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Palić, Petra; Posedel Šimović, Petra; Vizek, Maruška

Petra Palić, Petra Posedel Šimović and Maruška Vizek

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THE DETERMINANTS OF COUNTRY´S RISK PREMIUM VOLATILITY: EVIDENCE FROM PANEL VAR MODEL

PETRA PALIĆ
Doctoral researcher
The Institute of Economics, Zagreb
ppalic@eizg.hr

PETRA POSEDEL ŠIMOVIĆ
Professor
Zagreb School of Economics and Management
pposedel@zsem.hr

MARUŠKA VIZEK
Senior research associate
The Institute of Economics, Zagreb
mvizek@eizg.hr

www.eizg.hr

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IZDAVAČ / PUBLISHER:
Ekonomski institut, Zagreb / The Institute of Economics, Zagreb
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E. eizagreb@eizg.hr
www.eizg.hr

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THE DETERMINANTS OF COUNTRY´S RISK PREMIUM VOLATILITY: EVIDENCE FROM PANEL VAR MODEL

Abstract:
We use data for 24 European countries, spanning from 1994 to 2015, in order to examine how changes in macroeconomic conditions influence the country's risk premium volatility proxied by sovereign spreads variance. In the first part of the empirical analysis we estimate the univariate generalised autoregressive conditional heteroskedasticity (GARCH) model in order to obtain the conditional variance of sovereign bond spreads. We show that the increase of this variance coincides with economic and financial crisis occurring either in the country or globally. In the second part of the empirical analysis we estimate panel vector autoregression (panel VAR) model in order to model the interplay among macroeconomic fundamentals (inflation, output gap, public debt and interest rates) and the country´s risk premium volatility. We show that overheating of the economy, along with the unexpected increase in public debt, inflation and interest rates increase the country´s risk premium volatility. We also show that sudden increase in country´s risk premium volatility depresses the economy, exerts deflationary pressures on consumer prices, and is followed by strong and permanent increase in public debt.

Key words: sovereign bond markets, panel VAR, European Union
JEL Classification: C33, E44, F34, G15

DETERMINANTE VOLATILNOSTI PREMIJE RIZIKA ZEMLJE: DOKAZ IZ PANEL VAR MODELA

Sažetak:
Koristeći podatke za 24 europske zemlje, za razdoblje od 1994. do 2015. godine, istražujemo kako promjene u makroekonomskim uvjetima utječu na volatilnost premije rizika zemlje, koja je predstavljena varijancom *spreada* državne obveznice. U prvom dijelu empirijske analize procjenjujemo univarijatni GARCH model kako bi ocjenili uvjetnu varijancu *spreada* državne obveznice. Ocjene uvjetne varijance *spreadova* sugeriraju da se povećanje varijance podudara s nastupanjem ekonomske i financijske krize tijekom 2008. U drugom dijelu empirijske analize procjenjujemo model panel vektorske autoregresije kako bi modelirali interakcije makroekonomskih fundamenata (inflacija, proizvodni jaz, javni dug i kamatne stope) i volatilnosti premije rizika zemlje. Procjene indiciraju da pregrijavanje gospodarstva, zajedno s neočekivanim porastom javnog duga, inflacije i kamatnih stopa, povećavaju volatilnost premije rizika zemlje. Također, nagli porast volatilnosti premije rizika zemlje hladi ekonomsku aktivnost, ima deflatorne učinke na potrošačke cijene, te je praćen jakim i trajnim povećanjem javnog duga.

Ključne riječi: tržište državnih obveznica, panel VAR, Europska unija
JEL klasifikacija: C33, E44, F34, G15

1. Introduction[1]

Sovereign spreads are defined as differentials between yields on government bonds and yields on what is considered risk-free government bond of the comparable maturity. Edwards (1986) indicates that country risk does play an important role in the bond market, as he finds evidence that sovereign spreads are positively associated with country risk. Consequently, sovereign spreads are widely considered a measure of the risk premium, which is defined as compensation to creditors for the risks of holding a risky asset until maturity. Sovereign spreads are thus associated with a country's probability of default on its debts. This in turn suggests that as economic and political conditions of a country change, so does its risk premium. Risk premiums proxied by sovereign spreads thus tend to exhibit substantial variation both across countries and over time. Last decade, characterized by the Great Recession and the European Debt Crisis, has demonstrated how this variation can bring forth adverse economic consequences.

Due to these developments, the economic literature witnessed a renewed interest in examining sovereign bond spread determinants. Studies like Baldacci, Gupta and Mati (2008), Ebner (2009), Von Hagen et al. (2011), Dumičić and Ridzak (2011), Aizenman et al. (2013), and Seungyeon et al. (2013) build on seminal work of Edwards (1984) and examine whether macroeconomic, fiscal and financial market variables influence sovereign bond spreads. An extension of this literature, represented by studies like Dell'Aricia, Goedde and Zettelmeyer (2000), Ferrucci (2003), Bellas et al. (2010), Alexopoulou et al. (2010) and Tkalec et al. (2014), focuses on the disentangling the short- and long-run effects of macroeconomic and financial market factors on sovereign spreads. Another strand of literature (Berganza et al., 2004; Malone, 2009; Tkalec et al., 2014) applies collateral value concept of Kiyotaki and Moore (1997) to sovereign spreads determination, thereby postulating that the cost of borrowing falls with the value of the collateral increasing. In general, reviewed studies conclude that sovereign spreads are influenced by changes in external debt, fiscal balance and stance, current account balance, public debt, inflation and reserves. If studies differentiate short- from long-term effects, then usually economic fundamentals matter more in the long run, while in the short run financial market conditions have a prevailing role in determining sovereign spreads. Although some empirical consistencies do exist, and they usually hold for specific regions or time periods, the debate about the determinants of sovereign bond spreads is far from being settled.

[1] This work was supported by Croatian Science Foundation under the project 1356.

We extend the existing literature by choosing to focus on the determinants of sovereign spread volatility, instead of sovereign spreads. Most of the literature implicitly recognizes that market conditions, especially market volatility, determine much of the overall spread movements. Studies such as Ebner (2009), Beber et al. (2009), Bellas et al (2010), Alexopoulou et al. (2010), Dumičić and Ridzak (2011) and Tkalec et al. (2014) thus control directly for market volatility using VIX or DAX volatility index. However, by doing that, most of the variance of sovereign spreads is naturally explained by market volatility as volatility indices are usually the only heteroscedastic explanatory variable in a model seeking to examine the determinants of sovereign spreads which are also heteroscedastic. Not surprisingly, if used in empirical studies, volatility indices usually emerge as the single most important explanatory variable in sovereign spread models, thus precluding us from establishing whether economic fundamentals influence economic uncertainty represented by sovereign spreads variance. This problem is also a natural consequence of the method of choice in empirical sovereign spreads studies; all reviewed studies except Seungyeon et al. (2013) use panel data models. As panel data models are designed to explain the mean spread value and not its variance, the determinants of sovereign spreads variance in panel data studies are almost completely ignored. This problem is also present in panel studies that do not control for market volatility, as panel data models are in effect not designed to model heteroscedastic series. However, as sovereign spreads variance is of crucial importance for public debt management and is a true reason why countries end up in sovereign debt crisis, one cannot afford not to understand how fundamentals affect sovereign spreads volatility and thus contribute to changes in uncertainty associated with country´s risk premium.

In order to understand how fundamentals affect sovereign spreads volatility, we estimate univariate generalized autoregressive conditional heteroskedasticity (GARCH(1,1)) models with the aim of obtaining the estimate of conditional variance of sovereign bond spreads. We use the estimated variance in panel vector autoregression model (VAR) along with output gap, public debt and interest rate and inflation in order to examine how changes in business cycle developments, fiscal policy, monetary policy and inflation affect sovereign spreads volatility. As panel VAR needs to satisfy the stability condition, we focus only on the short-run analysis. Using panel VAR for this purpose not only enables us to trach how changes in economic fundamentals influence sovereign spreads variance over time, but it also allows us to examine whether changes in sovereign spreads variance can influence real economic outcomes. The rest of the paper is organized as follows. Section 2 presents the data. Section 3 explains the methodology, while section 4 discusses the empirical results. Section 5 concludes the paper.

2. Data

First part of this research uses weekly data set based on the combination of the Government bond spreads and Emerging Market Bond Index (EMBI) for 24 European Union countries. EMBI spread is typical and widely used proxy for sovereign spreads calculated by Morgan Stanly for emerging countries´ sovereign bonds, while government bond spread is a metric provided by Bloomberg database. We are forced to combine data for sovereign bond spreads from two different sources because Bloomberg does not provide its own government bond spreads indicator for European emerging countries. For Germany, we use 5-year sovereign bond yield, instead of spread because Germany itself is a benchmark country for calculating spreads.

We use first differences of government bond spreads in order to estimate the conditional variance of the government bond markets for Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and United Kingdom. As our study has broad country coverage, data time span varies between countries. As a rule, we use the longest available data range for each country in order to capture as many economic cycles as possible. In general, data ranges for the emerging economies are much shorter than for the developed economies, and are available mostly from the 2000s onwards. Slovakia has the shortest data range, where data are only available from the third quarter of 2013 to the first quarter of 2015. On the other hand, bond spreads for Denmark, Finland, France, Germany, and Spain are available from the first quarter of 1994 to the first quarter of 2015. For many other developed European countries government bond spreads are available from late 1990s to the first quarter of 2015.

Table 1 displays basic descriptive statistics for government bond spreads. Austrian, Dutch, French and Swedish spreads stand out with the lowest means and standard deviations. On the other side, emerging countries are characterized by higher means and standard deviations. In that regard Croatian, Latvian and Lithuanian spreads are particularly striking. As far as the distribution of spreads is concerned, the majority of the analyzed spreads are positively skewed, with German, Romanian and Slovenian spreads being the most notable exception. Further on, all spreads distributions except Belgian and Finnish are platykurtic. As expected, normality tests results suggest that all spread distributions deviate from the standard Gauss distribution.

In the second part of our empirical analysis we use quarterly panel VAR model in order to assess short-run interactions between conditional volatility of sovereign spreads ($condv_t$) and four macroeconomic variables: output gap ($outputgap_t$), harmonized consumer price inflation (p_t), public debt ($pdebt_t$) and referent interest rates (ir_t). Weekly estimates of conditional volatility are transformed to quarterly frequency using the arithmetic mean. Output gap is calculated as a difference between actual and potential GDP, whereby potential GDP is estimated using Hodric-Prescott filter and expressed as a percent of actual GDP. Source for real GDP, consumer price index and public debt series is Eurostat, interest rates were collected from International Financial Statistics database. Conditional volatility enters panel VAR model in log-levels (as it is by definition stationary), while macroeconomic series are first transformed to logarithms (in case they are not already expressed in percentages) and then differenced.

Table 1. Government Bond Spreads – Descriptive Statistics

Country	GBS/ EMBI	Observations	Mean	Standard deviation.	Skewness	Excess kurtosis	Normality
Austria	GBS	830	0.28	0.28	1.33	2.59	283.0 [0.00]
Belgium	GBS	830	0.46	0.50	2.04	5.20	942.6 [0.00]
Bulgaria	EMBI	678	1.7	1.03	0.43	0.04	26.6 [0.00]
Croatia	EMBI	783	2.08	1.41	0.71	-0.16	144.9 [0.00]
Czech Republic	GBS	422	0.80	0.54	0.53	-0.56	59.6 [0.00]
Denmark	GBS	1108	0.37	0.42	1.55	2.11	982.2 [0.00]
Finland	GBS	1108	0.52	0.96	2.61	5.46	5877 [0.00]
France	GBS	1108	0.26	0.29	1.42	2.00	688.2 [0.00]
Germany	GBS	1108	3.40	1.71	-0.28	-0.55	47.4 [0.00]
Greece	GBS	422	7.72	7.67	1.35	1.25	307.9 [0.00]
Hungary	EMBI	798	1.85	1.59	1.00	0.08	388.8 [0.00]
Ireland	GBS	804	1.52	2.29	1.59	1.27	1356 [0.00]
Italy	GBS	804	1.04	1.17	1.55	1.60	962.2 [0.00]
Latvia	EMBI	798	4.93	2.35	1.14	1.07	315.8 [0.00]
Lithuania	EMBI	282	2.34	0.98	0.52	-0.75	49.3 [0.00]
Netherlands	GBS	830	0.18	0.16	1.14	1.56	236.7 [0.00]
Poland	GBS	831	3.03	1.56	1.21	1.05	420.6 [0.00]
Portugal	GBS	830	1.83	2.77	1.86	2.64	1547.2 [0.00]
Romania	GBS	251	3.22	1.18	-0.1	-1.24	30.6 [0.00]
Slovakia	GBS	671	0.84	0.77	0.14	0.41	6.7 [0.044]
Slovenia	GBS	212	3.27	1.35	-0.33	-1.48	69.9 [0.00]
Spain	GBS	1108	1.25	1.48	1.11	-0.03	913.5 [0.00]
Sweden	GBS	429	0.11	0.26	0.30	-0.47	16.8 [0.0002]
UK	GBS	1108	0.72	0.48	0.24	-0.89	86.3 [0.00]

Source: authors´ calculation.

3. Modelling strategy

The modelling strategy employed in this paper consists of two steps. In the first step we obtain conditional variance of sovereign bond spreads using univariate GARCH (1,1) model. In the second step we employ panel VAR in order to assess whether macroeconomic outcomes affect volatility of country risk, and to examine under which conditions may changes in volatility of country risk produce real economic consequences.

The evaluation of risk of financial assets is based on statistical models describing underlying asset prices and their volatilities, namely deviations of asset prices from their expected values. Since the volatility of an asset is not observable, it needs to be modelled. Empirically, conditional first and second moments of asset returns are time-varying, and this stylized fact must be accounted for in the modelling framework. In fact, during periods of market stress (political changes or disorders, economic crises, but also changes that are not so drastic, e.g., announcements of macroeconomics data) prices of financial assets fluctuate very much and the volatility changes over time, i.e. the process of interest is heteroscedastic. Therefore, in the modelling procedure, we aim to analyse the country risk volatility by modelling the conditional variance of sovereign spread for 24 countries with standard GARCH (1,1) model introduced by Bollerslev (1986). In particular, we will combine the regression model with a GARCH structure of the residuals and use a maximum likelihood estimation procedure. The model has been widely used in the finance literature, playing an important role in financial analysis, option pricing and risk management and capturing many stylized features of financial assets, like volatility clustering, serial correlation and quasi long range dependence (Taylor, 2008).

Suppose we are observing a discrete economy and denote with $B_{t,i}$ the weekly bond spread of country *i* in time *t*, for all countries. In order to infer a specific country risk, we define the first differences of bond spreads on weekly basis,

$$X_{i,t} = B_{i,t} - B_{i,t-1}, \quad \text{for every } i=1,...,24 \text{ and for every } t=1,...,T_i.$$

We consider a GARCH (1,1) model of bond spread differences X_t with an intercept, an AR(1) term an FCD (Crisis) dummy in the conditional mean equation. In order to simultaneously model the contemporaneous impact of the crises in both conditional mean and variance, we assume the FCD dummy in the variance equation as well (Kosturov and Stock, 2010). Suppose that in each country *i* the conditional mean and conditional variance of bonds' spread given $\Im t-1$ are generated by:

$$X_{i,t} = \mu_i + a_i X_{i,t-1} + b_i FCD_{i,t} + \varepsilon_{i,t}, \quad \varepsilon_{i,t} = \sigma_i^t \cdot Z_t,$$

$$\sigma_{i,t}^2 = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i \sigma_{i,t-1}^2 + \gamma_i FCD_{i,t},$$

where $\Im_{t-1}$ denotes the information set available at a time *t*-1, and FCD is the financial crisis dummy indicator, assuming values one for dates on and after September 11, 2008, and zero otherwise. Variables Z_t are assumed to be independent and identically distributed standard normal random variables and it is assumed that:

$\omega_i > 0$, $\alpha_i \geq 0, \beta_i \geq 0$ and $\alpha_i + \beta_i < 1$, for every *i*=1,..,24

in order to assure the non-negativity and stationarity of the unconditional variance process. If this condition is fulfilled, then the process for the squares, $X_{i,t}^2$, is covariance stationary.

For each country *i* in consideration, the coefficient b_i measures changes in mean bond spread after the financial crisis in September 2008. Because of the negative autocorrelation found in bond spreads for some countries, we allow for the AR(1) term in the conditional mean equation. For a specific set of five countries, namely Greece, Ireland, Italy, Portugal and Spain, in the first-moment equation we additionally assume a dummy variable representing European Debt Crisis (EDC). Thus, in these countries we consider the following model:

$$X_{i,t} = \mu_i + a_i X_{i,t-1} + b_i FCD_{i,t} + c_i ECD + \varepsilon_{i,t}, \quad \varepsilon_{i,t} = \sigma_i^t \cdot Z_t,$$

$$\sigma_{i,t}^2 = w_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i \sigma_{i,t-1}^2 + \gamma_i FCD_{i,t},$$

where the coefficient c_i measures changes in mean bond spread in case of political announcements/changes. Since the conditional variance is a non-observable variable, it has to be estimated along the other parameters of the model. For the model parameters estimation, we use the maximum likelihood method. For each country *i*, *i*=1,…,24, we estimate the conditional variance of bonds' spread from the corresponding equation.

In the second part of our empirical exercise we use panel vectorautoregression (Holt-Eakin et al., 1988; Love and Zicchino, 2006; Abrigo and Love, 2015) in order to examine how changes in volatility of perceived riskiness of a country affect the country´s economic outcomes. Panel vector autoregression is used to complement the multivariate analysis and identify the transmission of shocks. In our analysis we consider a following system of linear equations:

$$Y_{i,t} = Y_{i,t-1}A_1 + Y_{i,t-2}A_2 + \ldots + Y_{i,t-p}A_p + u_i + \varepsilon_{i,t}$$

where $Y_{i,t}$ presents a $(1xk)$ vector of endogenous variables; u_i and $\varepsilon_{i,t}$ are $(1xk)$ vectors of dependent variable-specific panel fixed-effects and idiosyncratic errors, respectively. Parameters required to be estimated are (kxk) matrices $A_1, A_2, \ldots, A_p$. We model the system of five endogenous variables: sovereign debt conditional variance ($condv_t$), output gap ($outputgap_t$), harmonized consumer price inflation (p_t), nominal referent interest rates (ir_t), and public debt ($pdebt_t$). This variable ordering is also used in Choleski decomposition to identify impulse responses and forecast-error variance decomposition. All variables are transformed to logarithms, and with exception of conditional variances, all are expressed as first differences. Besides impulse responses and forecast-error variance decomposition, we also report the VAR lag selection criteria, Granger causality test results and roots of VAR companion matrix. The estimation is conducted with generalized method of moments (GMM) panel, whereby panel fixed-effects are removed using forward orthogonal deviation.

4. Results

Table 2 displays results obtained from estimating GARCH(1,1) models of sovereign bond spreads in first differences. As one can note, in most cases AR(1) terms were not significant in regression and were consequently dropped out from the estimation. Two dummies controlling for the global financial crisis and European debt crisis are only significant in the variance equation. If these two dummies were found to be insignificant and GARCH model could have been estimated without them (thereby assuring that GARCH model condition remained satisfied), they were excluded from estimation. However, in the majority of cases these dummies are either strongly statistically significant or insignificant, but still necessary in the model in order to preserve the GARCH stability condition. This result suggests that in the last decade financial markets in general, and sovereign bond markets in particular were characterised by several major structural shifts, which in turn created regime changes on sovereign bond markets that one needs to account for when trying to estimate sovereign bond market volatility.

Conditional variance estimates are presents in Figure A1 in the Appendix. Upon observing these figures, one can conclude that the volatility of sovereign spreads increased significantly after the inception of the global financial crisis even in highly developed European countries which fared through the initial financial crisis and consequent European debt crisis rather smoothly. There are some notable exceptions to this rule: sovereign bond market volatility in Poland, Germany and Finland has not increased after September 2008, while in the UK the Exchange rate mechanism crisis in early 1990s influenced sovereign bond market volatility more than 2008 financial crisis. One can also note that sovereign bond markets of the eurozone countries in the period from the introduction of common currency to the bankruptcy of Lehman Brothers was characterised by very low volatility.

In order to obtain orthogonalised impulse response functions, forecast-error variance decomposition and Granger causality tests, we estimated a panel VAR model using GMM estimation. Lag selection criteria presented in Table A1 in the Appendix suggest estimating first order VAR. Table A2 suggests selected VAR is stable, as modulus of each eigenvalue is strictly less than 1. Figure 1 displays the orthogonalised impulse response functions obtained after estimating panel VAR model.[2] The 95 percent confidence intervals of the impulse responses are computed using 200 Monte Carlo draws based on the estimated model. Impulse response functions presented in the last column of Figure 1 display the response of conditional variance to one standard deviation innovation in macroeconomic variables and conditional variance itself. An unexpected rise in public debt increases the conditional variance of sovereign bond market by 0.07 percent two quarters after the initial shock. Conditional variance also increases by approximately 0.2 percent with unexpected rise in inflation, with this effect being significant even five quarters after the initial shock. Overheating of the economy represented by an output gap increase also positively stimulates the variance, along with an unexpected interest rate hike.

Sudden increase of the conditional variance, which suggests an increase in the general level of country risk, causes strong and permanent increase in public debt. Namely, immediately after one percent increase in the conditional variance of sovereign spreads, public debt has increase by 0.5 percent. Ten quarters after the initial shock, its effect on public debt is smaller, but still statistically significant. Moreover, it is quite interesting to note that increase in sovereign bond spreads volatility lowers the output gap, thus depressing the economy. Increased sovereign spreads variance also

[2] Due to the conservation of space, panel VAR model estimates are displayed in the Appendix.

exhibits deflationary pressures on consumer prices. In both cases, the reaction of macroeconomic variables is statistically significant and does not die out over the observed 10-quarter horizon, although in case of inflation the magnitude of the reaction is quite small. We can thus conclude that sovereign bond market crisis, if described as increased volatility of that market, can result in permanently higher public debt due to increasing borrowing costs, but it can also dampen the economic activity and depress prices.

The response of interest rates to an increase in sovereign spreads variance is particularly curious. Immediately after the shock, a rise in interest rates is observed, although it is not statistically significant. This rise can be explained as the attempt of monetary authorities to stabilise the exchange rate immediately after the debt crisis represented by surge in variance. However, three quarters later interest rates fall by 0.03 percent and remain subdued throughout the observed time horizon. The lowering of interest rates represents an attempt of the monetary authorities to stimulate the economy after the debt crisis drove it into deflationary spiral. Thus, the reaction of interest rate, along with the reaction of the other macroeconomic variables to an unexpected increase of sovereign spreads variance observed from impulse responses, fits quite well into stylized facts about the behaviour of the economy during the financial or debt crisis.

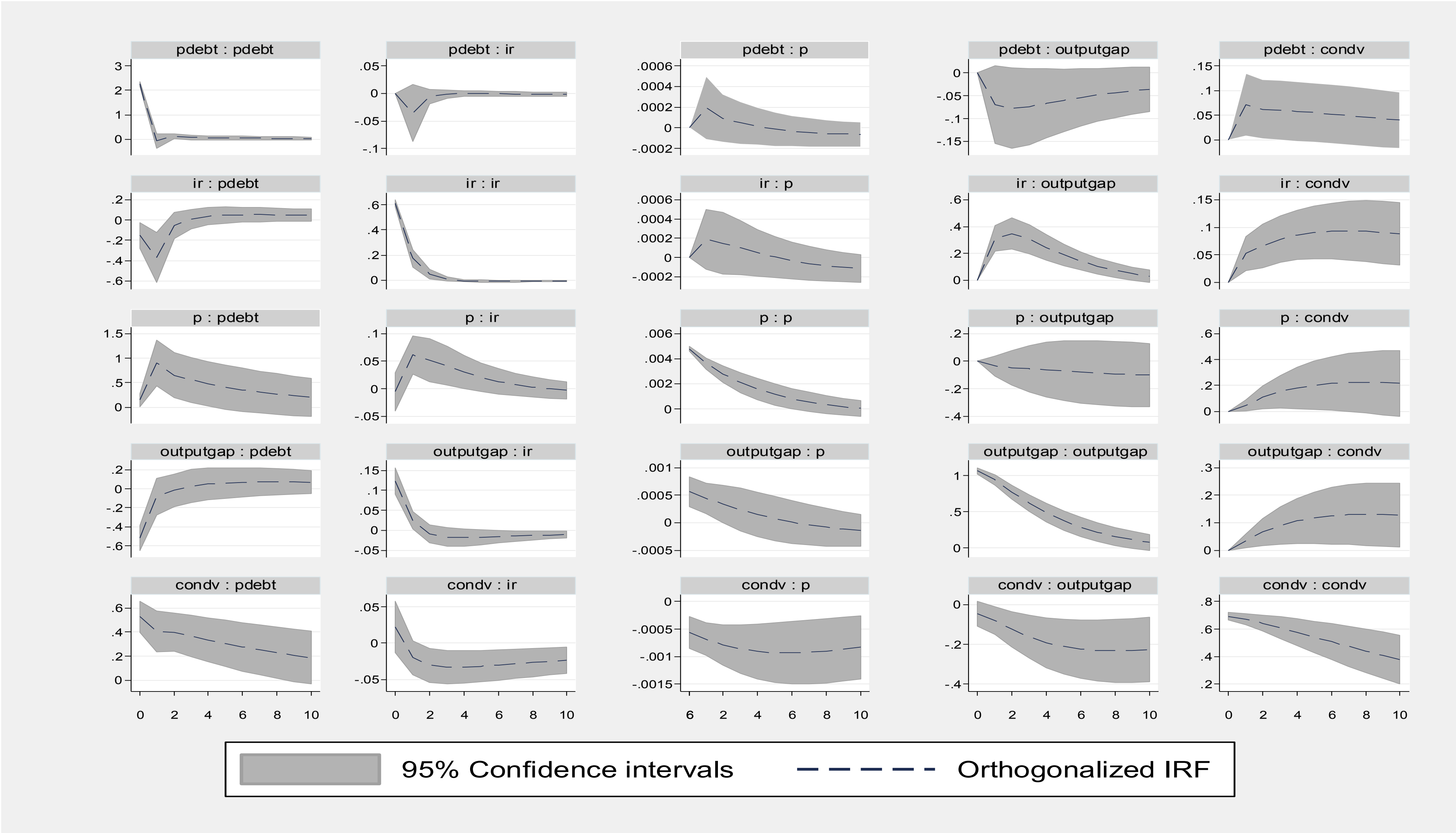
Impulse response results also capture nicely the fundamental relations between macroeconomic variables: increase in output gap decreases public debt, but stimulates inflation and consequently interest rates. At the same time, unexpected rise in inflation boosts interest rates and public debt. The results of Granger causality test reaffirm the main findings from orthogonalised impulse responses estimates. Changes in all four macroeconomic variables Granger cause conditional volatility of sovereign bond markets, although inflation changes are only significant at a 10 percent level of significance. On the other hand, conditional volatility Granger causes public debt, inflation, and interest rates. Block exclusion tests also suggest that conditional volatility Granger causes output gap, albeit this result is only significant at a 10 percent significance level.

Table 2. GARCH(1,1) Estimates of Sovereign Bond Spreads

	MEAN EQUATION				VARIANCE EQUATION					INFORMATION CRITERIA		
	C	FCD	EDC	AR(1)	C	FCD	EDC	ARCH	GARCH	A	S	H-Q
Austria	0.0005	-0.0006	-	-0.01	0.46**	0.0004***	-	0.4***	0.6***	-4.2	-4.16	-4.18
Belgium	0.00005	-0.003	-	-0.16***	0.43*	0.0006*	-	0.25***	0.7***	-3.79	-3.75	-3.77
Bulgaria	-0.005	0.005	-	-	0.0002***	0.004**	-	0.2***	0.77***	-1.34	-1.3	-1.33
Croatia	-0.004***	-	-	-	0.00006***	0.0012**	-	0.17***	0.82***	-2.1	-2.05	-2.07
Czech Republic	0.013	-0.02	-	-	0.0007	-0.0003	-	0.176***	0.81***	-1.44	-1.38	-1.42
Denmark	-0.00006	-0.0009	-	-	2.33**	0.0003	-	0.364**	0.61***	-3.22	-3.19	-3.21
Finland	0.005***	-	-	-	0.02	0.00005***	-	0.065	0.93***	-2.36	-2.34	-2.35
France	0.0005	-0.001	-	-	0.0623	0.00005***	-	0.07***	0.92***	-3.84	-3.82	-3.83
Germany	-0.007**	-	-	-	0.0002***	-	-	0.05***	0.93***	-1.65	-1.63	-1.64
Greece	0.0061	-	-0.0324	-	0.0004	-	0.03	0.57***	0.63***	1.09	1.15	1.12
Hungary	0.26	-0.053*	-	-	0.002*	0.0174*	-	0.41	0.55***	-0.69	-0.66	-0.68
Ireland	-0.003	-0.0009	0.03	-	4.2	0.007**	0.12	0.64**	0.23**	2.37	-2.32	-2.35
Italy	-0.0005	-0.005	-0.0013	-0,2***	1.252	0.006*	0.013	0.41	0.4	-3.09	-3.04	-3.07
Latvia	-0.014	0.001	-	-	0.0023**	0.0006	-	0.3***	0.73***	-0.06	-0.02	-0.05
Lithuania	-0.008	-	-	-	0.00022	-	-	0.07	0.93***	-0.45	-0.4	-0.43
Netherlands	-0.0002	-0.0011	-	-	1.22***	0.0006***	-	0.36***	0.36***	-4.45	-4.42	-4.44
Poland	-0.008	0.006	-	-	0.02	-0.01	-	0.07	0.62**	-0.44	-0.40	-0.43
Portugal	-0.0006	0.011	-0.02	-	0.764**	0.003*	0.007	0.56***	0.6***	-2.19	-2.15	-2.18
Romania	-0.014	-	-	-	0.0242	-	-	0	0.28	-0.50	-0.45	-0.5
Slovakia	0.004	-0.00134	-	-	0.0032	-0.0001	-	0.46	0.44	-1.51	-1.5	-1.5
Slovenia	0.0008	-	-	-	0.005**	-	-	0.18*	0.71***	-0.59	-0.53	-0.56
Spain	0.0004	0.004	-0.014	-	0.11	0.0008*	-0.0004	0.09**	0.903***	-2.75	-2.72	-2.74
Sweden	0.002	-0.002	-	-	5.08	0.0008	-	0.26**	0.48**	-2.78	-2.73	-2.76
United Kingdom	-0.0002	0.006	-	-	0.00005***	0.00004***	-	0.1***	0.9***	-2.37	-2.35	-2.36

Note: ***- significant at 1 percent significance level, **- significant at 5 percent significance level, * - significant at 10 percent significance level.
Source: authors´ calculation.

Figure 1. Orthogonalised Impulse Response Functions



Source: authors´ calculation.

Table 3. Granger Causality Wald Test

equation	excluded variable	chi^2 statistic	p-value
condv	outputgap	6.52	0.01
	p	3.57	0.06
	ir	12.59	0.00
	pdebt	4.17	0.04
	ALL	26.70	0.00
outputgap	condv	3.27	0.07
	p	0.43	0.51
	ir	34.13	0.00
	pdebt	2.13	0.15
	ALL	56.07	0.00
p	condv	8.26	0.00
	outputgap	0.08	0.78
	ir	1.55	0.21
	pdebt	1.63	0.20
	ALL	10.30	0.04
ir	condv	1.17	0.28
	outputgap	5.55	0.02
	p	16.50	0.00
	pdebt	1.95	0.16
	ALL	31.02	0.00
pdebt	condv	32.50	0.00
	outputgap	1.78	0.18
	p	15.43	0.00
	ir	8.74	0.00
	ALL	48.47	0.00

Source: authors´ calculation.

The results of forecast-error variance decomposition suggest that over the 10 quarter forecast horizon, inflation has the greatest role in explaining the variance of sovereign bond market conditional variance, as it explains up to 8 percent of entire variance. On the other hand, conditional variance over the same horizon explains up to 12 and 13 percent of public debt and inflation variance respectively. Conditional variance of sovereign bond market exerts a somewhat lesser influence on output gap (it helps explain up to 8 percent of its variance) and interest rates, where its influence over two and a half years horizon is almost negligible.

Table 4. Forecast Error Variance Decomposition

response variable	forecast horizon	impulse variable				
		condv	outputgap	p	ir	pdebt
condv	1	1.00	0.00	0.00	0.00	0.00
	3	0.97	0.00	0.01	0.01	0.01
	6	0.92	0.02	0.04	0.01	0.01
	8	0.89	0.02	0.07	0.01	0.01
	10	0.86	0.03	0.08	0.02	0.01
outputgap	1	0.00	1.00	0.00	0.00	0.00
	3	0.01	0.91	0.00	0.08	0.00
	6	0.03	0.85	0.00	0.10	0.01
	8	0.06	0.83	0.01	0.10	0.01
	10	0.08	0.80	0.01	0.10	0.01
p	1	0.01	0.01	0.97	0.00	0.00
	3	0.03	0.01	0.95	0.00	0.00
	6	0.07	0.01	0.92	0.00	0.00
	8	0.09	0.01	0.89	0.00	0.00
	10	0.12	0.01	0.87	0.00	0.00
ir	1	0.00	0.04	0.00	0.96	0.00
	3	0.00	0.04	0.02	0.94	0.00
	6	0.01	0.04	0.02	0.93	0.00
	8	0.02	0.04	0.02	0.92	0.00
	10	0.02	0.04	0.02	0.92	0.00
pdebt	1	0.05	0.05	0.00	0.00	0.90
	3	0.08	0.04	0.17	0.02	0.69
	6	0.11	0.03	0.23	0.02	0.60
	8	0.12	0.03	0.25	0.02	0.58
	10	0.13	0.03	0.26	0.02	0.56

Source: authors´ calculation.

As the ordering of variables in Choleski decomposition can have a significant impact on the results obtained after estimating VAR, we have also tried the reverse ordering in order to test the robustness of the results. We have found that all main findings remain intact. Due to the conservation of space, we do not report these results in the paper, but they can be obtained upon the request from the authors.

5. Concluding Remarks

The aim of this study is to examine whether short-run changes in economic fundamentals can influence the variance of country´s risk premium measured by sovereign bond spreads. For that purpose, we used data on sovereign spreads and macroeconomic indicators of interest ranging from

1994 to 2015 for 24 European Union countries. In the first part of empirical analysis we estimate conditional variance of sovereign bond spreads, which is then used in the second step along with macroeconomic indicators in order to assess whether changes in business cycle, monetary policy, public indebtedness and inflation affect sovereign spreads variance. In addition to using panel VAR in order to investigate the short-run impact of changes in economic fundamentals on sovereign spreads variance, panel VAR model can be also exploited to examine whether changes in sovereign spreads variance can have an impact on real economic outcomes.

The outcomes of our empirical investigation strongly suggest that macroeconomic results determine the variance of country risk premiums. An unexpected increase in public debt increases the variance two quarters after the shock. Conditional variance also increases after unexpected rise in inflation, with this effect being significant even five quarters after the initial shock. Overheating of the economy and unexpected interest rate increases positively stimulate the variance. Granger causality test results corroborate conclusions obtained from sovereign spreads impulse response functions, as changes in all four macroeconomic variables Granger cause sovereign spreads variance, albeit inflation changes are only significant at 10 percent level of significance.

Panel VAR estimates also suggest that changes in sovereign spreads variance result in strong and permanent increase in public debt, as the reaction of public debt to a sudden increase of sovereign spreads variance does not die out even two and a half years after the initial shock. This finding has important repercussions for public debt management policies, which should aim at stabilising the variance of sovereign spreads in order to prevent unnecessary permanent debt increases. In addition, increase in sovereign spreads is shown to have a permanent adverse effect on the business cycle, as sovereign spreads variance lowers the output gap. It also results in a small, but permanent and statistically significant drop in consumer prices. Having taken all things into consideration, our empirical analysis clearly suggests that policy-makers should pay closer attention to movements of sovereign spreads variance. It is evident from this study that neglecting to do so can have adverse and permanent economic consequences.

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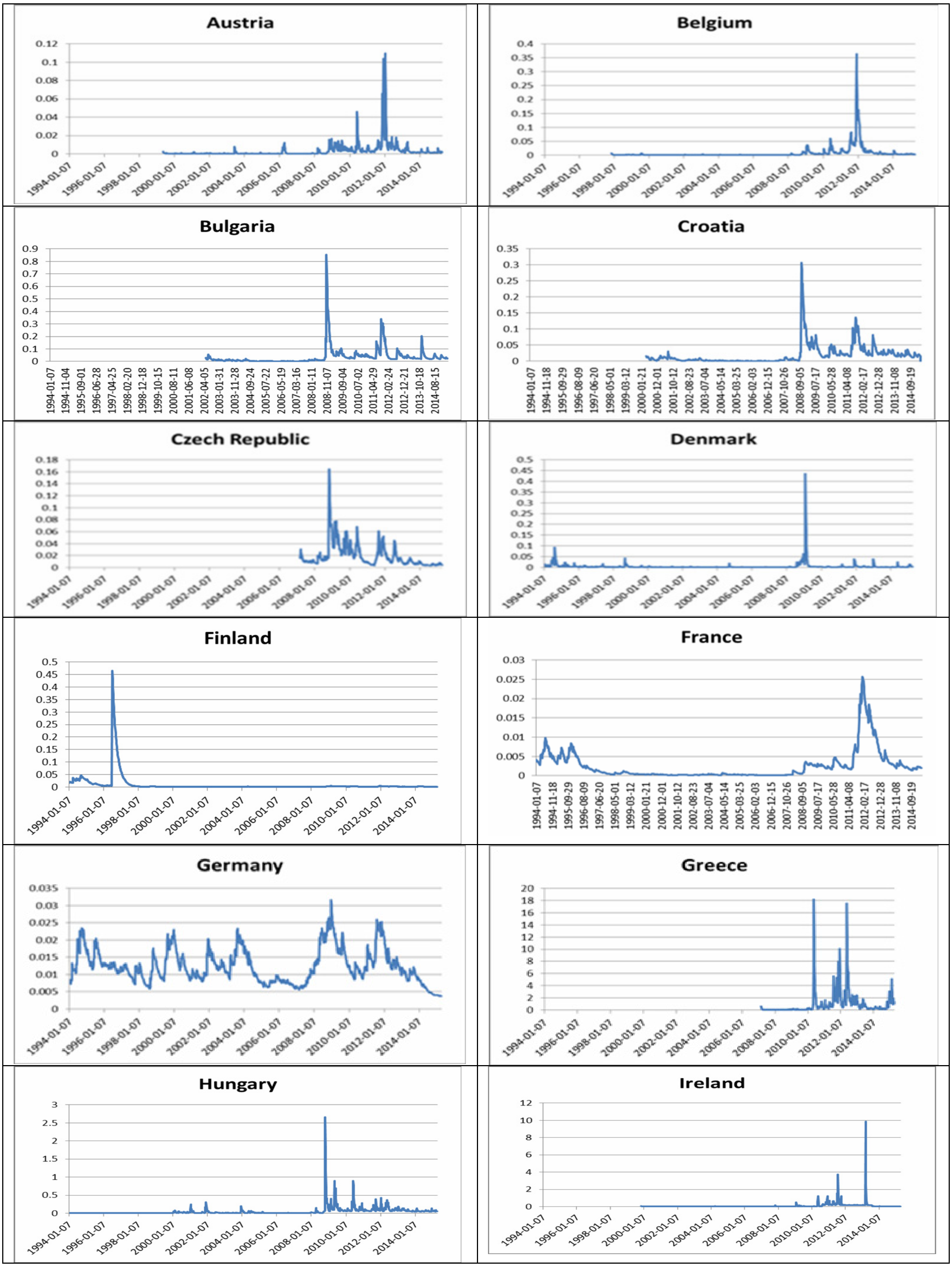
Appendix

Figure A1. Conditional Variance of Sovereign Bond Markets



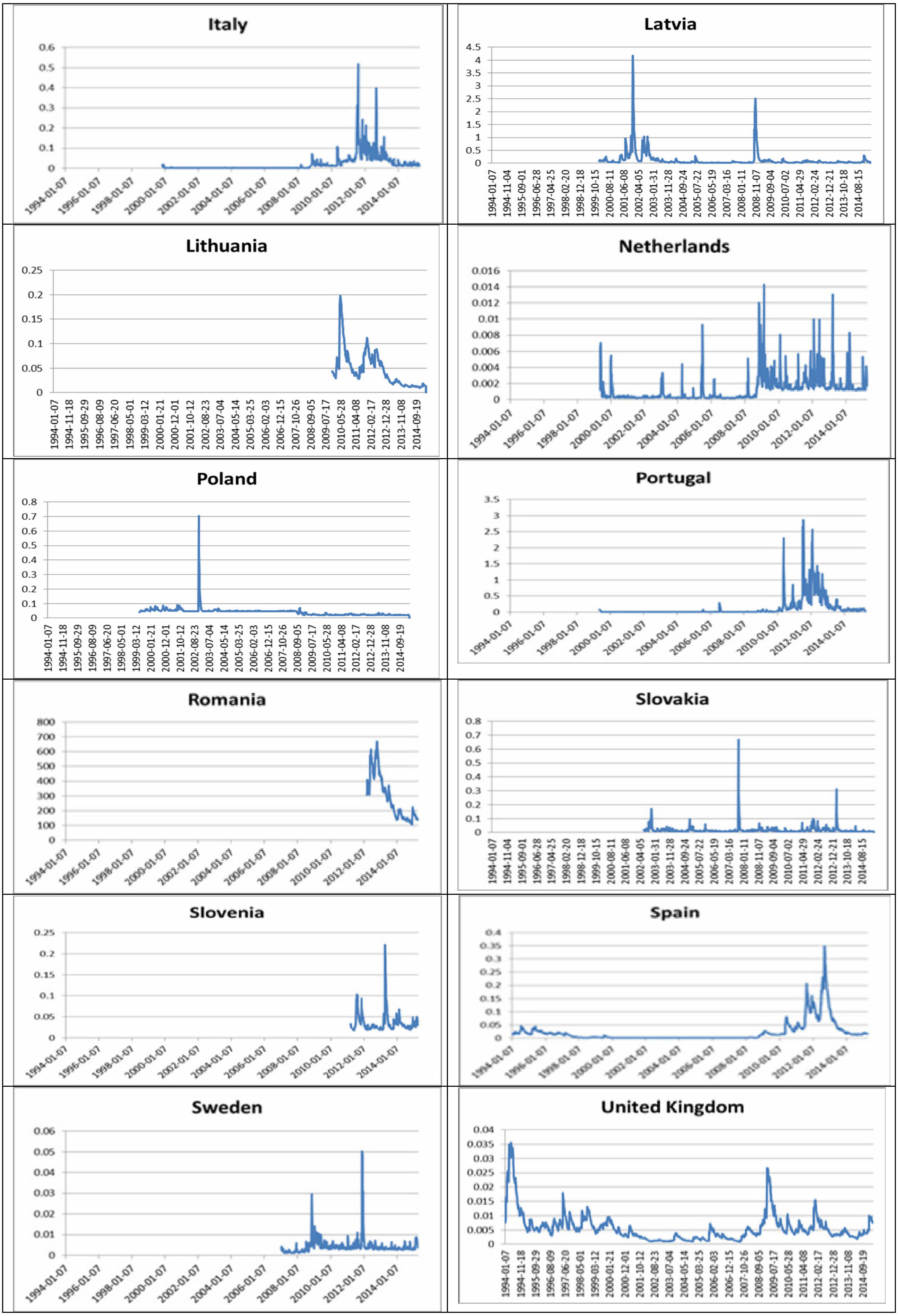

Italy
0.6 0.5 0.4 0.3 0.2 0.1 0
Latvia
4.5 4 3.5 3 2.5 2 1.5 1 0.5 0
Lithuania
0.25 0.2 0.15 0.1 0.05 0
Netherlands
0.016 0.014 0.012 0.01 0.008 0.006 0.004 0.002 0
Poland
0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0
Portugal
3.5 3 2.5 2 1.5 1 0.5 0
Romania
800 700 600 500 400 300 200 100 0
Slovakia
0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0
Slovenia
0.25 0.2 0.15 0.1 0.05 0
Spain
0.4 0.35 0.3 0.25 0.2 0.15 0.1 0.05 0
Sweden
0.06 0.05 0.04 0.03 0.02 0.01 0
United Kingdom
0.04 0.035 0.03 0.025 0.02 0.015 0.01 0.005 0
1994-01-07 1996-01-07 1998-01-07 2000-01-07 2002-01-07 2004-01-07 2006-01-07 2008-01-07 2010-01-07 2012-01-07 2014-01-07

Table A1. Lag Selection Criteria

lag	MBIC	MAIC	MQIC
1	-355.8	18.5	-123.2
2	-244.3	5.3	-89.2
3	-151.9	-27.2	-74.4
4	1.21E-29	1.21E-29	1.21E-29

Source: authors´ calculation.

Table A2. Moduli of VAR Companion Matrix

Eigenvalues		Modulus
Real	Imaginary	
0.8955	0	0.8955
0.8611	0	0.8611
0.7889	0	0.7889
0.3266	0	0.3265
-0.1113	0	0.1113

Source: authors´ calculation.

Table A3. Panel VAR Estimates

	Coefficient	Standard errors	z-value	p-value	95% confidence interval	
$condv_t$						
$condv_{t-1}$	0.95	0.02	38.39	0.00	0.90	1.00
$outputgap_{t-1}$	0.03	0.01	2.55	0.01	0.01	0.06
p_{t-1}	8.66	4.59	1.89	0.06	-0.33	17.6
ir_{t-1}	0.09	0.03	3.55	0.00	0.04	0.15
$pdebt_{t-1}$	0.03	0.02	2.04	0.04	0.00	0.06
$outputgap_t$						
$condv_{t-1}$	-0.06	0.03	-1.81	0.07	-0.12	0.01
$outputgap_{t-1}$	0.81	0.02	35.76	0.00	0.77	0.86
p_{t-1}	-5.70	8.72	-0.65	0.51	-22.8	11.4
ir_{t-1}	0.50	0.09	5.84	0.00	0.33	0.67
$pdebt_{t-1}$	-0.03	0.02	-1.46	0.15	-0.07	0.01
p_t						
$condv_{t-1}$	0.00	0.00	-2.87	0.00	0.00	0.00
$outputgap_{t-1}$	0.00	0.00	0.28	0.78	0.00	0.00
p_{t-1}	0.75	0.05	15.68	0.00	0.66	0.84
ir_{t-1}	0.00	0.00	1.25	0.21	0.00	0.00
$pdebt_{t-1}$	0.00	0.00	1.28	0.20	0.00	0.00
ir_t						
$condv_{t-1}$	-0.02	0.02	-1.08	0.28	-0.05	0.01
$outputgap_{t-1}$	-0.02	0.01	-2.36	0.02	-0.04	0.00
p_{t-1}	13.64	3.36	4.06	0.00	7.06	20.23
ir_{t-1}	0.28	0.06	4.78	0.00	0.17	0.40
$pdebt_{t-1}$	-0.02	0.01	-1.4	0.16	-0.04	0.01
$pdebt_t$						
$condv_{t-1}$	0.77	0.14	5.7	0.00	0.51	1.04

$outputgap_{t-1}$	-0.12	0.09	-1.33	0.18	-0.30	0.06
p_{t-1}	189.5	48.2	3.93	0.00	94.9	284
ir_{t-1}	-0.61	0.21	-2.96	0.00	-1.01	-0.21
$pdebt_{t-1}$	-0.03	0.07	-0.45	0.65	-0.18	0.11

No. of obs = 1111
No. of panels = 24
Ave. no. of T = 46.3
Final GMM Criterion Q(b) = 0.135
Instruments : lags 1/3 of condv outputgap p ir pdebt

Source: authors´ calculation.

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