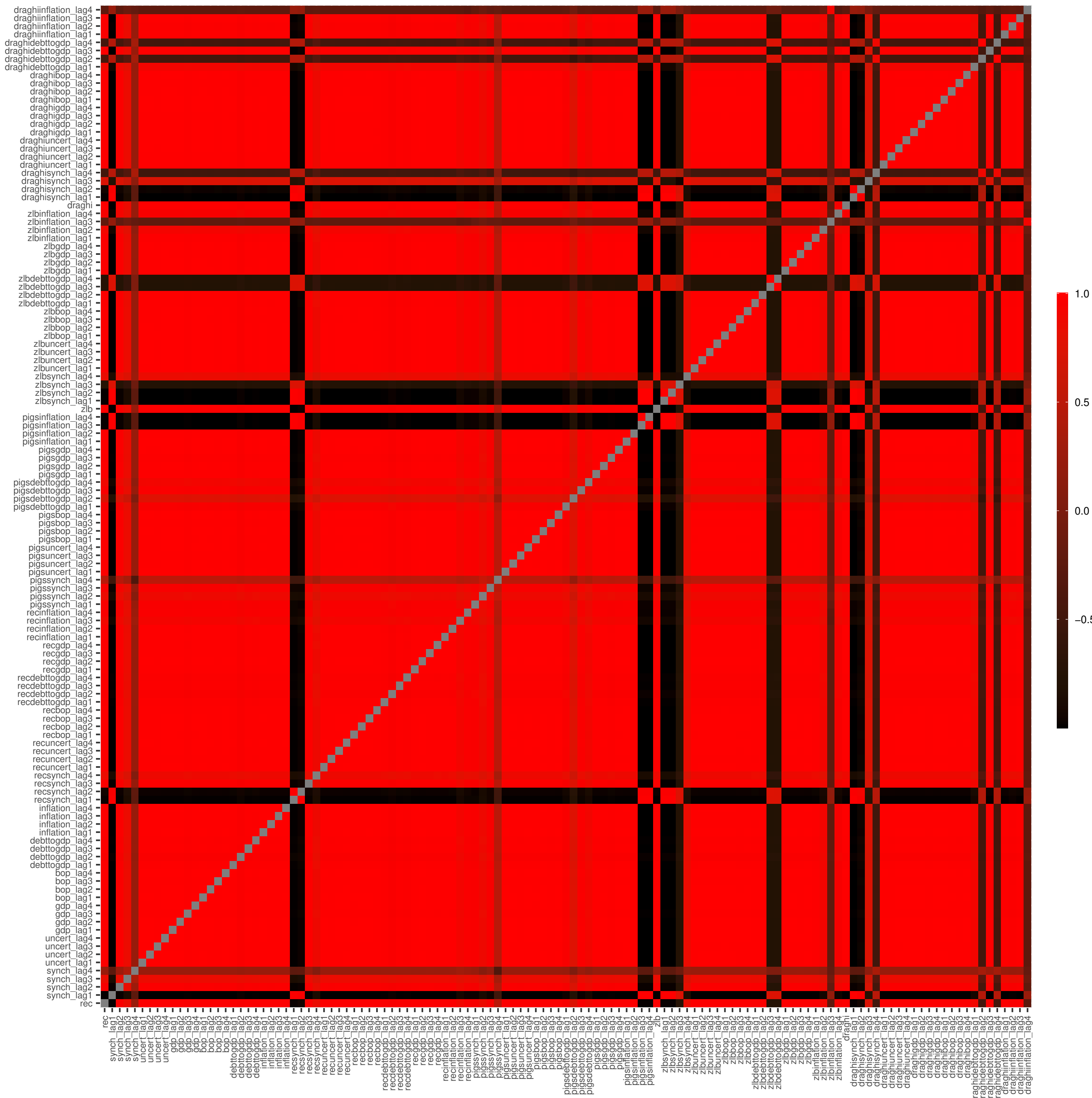


Figure 5: **Jointness results**. The heatmap depicts the jointness between the variables in the model where we regress the yield synchronization rates against the *synchronization rates* of the independent variables. The measure used is the one by Hofmarcher et al. (2018).

4 Forecasting Sovereign Yield Synchronization Rates

In this section, we examine the extent to which assessing model uncertainty can improve the forecasting accuracy of long-term yield synchronization by performing a comprehensive comparison of predictive quality across a battery of models in a pseudo out-of-sample forecasting exercise. We compare the predictive ability of model-averaged forecasts with those obtained from a panel autoregressive model (pooled AR(1), including country-fixed effects and year effects), as well as country-specific autoregressive specifications. In addition, we also evaluate the predictive accuracy of so-called median probability models, that is, single specifications that include those covariates whose posterior inclusion probability is above 0.5. The predictive ability of such a model specification is known to be optimal for selection among normal linear models (M. M. Barbieri et al., 2004).

BMA point forecasts of the synchronization measure are based on weighting model-specific out-of-sample predictions using their corresponding posterior model probability,

$$\widehat{synch}_{i\tau+1}^{\text{BMA}} = \sum_{j=1}^{J} E(synch_{i\tau+1}|y, M_j, \{y_{\cdot t}\}_{t=1}^{\tau}) P(M_j|y, \{y_{\cdot t}\}_{t=1}^{\tau}), \tag{10}$$

where conditioning on $\{y_{\cdot t}\}_{t=1}^{T}$ implies that only information ranging from period 1 to period T is employed to compute the corresponding quantities.

We start by using the sample corresponding to 2001Q1-2018Q4 as an initial period sample and create one-quarter ahead predictions for all countries in the period 2019Q1. The estimation sample is then extended with the observations for 2019Q1 and the exercise is repeated recursively until the last observation of our full sample, 2020:Q4, is reached. We entertain five different types of specifications: Pooled AR(1) model, country-specific AR(1) models, BMA based on explanatory variables in levels, BMA based on explanatory variables in the form of synchronization measures, median probability model based on BMA with explanatory variables in levels and median probability model based on BMA with explanatory variables in synchronization form. We analyze the forecasting ability of each model using standard measures such as the root mean square error (RMSE), given by

$$\text{RMSE} = \sqrt{\frac{1}{C(T-T_0)} \sum_{i=1}^{N} \sum_{t=T_0}^{T} \left(synch_t - \widehat{synch}_{it} \right)^2}, \tag{11}$$

where C is the number of countries for which forecasts are obtained, T_0 is the first period of the out-of-sample subsample and T is the final period for which data are available. We also evaluate measures that provide information on the directional accuracy of the forecasts produced by the models considered (see for example Böck et al., 2021, for a use of these statistics in the context of prediction of credit default swap volatility). The overall directional accuracy measure is defined as the ratio of correctly predicted direction change (increase versus decrease) to all predicted changes. We complement this statistic with information about the relative number of correct predictions of increases in the synchronization measure (the hit rate) and of incorrect ones (the false alarm rate). The Hanssen and Kuipers Score is given by the difference between these two measures and is often used to evaluate forecasts of binary variables. The Hanssen and Kuipers Score is bounded between -1 and 1, with positive values of the score implying a hit rate that is higher than the false alarm.

The results of the forecasting exercise are presented in Table 3, which shows the RMSE, hit rate, false alarm rate, and Hanssen and Kuipers Score for the full sample of EMU countries, as well as for GIIPS and non-GIIPS economies separately. The predictions from country-specific AR(1) models yield the lowest RMSE systematically across all samples considered, with the second-best forecasts being achieved by the median probability model based on covariates in levels. The results for measures of out-of-sample directional accuracy indicate a very low degree of predictability in government bond yield synchronization changes, and thus a limited informational contribution of differences in macroeconomic fundamentals. A (small) positive value of the Hanssen and Kuipers Score is only achieved for the subsample of non-GIIPS countries when using BMA forecasts with both levels and synchronization covariates, and the rest of the forecasts are characterized by relatively high false alarm rates coupled with hit rates that do not tend to exceed 0.5. These findings reveal that monitoring those macroeconomic fundamentals with the highest PIPs (both in levels and synchronization dynamics) may allow policymakers, in particular those belonging to GIIPS countries, to improve predictions of short-term changes in their yield synchronization rates. For the other subsamples, the overall performance of these models and specification-averaged predictions is relatively poor.

5 Conclusions

In this paper, we examine the predictability of synchronization measures for sovereign yields within the EMU. Our findings reveal disparities in the dynamics of synchronization measures between recessions and expansion periods and distinct autocorrelation patterns during the years characterized by zero interest rates and the period following Draghi's *whatever it takes* speech. Our analysis indicates that, in general, fundamental macroeconomic variables are not able to predict government bond yield synchronization levels. The latter is attributable to our specific choice of the synchronization measure, which takes into account the structure of the monetary union. Our findings reveal that a rigorous assessment of model uncertainty appears necessary to assess empirically the drivers of sovereign yield

Table 3: **Results of the forecasting exercise.**

	RMSE	Directional Accuracy	Hit Rate	False Alarm Rate	Kuiper Score
All countries					
Pooled AR(1)	0.0330	0.3571	0.4737	0.7167	-0.2430
Country-specific AR(1)	0.0089	0.4490	0.3158	0.4667	-0.1509
BMA (levels)	0.0105	0.3673	0.4211	0.6667	-0.2456
BMA (synchronization)	0.0153	0.4388	0.3684	0.5167	-0.1482
Median prob. model (levels)	0.0103	0.5000	0.4211	0.4500	-0.0289
Median prob. model (synchronization)	0.0152	0.5000	0.5000	0.5000	0.0000
GIIPS					
Pooled AR(1)	0.0332	0.3429	0.4706	0.7778	-0.3072
Country-specific AR(1)	0.0146	0.3714	0.3529	0.6111	-0.2582
BMA (levels)	0.0169	0.4286	0.3200	0.6111	-0.2911
BMA (synchronization)	0.0246	0.4857	0.5294	0.5556	-0.0261
Median prob. model (levels)	0.0168	0.5143	0.5294	0.5000	0.0294
Median prob. model (synchronization)	0.0244	0.5143	0.5882	0.5556	0.0327
Non-GIIPS					
Pooled AR(1)	0.0329	0.3651	0.4762	0.6905	-0.2143
Country-specific AR(1)	0.0022	0.4921	0.2857	0.4048	-0.1190
BMA (levels)	0.0037	0.3333	0.2759	0.6905	-0.4146
BMA (synchronization)	0.0054	0.4127	0.2381	0.5000	-0.2619
Median prob. model (levels)	0.0030	0.4921	0.3333	0.4286	-0.0952
Median prob. model (synchronization)	0.0055	0.4921	0.4286	0.4762	-0.0476

Note: Predictive accuracy statistics based on pseudo out-of-sample forecasts for the period 2019Q1-2020Q4, computed using a recursively expanding sample starting in 2001Q1. See text for details on the predictive accuracy measures.

misalignment within the EMU and that the benefits that can be reaped from such modeling efforts in terms of predictive improvements may be relevant for GIIPS countries, although not for other EMU members.

Our results stand in contrast with those found in the empirical literature on sovereign yield spreads, which tend to indicate that economic fundamentals (and in particular, fiscal variables) are good predictors of government bond yield spreads. Our analysis shows that, while fiscal variables may have an effect on government bond yields, they are not able to robustly explain how their synchronization across EMU countries has evolved over the last decades.

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6 Appendix

Country	Start date	End date
Austria	2001-01-01	2021-07-01
Belgium	2004-01-01	2021-07-01
Finland	2001-01-01	2021-07-01
France	2001-01-01	2021-07-01
Germany	2001-01-01	2021-07-01
Greece	2003-01-01	2021-07-01
Ireland	2003-01-01	2021-07-01
Italy	2001-01-01	2021-07-01
Latvia	2015-01-01	2019-10-01
Lithuania	2016-01-01	2020-01-01
Netherlands	2004-04-01	2021-07-01
Portugal	2001-01-01	2021-07-01
Slovakia	2010-01-01	2021-07-01
Slovenia	2008-01-01	2021-07-01
Spain	2001-01-01	2021-07-01

Table 4: **Data availability for all countries considered**

	Austria				Belgium				Finland			
	Mean	St. Dev.	Min	Max	Mean	St. Dev.	Min	Max	Mean	St. Dev.	Min	Max
Yield synch.	0.012	0.005	0.001	0.021	0.014	0.003	0.009	0.021	0.009	0.007	-0.016	0.021
Uncertainty	0.167	0.161	0.000	0.639	0.140	0.130	0.000	0.616	0.145	0.159	0.000	0.658
GDP	0.334	1.977	-12.135	10.261	0.381	2.125	-12.374	11.228	0.314	1.465	-6.697	4.907
Debt to GDP	76.510	6.536	65.000	87.000	103.101	6.432	87.300	116.900	49.539	11.620	28.700	70.400
Inflation	1.881	0.803	-0.067	3.800	1.878	1.216	-1.133	5.600	1.540	1.091	-0.333	4.533
Recession	0.410	0.495	0	1	0.366	0.485	0	1	0.458	0.501	0	1
	France				Germany				Greece			
Yield synch.	0.010	0.006	-0.014	0.020	-0.018	0.035	-0.119	0.012	-0.184	0.147	-0.689	-0.010
Uncertainty	0.217	0.151	0.000	0.780	0.221	0.191	0.000	0.928	0.185	0.176	0.000	0.689
GDP	0.283	2.619	-14.461	17.043	0.281	1.785	-10.532	8.657	-0.178	2.552	-14.442	5.223
Debt to GDP	83.604	17.261	57.900	117.900	68.624	6.854	57.700	82.000	149.611	36.120	99.900	209.800
Inflation	1.518	0.878	-0.467	3.700	1.516	0.834	-0.633	3.533	1.502	2.060	-2.233	5.600
Recession	0.434	0.499	0	1	0.482	0.503	0	1	0.360	0.483	0	1
	Ireland				Italy				Latvia			
Yield synch.	0.006	0.018	-0.076	0.021	-0.015	0.035	-0.104	0.017	0.013	0.001	0.011	0.014
Uncertainty	0.266	0.286	0.000	1.433	0.246	0.194	0.000	0.865	0.268	0.140	0.071	0.532
GDP	1.258	3.755	-4.325	21.711	0.011	2.442	-13.503	14.853	0.741	0.762	-0.954	1.841
Debt to GDP	65.579	31.839	23.600	124.600	123.407	15.096	103.900	159.600	37.845	1.287	35.900	40.400
Inflation	1.072	1.628	-2.767	4.933	1.651	1.141	-0.400	4.067	1.708	1.396	-0.700	3.300
Recession	0.480	0.503	0	1	0.313	0.467	0	1	0.550	0.510	0	1
	Lithuania				Netherlands				Portugal			
Yield synch.	0.009	0.005	-0.0003	0.015	0.007	0.006	-0.018	0.019	0.010	0.019	-0.028	0.055
Uncertainty	0.252	0.207	0.000	0.676	0.209	0.182	0.000	0.757	0.207	0.148	0.000	0.591
GDP	0.970	0.280	0.397	1.393	0.357	1.614	-8.748	7.237	0.130	2.611	-16.546	13.691
Debt to GDP	37.035	2.798	32.800	41.300	56.513	7.477	43.000	68.900	100.230	30.047	54.000	139.100
Inflation	2.306	1.150	0.367	4.433	1.523	0.907	-0.500	3.300	1.713	1.512	-1.500	4.767
Recession	0.294	0.470	0	1	0.400	0.493	0	1	0.410	0.495	0	1
	Slovakia				Slovenia				Spain			
Yield synch.	0.014	0.002	0.006	0.017	0.012	0.006	-0.008	0.017	0.014	0.004	0.004	0.021
Uncertainty	0.134	0.131	0.000	0.569	0.191	0.151	0.000	0.538	0.235	0.167	0.000	0.819
GDP	0.553	1.896	-7.501	8.680	0.283	2.476	-9.911	11.178	0.288	2.914	-19.422	15.528
Debt to GDP	51.434	6.004	36.800	61.100	61.338	20.351	21.800	85.000	72.592	27.494	35.000	125.300
Inflation	1.654	1.544	-0.733	4.667	1.497	1.677	-1.167	6.433	1.922	1.604	-1.167	4.933
Recession	0.362	0.486	0	1	0.436	0.501	0	1	0.470	0.502	0	1

Table 5: **Summary statistics for the variables of interest (by country)**

Table 6: **Bayesian Model Averaging results**. The table depicts the results where the yield spreads are regressed against the *levels* of the independent variables. Note: PIP stands for Posterior Inclusion Probability.

	Time and country fixed effects			Standard BMA			Strong heredity prior		
	PIP	Post. Mean	Post. SD	PIP	Post. Mean	Post. SD	PIP	Post. Mean	Post. SD
$spread_{t-1}$	1	1,0113	0,0719	1	1,041	0,0694	1	0,9639	0,0642
$spread_{t-2}$	1	-0,5048	0,0965	1	-0,5149	0,0943	1	-0,4148	0,0763
$spread_{t-3}$	0,9999	0,2421	0,056	0,9999	0,2542	0,0442	0,9995	0,2514	0,0509
$spread_{t-4}$	0,0862	-0,0077	0,0265	0,0121	-0,0008	0,0079	0,9991	-0,0225	0,0288
$uncert_{t-1}$	0,0024	0	0,0006	0,0066	-0,0001	0,0013	0,0057	-0,0001	0,001
$uncert_{t-2}$	0,0009	0	0,0002	0,0016	0	0,0003	0,0016	0	0,0003
$uncert_{t-3}$	0,0011	0	0,0003	0,0024	0	0,0005	0,002	0	0,0004
$uncert_{t-4}$	0,0009	0	0,0002	0,0015	0	0,0004	0,0013	0	0,0003
gdp_{t-1}	0,0017	0	0,0004	0,0026	0	0,0006	0,001	0	0,0002
gdp_{t-2}	0,0029	0	0,0008	0,0028	0	0,0007	0,0041	-0,0001	0,001
gdp_{t-3}	0,0008	0	0,0002	0,0013	0	0,0003	0,0045	0,0001	0,0009
gdp_{t-4}	0,0017	0	0,0004	0,0017	0	0,0004	0,0037	0	0,0007
bop_{t-1}	0,0055	-0,0001	0,0014	0,1459	-0,004	0,0103	0,5185	-0,0138	0,0143
bop_{t-2}	0,0009	0	0,0003	0,0031	0	0,001	0,0056	-0,0001	0,0013
bop_{t-3}	0,001	0	0,0004	0,0126	-0,0003	0,0032	0,0371	-0,0008	0,0043
bop_{t-4}	0,0008	0	0,0003	0,0068	-0,0002	0,0026	0,0117	-0,0002	0,0022
$debt_{t-1}$	0,0017	0,0001	0,0024	0,0009	0	0,0004	0,005	0,0011	0,0234
$debt_{t-2}$	0,0015	0	0,0019	0,0011	0	0,0008	0,2898	-0,0865	0,1441
$debt_{t-3}$	0,0014	0,0001	0,002	0,0012	0	0,0008	0,9964	0,5932	0,1892
$debt_{t-4}$	0,0009	0	0,0014	0,0012	0	0,0004	0,9982	-0,4906	0,1309
inf_{t-1}	0,0022	0	0,0012	0,0071	0,0003	0,0035	0,0011	0	0,0005
inf_{t-2}	0,0274	0,0013	0,0084	0,3632	0,0252	0,0349	0,018	0,0008	0,0071
inf_{t-3}	0,0923	0,0052	0,0175	0,4925	0,036	0,0385	0,9817	0,0398	0,0389
inf_{t-4}	0,002	0	0,002	0,0063	-0,0003	0,0042	0,2766	-0,0214	0,0369
$I(rec_{it}=1)$	0,817	-0,0383	0,0224	0,1285	-0,0055	0,015	1	-0,0353	0,0109
$I(rec_{it}=1)\times spread_{t-1}$	0,4732	0,0732	0,0809	0,4157	0,0647	0,0806	0,9008	0,1776	0,0638
$I(rec_{it}=1)\times spread_{t-2}$	0,5333	0,1203	0,1142	0,5914	0,1309	0,1108	0,1067	0,0217	0,064
$I(rec_{it}=1)\times spread_{t-3}$	0,3941	0,0623	0,0808	0,3336	0,0512	0,0756	0,0672	0,0082	0,0328
$I(rec_{it}=1)\times spread_{t-4}$	1	-0,1593	0,0408	1	-0,1574	0,0375	0,9991	-0,1069	0,028
$I(rec_{it}=1)\times uncert_{t-1}$	0,0157	-0,0004	0,0031	0,0192	-0,0004	0,0034	0	0	0
$I(rec_{it}=1)\times uncert_{t-2}$	0,002	0	0,0006	0,0024	0	0,0006	0	0	0
$I(rec_{it}=1)\times uncert_{t-3}$	0,0019	0	0,0007	0,0021	0	0,0006	0	0	0,0001
$I(rec_{it}=1)\times uncert_{t-4}$	0,021	-0,0005	0,0035	0,0189	-0,0004	0,003	0	0	0
$I(rec_{it}=1)\times gdp_{t-1}$	0,001	0	0,0002	0,001	0	0,0002	0	0	0
$I(rec_{it}=1)\times gdp_{t-2}$	0,0009	0	0,0002	0,0008	0	0,0002	0	0	0
$I(rec_{it}=1)\times gdp_{t-3}$	0,0012	0	0,0002	0,0012	0	0,0002	0	0	0
$I(rec_{it}=1)\times gdp_{t-4}$	0,002	0	0,0005	0,0025	0	0,0005	0	0	0,0001
$I(rec_{it}=1)\times bop_{t-1}$	0,0068	-0,0001	0,0014	0,148	-0,0034	0,0085	0,0007	0	0,0003

Table 6 continued from previous page

	Time and country fixed effects			Standard BMA			Strong heredity prior		
	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD
$I(rec_{it}=1)\times\ bop_{t-2}$	0,0012	0	0,0003	0,0106	-0,0002	0,0018	0	0	0
$I(rec_{it}=1)\times\ bop_{t-3}$	0,0034	0	0,0009	0,0514	-0,0011	0,005	0,0001	0	0,0001
$I(rec_{it}=1)\times\ bop_{t-4}$	0,0036	-0,0001	0,001	0,0747	-0,0017	0,0064	0,0001	0	0,0002
$I(rec_{it}=1)\times\ debt_{t-1}$	0,021	0,0009	0,007	0,0031	0,0001	0,0025	0	0	0,0001
$I(rec_{it}=1)\times\ debt_{t-2}$	0,0129	0,0004	0,005	0,0032	0	0,0022	0,001	0	0,0009
$I(rec_{it}=1)\times\ debt_{t-3}$	0,0131	0,0004	0,0051	0,0027	0,0001	0,0017	0,0034	0,0001	0,0018
$I(rec_{it}=1)\times\ debt_{t-4}$	0,0121	0,0004	0,0046	0,0031	0	0,0016	0,004	0,0001	0,002
$I(rec_{it}=1)\times\ inf_{t-1}$	0,0031	-0,0001	0,002	0,008	-0,0002	0,0041	0	0	0
$I(rec_{it}=1)\times\ inf_{t-2}$	0,0073	0,0003	0,0041	0,0309	0,0009	0,0067	0,0087	0,0005	0,0053
$I(rec_{it}=1)\times\ inf_{t-3}$	0,954	0,0863	0,0254	0,436	0,0251	0,0332	0,7754	0,0565	0,0327
$I(rec_{it}=1)\times\ inf_{t-4}$	0,0242	0,0012	0,0082	0,1562	0,0059	0,0144	0,2114	0,0151	0,0299
$I(GIIPS_i=1)$	-	-	-	0,0032	-0,0001	0,0023	0,9999	0,0298	0,0197
$I(GIIPS_i=1)\times\ spread_{t-1}$	1	0,3686	0,0455	1	0,365	0,0471	0,9999	0,371	0,0457
$I(GIIPS_i=1)\times\ spread_{t-2}$	0,998	-0,2629	0,0454	0,9993	-0,2824	0,0455	0,9995	-0,2919	0,0447
$I(GIIPS_i=1)\times\ spread_{t-3}$	0,0021	0,0001	0,0039	0,0024	0	0,0047	0,0015	0	0,0039
$I(GIIPS_i=1)\times\ spread_{t-4}$	0,0019	0,0001	0,0021	0,0011	0	0,0009	0,0029	0,0001	0,003
$I(GIIPS_i=1)\times\ uncert_{t-1}$	0,003	0	0,0009	0,0364	-0,0009	0,0047	0	0	0,0001
$I(GIIPS_i=1)\times\ uncert_{t-2}$	0,0013	0	0,0004	0,0056	-0,0001	0,0014	0	0	0,0002
$I(GIIPS_i=1)\times\ uncert_{t-3}$	0,0021	0	0,0007	0,009	-0,0002	0,0018	0,0001	0	0,0002
$I(GIIPS_i=1)\times\ uncert_{t-4}$	0,0012	0	0,0004	0,0027	0	0,0008	0	0	0
$I(GIIPS_i=1)\times\ gdp_{t-1}$	0,0015	0	0,0003	0,0013	0	0,0003	0	0	0
$I(GIIPS_i=1)\times\ gdp_{t-2}$	0,0043	-0,0001	0,0009	0,0039	0	0,0008	0	0	0
$I(GIIPS_i=1)\times\ gdp_{t-3}$	0,0015	0	0,0003	0,0018	0	0,0004	0,0001	0	0,0001
$I(GIIPS_i=1)\times\ gdp_{t-4}$	0,0008	0	0,0002	0,0011	0	0,0002	0	0	0
$I(GIIPS_i=1)\times\ bop_{t-1}$	0,0018	0	0,0005	0,0239	-0,0004	0,003	0,0007	0	0,0003
$I(GIIPS_i=1)\times\ bop_{t-2}$	0,0009	0	0,0002	0,0041	-0,0001	0,001	0	0	0
$I(GIIPS_i=1)\times\ bop_{t-3}$	0,0009	0	0,0002	0,0032	0	0,0008	0,0001	0	0,0001
$I(GIIPS_i=1)\times\ bop_{t-4}$	0,001	0	0,0003	0,0024	0	0,0006	0	0	0
$I(GIIPS_i=1)\times\ debt_{t-1}$	0,0153	0,0062	0,0545	0,066	0,0339	0,1357	0	0	0,0003
$I(GIIPS_i=1)\times\ debt_{t-2}$	0,9848	-0,8356	0,2104	0,9143	-0,7084	0,3088	0,0036	-0,0017	0,0375
$I(GIIPS_i=1)\times\ debt_{t-3}$	1	1,9376	0,2461	1	1,8866	0,2981	0,0641	0,0634	0,2668
$I(GIIPS_i=1)\times\ debt_{t-4}$	1	-1,122	0,167	1	-1,1743	0,1705	0,0602	-0,0574	0,2428
$I(GIIPS_i=1)\times\ inf_{t-1}$	0,0027	0,0001	0,0024	0,0203	0,001	0,0085	0	0	0
$I(GIIPS_i=1)\times\ inf_{t-2}$	0,0763	-0,0035	0,013	0,3371	-0,0138	0,0216	0,0154	-0,0008	0,0067
$I(GIIPS_i=1)\times\ inf_{t-3}$	0,4411	-0,0226	0,0271	0,4899	-0,0193	0,0208	0,9535	-0,0506	0,015
$I(GIIPS_i=1)\times\ inf_{t-4}$	0,2166	-0,0105	0,0208	0,1161	-0,0041	0,0117	0,0115	-0,0005	0,0051
$I(ZLB_t=1)$	0,0015	0	0,0015	0,0014	0	0,0014	0,0023	0	0,0006
$I(ZLB_t=1)\times\ spread_{t-1}$	0,0012	0	0,0004	0,001	0	0,0003	0	0	0
$I(ZLB_t=1)\times\ spread_{t-2}$	0,0011	0	0,0003	0,0011	0	0,0003	0	0	0
$I(ZLB_t=1)\times\ spread_{t-3}$	0,0012	0	0,0004	0,001	0	0,0003	0	0	0
$I(ZLB_t=1)\times\ spread_{t-4}$	0,0008	0	0,0003	0,0012	0	0,0003	0	0	0
$I(ZLB_t=1)\times\ uncert_{t-1}$	0,0009	0	0,0003	0,001	0	0,0004	0	0	0

Table 6 continued from previous page

	Time and country fixed effects			Standard BMA			Strong heredity prior		
	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD
$I(ZLB_t = 1)\times$ $uncert_{t-2}$	0,0011	0	0,0004	0,0013	0	0,0004	0	0	0
$I(ZLB_t = 1)\times$ $uncert_{t-3}$	0,0009	0	0,0004	0,0016	0	0,0006	0	0	0
$I(ZLB_t = 1)\times$ $uncert_{t-4}$	0,0011	0	0,0003	0,0011	0	0,0003	0	0	0
$I(ZLB_t = 1)\times$ gdp_{t-1}	0,0042	0	0,0008	0,0058	0,0001	0,001	0	0	0
$I(ZLB_t = 1)\times$ gdp_{t-2}	0,0017	0	0,0004	0,0016	0	0,0004	0	0	0
$I(ZLB_t = 1)\times$ gdp_{t-3}	0,0012	0	0,0003	0,0012	0	0,0003	0	0	0
$I(ZLB_t = 1)\times$ gdp_{t-4}	0,0008	0	0,0002	0,0008	0	0,0002	0	0	0
$I(ZLB_t = 1)\times$ bop_{t-1}	0,0011	0	0,0002	0,0038	0,0001	0,0012	0,0001	0	0,0002
$I(ZLB_t = 1)\times$ bop_{t-2}	0,0019	0	0,0005	0,0021	0	0,0006	0	0	0,0001
$I(ZLB_t = 1)\times$ bop_{t-3}	0,0011	0	0,0002	0,0023	0	0,0009	0	0	0,0001
$I(ZLB_t = 1)\times$ bop_{t-4}	0,0024	0	0,0005	0,0033	0	0,0011	0	0	0,0001
$I(ZLB_t = 1)\times$ $debt_{t-1}$	0,0009	0	0,0022	0,0015	0	0,0022	0	0	0
$I(ZLB_t = 1)\times$ $debt_{t-2}$	0,0011	0	0,0009	0,0014	0	0,0007	0	0	0,0001
$I(ZLB_t = 1)\times$ $debt_{t-3}$	0,0013	0	0,0011	0,0014	0	0,0019	0	0	0,0023
$I(ZLB_t = 1)\times$ $debt_{t-4}$	0,0012	0	0,002	0,0014	0	0,0011	0	0	0,0023
$I(ZLB_t = 1)\times$ inf_{t-1}	0,0013	0	0,0007	0,0024	0	0,001	0	0	0
$I(ZLB_t = 1)\times$ inf_{t-2}	0,0013	0	0,0006	0,0016	0	0,0008	0	0	0
$I(ZLB_t = 1)\times$ inf_{t-3}	0,0017	0	0,0007	0,0017	0	0,0007	0	0	0
$I(ZLB_t = 1)\times$ inf_{t-4}	0,0027	0	0,0012	0,0027	0	0,0013	0	0	0
$I(Draghi_t = 1)$	0,0522	-0,0043	0,0194	0,0114	-0,0009	0,0088	0,0041	0,0002	0,0034
$I(Draghi_t = 1) \times spread_{t-1}$	0,0048	-0,0001	0,0023	0,001	0	0,0006	0	0	0
$I(Draghi_t = 1) \times spread_{t-2}$	0,0045	-0,0002	0,003	0,0011	0	0,0007	0	0	0
$I(Draghi_t = 1) \times spread_{t-3}$	0,0039	-0,0002	0,0049	0,0012	0	0,0007	0	0	0
$I(Draghi_t = 1) \times spread_{t-4}$	0,0016	0,0001	0,0039	0,0016	0	0,0009	0	0	0,0003
$I(Draghi_t = 1) \times uncert_{t-1}$	0,0014	0	0,0005	0,0017	0	0,0006	0	0	0
$I(Draghi_t = 1) \times uncert_{t-2}$	0,001	0	0,0003	0,0011	0	0,0004	0	0	0
$I(Draghi_t = 1) \times uncert_{t-3}$	0,0023	0	0,0009	0,0064	-0,0001	0,0017	0	0	0
$I(Draghi_t = 1) \times uncert_{t-4}$	0,001	0	0,0003	0,001	0	0,0003	0	0	0
$I(Draghi_t = 1) \times gdp_{t-1}$	0,0033	0	0,0007	0,0049	0,0001	0,0009	0	0	0
$I(Draghi_t = 1) \times gdp_{t-2}$	0,0013	0	0,0004	0,0013	0	0,0004	0	0	0
$I(Draghi_t = 1) \times gdp_{t-3}$	0,0011	0	0,0002	0,0012	0	0,0003	0	0	0
$I(Draghi_t = 1) \times gdp_{t-4}$	0,0007	0	0,0002	0,0011	0	0,0002	0	0	0
$I(Draghi_t = 1) \times bop_{t-1}$	0,0014	0	0,0003	0,0033	0	0,0009	0	0	0,0001
$I(Draghi_t = 1) \times bop_{t-2}$	0,0015	0	0,0004	0,002	0	0,0006	0	0	0
$I(Draghi_t = 1) \times bop_{t-3}$	0,0013	0	0,0003	0,0033	0,0001	0,0014	0,0001	0	0,0004
$I(Draghi_t = 1) \times bop_{t-4}$	0,0018	0	0,0004	0,0036	0,0001	0,0014	0,0001	0	0,0003
$I(Draghi_t = 1) \times debt_{t-1}$	0,008	-0,0015	0,0274	0,0192	-0,0026	0,0334	0,0018	-0,002	0,0484
$I(Draghi_t = 1) \times debt_{t-2}$	0,0055	-0,0009	0,0248	0,0153	-0,0036	0,0491	0	0	0,0009
$I(Draghi_t = 1) \times debt_{t-3}$	0,0061	0,0018	0,0348	0,0168	0,0046	0,0562	0,0018	0,002	0,0461
$I(Draghi_t = 1) \times debt_{t-4}$	0,0034	-0,0001	0,0035	0,0106	-0,0004	0,005	0	0	0,0001
$I(Draghi_t = 1) \times inf_{t-1}$	0,0066	-0,0001	0,002	0,0073	-0,0002	0,0026	0	0	0
$I(Draghi_t = 1) \times inf_{t-2}$	0,0578	-0,0018	0,0079	0,3073	-0,0129	0,0203	0,0018	-0,0001	0,0019

Table 6 continued from previous page

	Time and country fixed effects			Standard BMA			Strong heredity prior		
	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD	PIP	Post Mean	Post SD
$I(Draghi_t = 1) \times inf_{t-3}$	0,0711	-0,0024	0,0092	0,1732	-0,0072	0,0165	0,0002	0	0,0005
$I(Draghi_t = 1) \times inf_{t-4}$	0,3928	-0,0155	0,0204	0,3647	-0,0158	0,0219	0,0001	0	0,0003

Jointness Measures

The measure of jointness by Doppelhofer & Weeks (2009) is given by

$$\mathcal{I}_{ij} = \ln\left(\frac{P(i \cap j|\mathbf{y})P(\tilde{i} \cap \tilde{j}|\mathbf{y})}{P(i \cap \tilde{j}|\mathbf{y})P(\tilde{i} \cap j|\mathbf{y})}\right), \tag{12}$$

where i and j denote the inclusion of specific regressors and $\tilde{i}, \tilde{j}$ denotes their exclusion. $P(i \cap j|\mathbf{y})$ thus denotes the probability that both regressor i and regressor j are included in a particular model, given the data. The second jointness measure builds upon the previous one, and is based on Ley & Steel (2009a),

$$\mathcal{I}_{ij} = \frac{P(i \cap j|\mathbf{y})}{P(i \cap \tilde{j}|\mathbf{y}) + P(\tilde{i} \cap j|\mathbf{y})}. \tag{13}$$

In words, this measure is obtained by dividing the joint inclusion probability of regressor i and j by the inclusion probability of regressor i or j (but not both). An alternative form for this measure is given by

$$\mathcal{I}_{ij} = \frac{P(i \cap j|\mathbf{y})}{P(i \cup j|\mathbf{y})}. \tag{14}$$

The last measure that we employ corresponds to a modified Yule's coefficient of association Q (Hofmarcher et al., 2018),

$$\mathcal{I}_{ij} = \frac{\left(P\left(i \cap j|\mathbf{y}\right) + \frac{1}{2}\right)\left(P\left(\tilde{i} \cap \tilde{j}|\mathbf{y}\right) + \frac{1}{2}\right) - \left(P\left(i \cap \tilde{j}|\mathbf{y}\right) + \frac{1}{2}\right)\left(P\left(\tilde{i} \cap j|\mathbf{y}\right) + \frac{1}{2}\right)}{\left(P\left(i \cap j|\mathbf{y}\right) + \frac{1}{2}\right)\left(P\left(\tilde{i} \cap \tilde{j}|\mathbf{y}\right) + \frac{1}{2}\right) + \left(P\left(i \cap \tilde{j}|\mathbf{y}\right) + \frac{1}{2}\right)\left(P\left(\tilde{i} \cap j|\mathbf{y}\right) + \frac{1}{2}\right) - \frac{1}{2}}. \tag{15}$$

It is straightforward to see from Equation (12) that the measure by Doppelhofer & Weeks (2009) is highly sensitive to variables that have posterior inclusion probabilities that are close to zero (Amini & Parmeter, 2020). In these particular cases, the measures by Ley & Steel (2009a); Hofmarcher et al. (2018) are preferred. In addition, the measure by Doppelhofer & Weeks (2009); Ley & Steel (2009a) results in jointness values that have infinite support, while that of Hofmarcher et al. (2018) has a support of $[-1, 1]$.

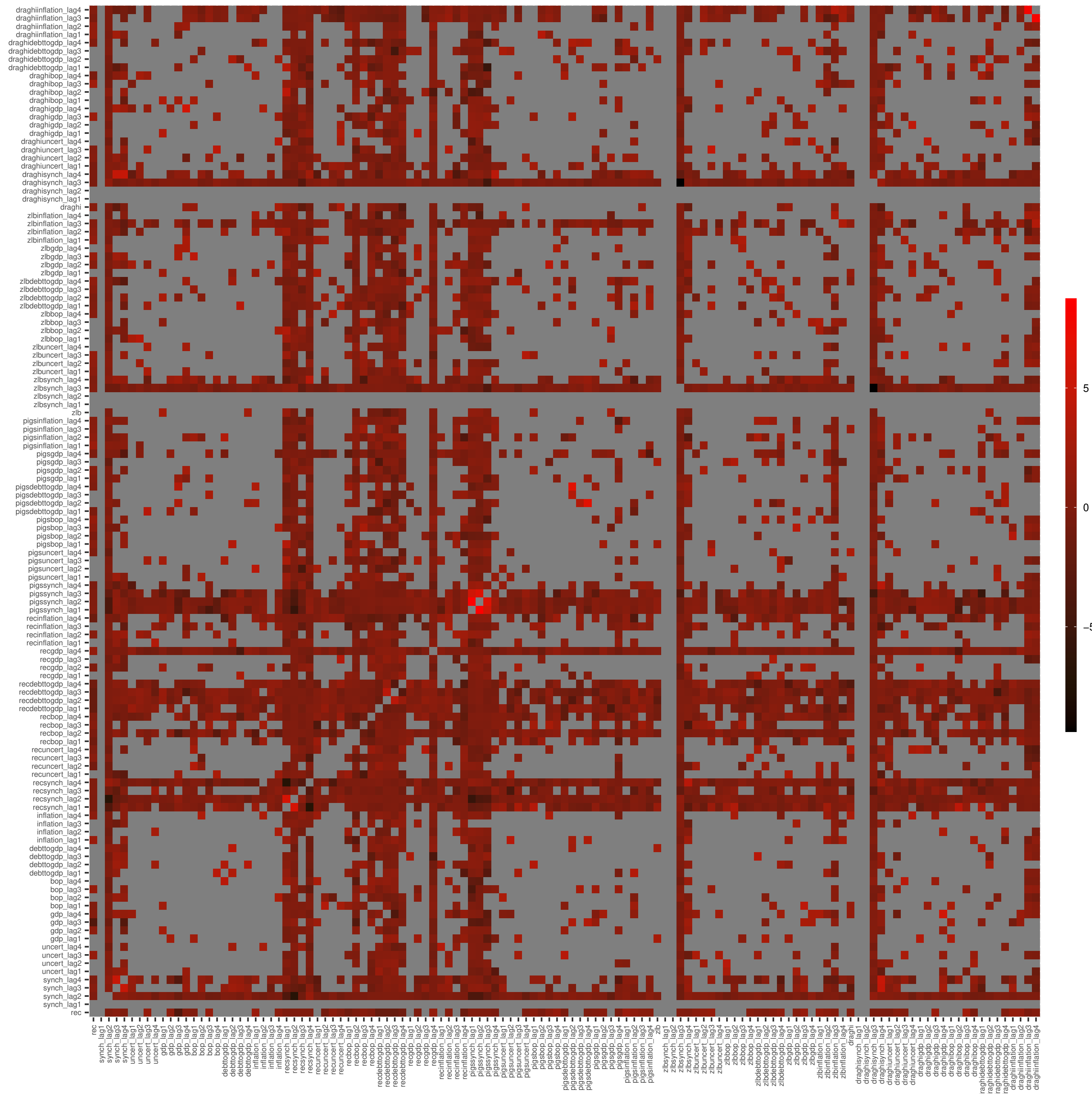

Figure 6: **Jointness results**. The heatmap depicts the jointness between the variables in the model where we regress the yield synchronization rates against the *levels* of the independent variables. The measure used is the one by Doppelhofer & Weeks (2009). Note: (minus) infinite values are not depicted in the heatmap given the unbounded support of the jointness measure.

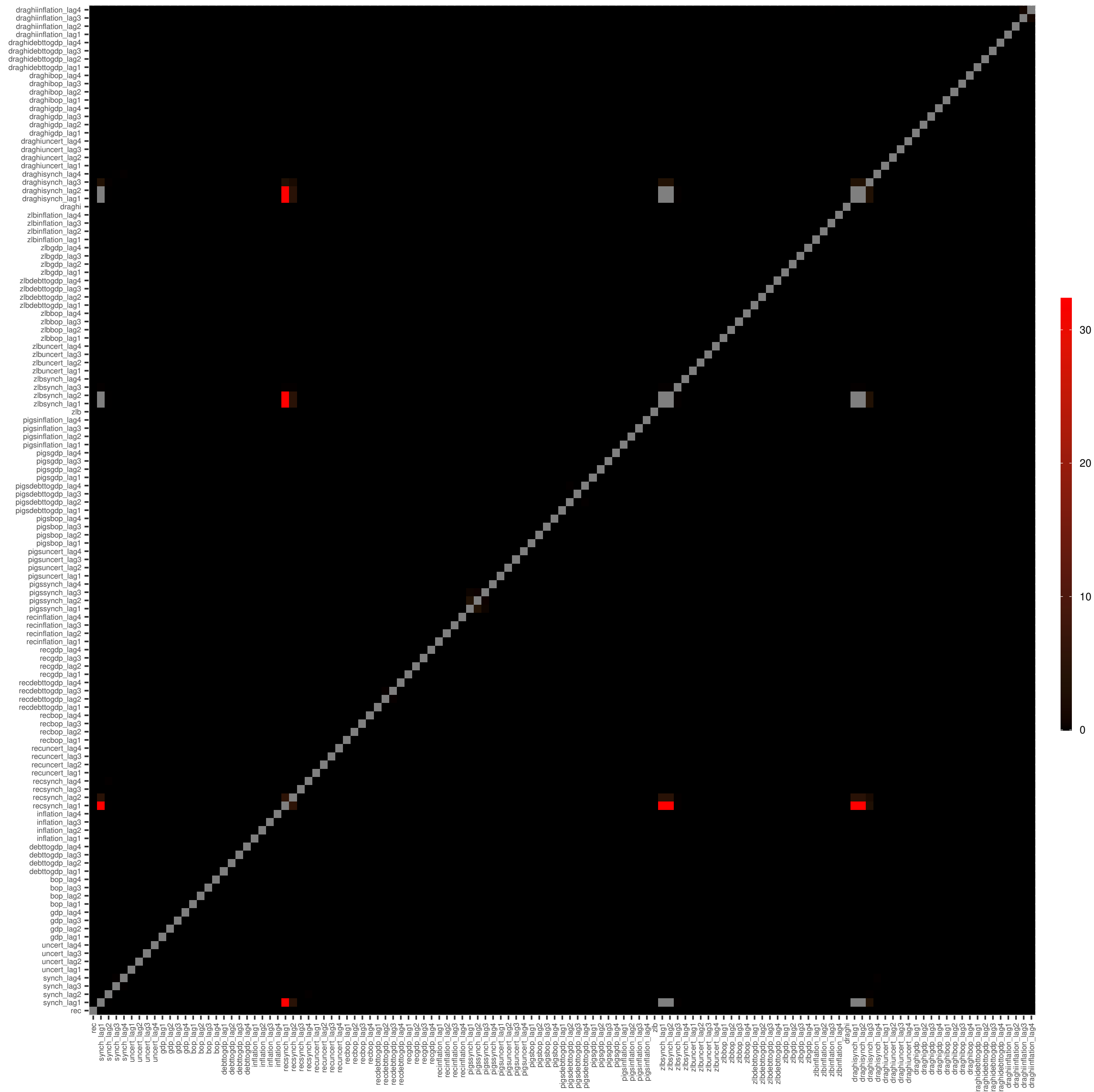

Figure 7: **Jointness results**. The heatmap depicts the jointness between the variables in the model where we regress the yield synchronization rates against the *levels* of the independent variables. The measure used is the one by Ley & Steel (2009a). Note: (minus) infinite values are not depicted in the heatmap given the unbounded support of the jointness measure.

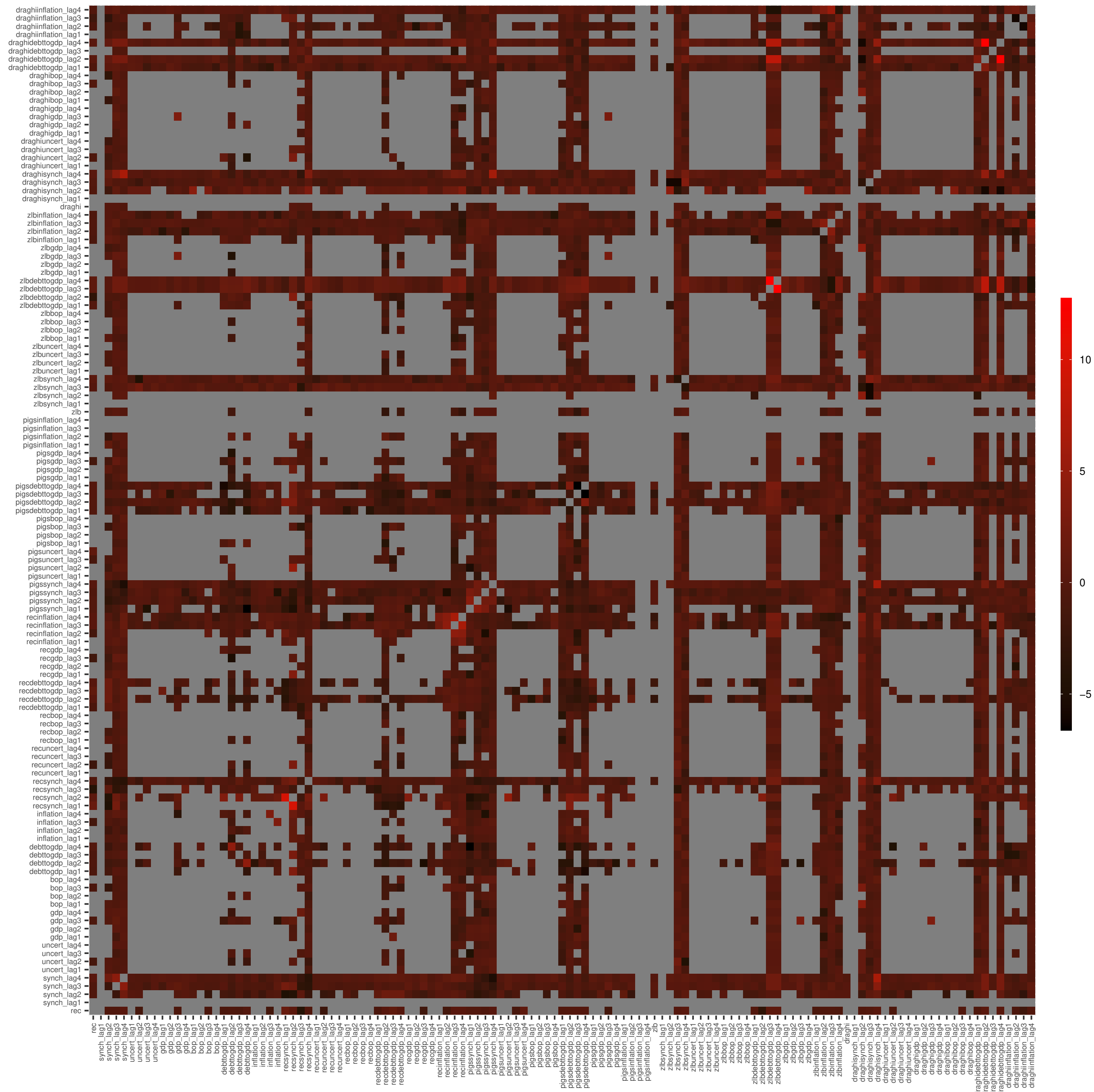

Figure 8: **Jointness results**. The heatmap depicts the jointness between the variables in the model where we regress the yield synchronization rates against the *synchronization rates* of the independent variables. The measure used is the one by Doppelhofer & Weeks (2009). Note: (minus) infinite values are not depicted in the heatmap given the unbounded support of the jointness measure.

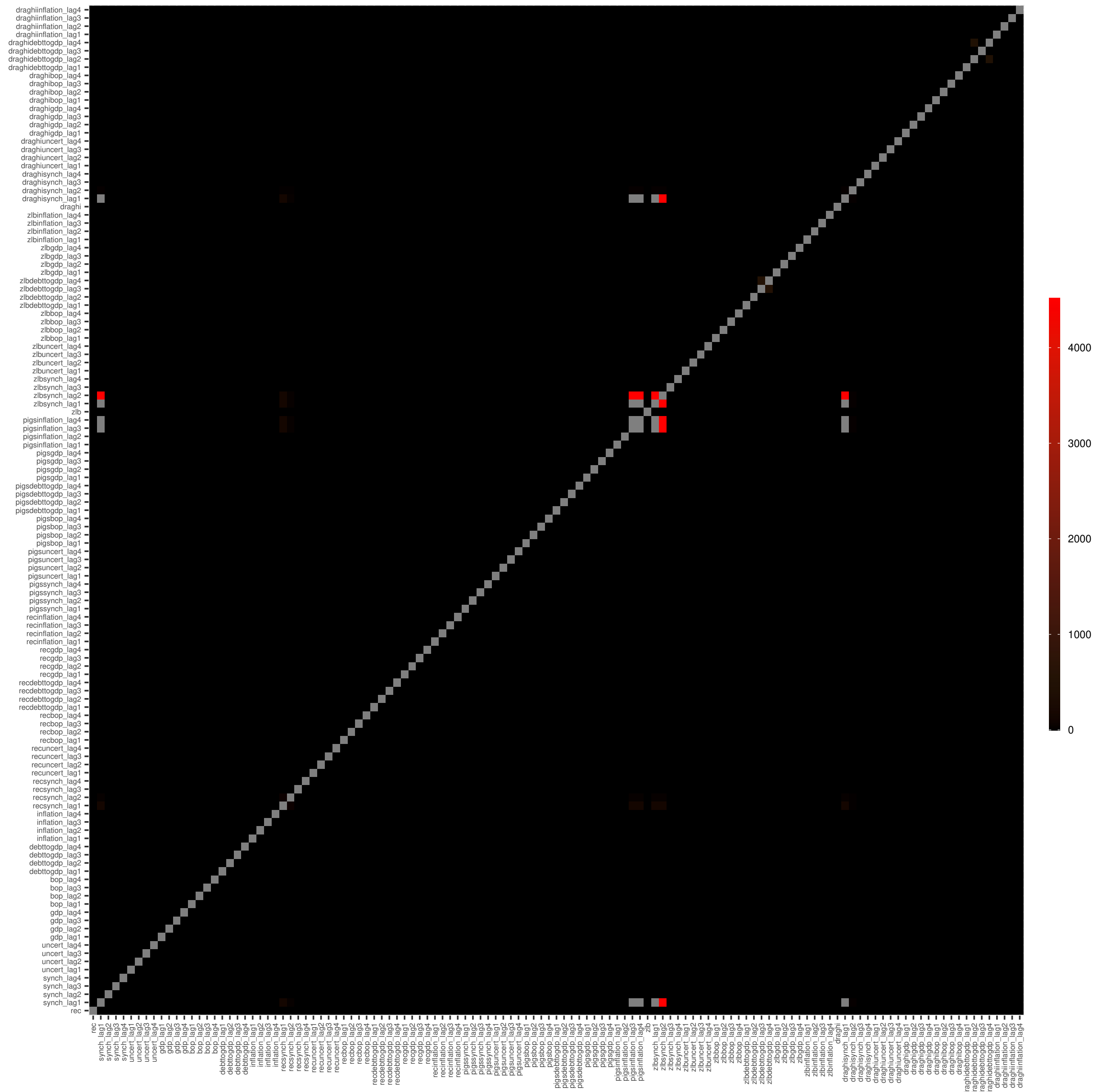

Figure 9: **Jointness results**. The heatmap depicts the jointness between the variables in the model where we regress the yield synchronization rates against the *synchronization rates* of the independent variables. The measure used is the one by Ley & Steel (2009a). Note: (minus) infinite values are not depicted in the heatmap given the unbounded support of the jointness measure.