The determinants of euro area sovereign bond yield spreads

An empirical analysis

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Summary of views & key findings

- In this paper we present the results of an empirical study on the determinants of the sovereign bond yield spreads in the euro area before and after the outbreak of the global financial crisis. As an additional step, we estimate a valuation model for the 10-year Greek government bond yield differentials, with the aim to measure the degree of any over- or under-valuation of Greek sovereign debt prices with respect to the macroeconomic- and market-related fundamentals.

- Although the disaggregation of sovereign credit spreads into their constituent components is a rather difficult exercise, we follow the relevant empirical literature and focus on three distinct classes of potential determinants; namely: *credit risk*; *liquidity risk*; and *global risk aversion*.

- Some of the main results of our study are highlighted below:

i. Our empirical results broadly indicate that the determinants of sovereign bond yield spreads in the euro area have changed significantly across time, with the underlying fiscal-, liquidity- and global risk sentiment-related fundamentals playing a much greater role in market pricing, especially at the height of the EMU crisis and for the so-called euro-area periphery economies.
ii. This compares with the period before the outbreak of the global crisis, which saw a significant disconnect between domestic macro/fiscal fundaments and the pricing of sovereign debt markets in the euro area.
iii. The baseline specification of our fundamentals-based valuation model for Greek debt securities explains around 60% of the volatility in the monthly series of Greek 10yr government bond yield spreads vs. Germany from January 2009 onwards.
iv. This implies that other factors (not accounted for in our empirical model) have been influencing the evolution of Greek sovereign debt spreads over the aforementioned period. Arguably, such factors may include: market liquidity conditions, increased political and macroeconomic uncertainty as well as periods of heightened investor fears over Greece's euro membership.
v. Taking these caveats and model limitations into account, our study provides an estimate of the (under-)valuation of the 10-yeak Greek bond prices relative to the underlying fundamentals over the period January 2009 to April 2017.
vi. The degree of this undervaluation has exhibited a tendency to peak in periods of increased macroeconomic and political uncertainty in Greece and the euro area, while, most recently, the market pricing of Greek government securities has broadly aligned with the macroeconomic- and market-related fundamentals examined in our study.
vii. If this is so, then an additional significant compression of Greek bond spreads would require a further improvement of domestic macro fundamentals and/or other, external developments, such as the provision of more clarity on the medium- and long term EU debt relief framework for Greece and the prospect of including eligible Greek debt in the ECB's QE programme.
viii. While the type of empirical models analyzed in the study may not be suitable for bond trading purposes, it nonetheless provides some useful insights on the way various influences (fundamentals- and non-fundamentals-related) have affected the pricing of Greek government bonds following the outbreak of the sovereign debt crisis.

Part I

Related literature, data & econometric methodology

Determinants of sovereign bond spreads

What the empirical literature says

- The disaggregation of sovereign credit spreads into constituent components is generally a difficult exercise. Yet, recent empirical studies document at least three distinct determinants; these include: *credit risk*; *liquidity risk*; and *risk aversion.*[1]

— ***Credit risk*** reflects a country's creditworthiness i.e., its ability (and willingness) to make full (and timely) principal and interest payments on its obligations to international creditors. Recent empirical studies find a close link between country-specific fundamentals and variations in respective credit risk premia. In particular, lower levels of political risk are often associated with tighter spreads. The same result applies for credible fiscal policies, especially in countries that experienced prior defaults. Fiscal transparency and the quality of data reporting are also found to have a positive influence. Finally, event studies show that macroeconomic data announcements may have a significant impact on government bond yield differentials, especially in short-term horizons. On the latter point, some recent studies find that US macroeconomic announcements not only affect US markets but also exert a significant effect on European bond markets.

— ***Liquidity risk*** relates to the notions of *i.* market *depth*, which indicates the existence of a sufficiently large number of buy and sell orders for a particular asset and *ii.* market *breadth*, which reflects the degree to which market orders to buy or sell a particular asset can move prices. Though many factors can affect market liquidity (which may itself be time-varying), more liquid markets generally deserve a lower risk premium (and vice-versa). This is because in a relatively illiquid market, big players run the risk of influencing the asset price against them when e.g. they execute consecutive market buy or sell orders. A less liquid market may also be easier to manipulate by *informed* traders at times of increased uncertainty and large information asymmetries.

— ***Risk aversion***: more recently, there has been increased emphasis on global factors such as contagion from systemically-important events, investor risk appetite, interest rate expectations and world market volatility.

[1]For a more comprehensive overview of the relevant literature on the determinants of sovereign bond spreads see e.g. Afonso et al. (2015)

Source: Eurobank Economic Research & related literature

Model specification

Empirical framework for explaining sovereign bond spreads in the EMU

Empirical framework: dynamic panel model to explain 10-year euro area government bond yield spreads vs. Germany.

Estimation methodology: Two-Stage Least Squares with cross-section weights.

General specification form:

$$Spread_{it} = c + \beta 1 * Spread_{it-1} + \beta 2 * Credit\_Risk_{it} + \beta 3 * Liquidity\_Risk_{it} + \beta 4 * Risk\_Aversion_{t} + \gamma_i + \varepsilon_{it} \quad (1)$$

Where,

t is time subscript and i cross-section indicator

$Spread_{it}$ denotes the 10-year government bond yield spread of country i vs. the German equivalent (in levels)

$Spread_{it-1}$ is the first lag of 10-year government bond yield spread (to capture any persistence in the dependent variable)

$Credit\_Risk_{it}$ denotes a suitable credit risk indicator for country i at time t

$Liquidity\_Risk_{it}$ denotes a suitable liquidity risk indicator for country i at time t

$Risk\_Aversion_{t}$ denotes a suitable international risk sentiment indicator at time t (to capture potential contagion effects)

γ_i indicates county-specific fixed effects

ε_{it} is the error term

Data frequency & time span: monthly observations, mostly spanning the period January 1999 to June 2017

Cross sections:

Number of cross-sections: 10

The countries examined in the study include Greece, Portugal, Spain, Belgium, Netherlands, Austria, Italy, Ireland, France, Finland and Germany. The rest of the euro area countries are excluded from the analysis, as they do not currently have liquid 10-year government bond markets.

Source: Eurobank Economic Research & related literature

Variables used in the empirical analysis

Definitions & acronyms

		Acronym	Description	Source	Frequency	Time span
Dependent variable		*10yr sovereign spread* $_{it}$	10-year government bond yield spread vs. Germany (levels)	Bloomberg	monthly	Jan 1999-Jun 2017
Explanatory variables	**Fiscal & macro**	*10yr sovereign spread* $_{it-1}$	1st lag of 10-year government bond yield spread vs. Germany	Bloomberg	monthly	Feb 1999-Jun 2017
		budget_balance $_{it}$	Forecasted (one-year-ahead) general government budget balance as % of GDP of country *i* minus corresponding metric for Germany	European Commission Forecasts (released bi-annually)	monthly	Jan 2002-Jun 2017
		debt_ratio $_{it}$	Forecasted (one-year-ahead) gross public debt as % of GDP of country *i* minus corresponding metric for Germany	European Commission Forecasts (released bi-annually)	monthly	Jan 2002-Jun 2017
		$(debt\_ratio_{it})^2$	difference between forecasted (one-year-ahead) debt ratios squared	European Commission Forecasts (released bi-annually)	monthly	Jan 2002-Jun 2017
		log_reer $_{it}$	Logarithmic difference of real effective exchange rates (country *i* minus Germany)	Eurostat	monthly	Jan 1999-Jun 2017
		ip_yoy $_{it}$	Difference of industrial production YoY growth rates (country *i* minus Germany)	Eurostat	monthly	Jan 2000-Aprl 2017

Source: Eurobank Economic Research & indicated sources

Variables used in the empirical analysis (continued)

Definitions & acronyms

		Acronym	Description	Source	Frequency	Time span
Explanatory variables	Risk aversion	$log\_iTraxx\ main_t$ log_vix_t	Logarithms of the Itraxx Main index and the S&P 500 implied stock market index (VIX)	Bloomberg	monhtly	Jun 2004-Jun 2017 & Jan 1999-Jun 2017, respectively
		$Risk\_aversion1_t$, $Risk\_aversion2_t$, $Risk\_aversion3_t$	Each of these variables is extracted as the 1st principal component of different combinations of the following metrics: *log_EURUSD_vol* (logarithm of implied volatility of the EUR/USD currency pair); *log_vix*; *log_Itraxx*; *Libor_OSI_Spread*; and *USBBB_UST10YR_Spread* (generic yield spread between 10yr US BBB-rated corporate paper and 10yr US Treasury security) – see Appendix	Bloomberg	monhtly	Sept 2002-Jun 2017, July 2004-Jun 2017 & Sept 2002-Jun 2017, respectively
	Core-periphery heterogeneity variable	$spreads\_2pc_t$	Defined as *minus* the second principal component of the euro area spreads examined in our study, to capture the dichotomy observed between core and periphery EMU countries at the height of the global financial crisis. Increases in this variable indicate higher periphery risk. See Appendix and Afonso et al. (2015).	Bloomberg	monhtly	Jan 1999-Jun 2017
	Dummies	*Dummy_Aug2007;* *Dummy_Mar2009;* *Dummy_Sept2009;* *Dummy_Jul2012;* *Dummy_Jan2015*	Dummy variables taking the value of 1 from the indicated date onwards and the value of 0 otherwise; *Dummy_Aug2007* to capture the point in time of the outbreak of the global crisis; *Dummy_Mar2009* to capture the point in time when the global credit crisis started being transformed into the euro area sovereign debt crisis; Dummy_Sept2009 to capture the point in time of the outbreak of the Greek crisis; *Dummy_Jul2012* to capture M. Draghi's *"Whatever it takes"*; and *Dummy_Jan2015* to capture the point in time of the initiation of ECB's extended asset purchase programme.	Eurobank Research	monhtly	Jan 1999-Jun 2017

Source: Eurobank Economic Research & indicated sources

Part II

Empirical results & interpretation

Empirical results (*all countries*)

Models 1-6 (dependent variable: 10yr sovereign spread$_{it}$)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.433	0.145	0.037**	0.058***	0.050***	0.049***
10yr sovereign spread $_{it-1}$	0.980***	0.971***	0.968***	0.966***	0.965***	0.965***
budget_balance $_{it}$	-0.013**	-0.004*	-0.004**	-0.007**	-0.006**	-0.006**
debt_ratio $_{it}$	-0.094	-0.052	0.025			
(debt_ratio $_{it}$)^2				2.05E-05		
log_reer $_{it}$		0.003	0.008***	0.006***	0.004*	0.004
ip_yoy $_{it}$		0.003***	0.003***	0.003***		
market liquidity $_{it}$						
log_iTraxx main $_{t}$	-0.062					
log_vix $_{t}$		-0.036				
Risk aversion 1 $_{t}$		0.020***	0.013***			
Risk aversion 2 $_{t}$				0.012***		
Risk aversion 3 $_{t}$	0.029***				0.005***	0.012***
spreads_2pc $_{t}$						0.011**
Dummy_Aug2007				-0.009		
Dummy_Mar2009	-0.174***					
Dummy_Sep2009			0.021**		0.024**	0.017
Dummy_Jul2012			-0.061***	-0.045***	-0.061***	-0.057***
Dummy_Jan2015				0.008		
*N*T*	1540	1700	1690	1480	1690	1690
Adj_R^2	98%	0.98	0.98	98%	98%	98%
SE or regression	37%	40%	38%	43%	41%	41%

Note: The regression models are estimated over the time period Jan 1999-Jun 2017 (number of observations *TxN* = 2,220). The panel members include Greece, Portugal, Spain, Belgium, Netherlands, Austria, Italy, Ireland, France and Finland (number of cross-sections=10). The models are estimated with Two-Stage Least Squares with cross-section weights. The instruments used are the second and third lag of the dependent variable and the first and second lag of the independent variables. The asterisks ***, **, * indicate significance at the 1, 5 and 10% confidence level, respectively.

Source: Eurobank Economic Research

Empirical results (*all countries*)

Models 7-10 (dependent variable: 10yr sovereign spread$_{it}$)

Variable	Model 7	Model 8	Model 9	Model 10
Constant	-0.005	-0.006	0.015	-0.354*
10yr sovereign spread$_{it-1}$	0.891***	0.894***	0.901***	0.904***
budget_balance$_{it}$	0.012			
debt_ratio$_{it}$	0.006***	0.003***	0.002**	0.002**
log_reer$_{it}$	0.027*	0.019		
log_vix$_{t}$				0.001*
Risk aversion 3$_{t}$	-0.011	-0.009	-0.009	
spreads_2pc$_{t}$	-0.044	-0.038	-0.040	0.001
*(budget_balance$_{it}$)*Dummy_Sep2009*	-0.001			
*(budget_balance$_{it}$)*Dummy_July2012*	0.043***			
*(debt_ratio$_{it}$)*Dummy_Sep2009*	0.012***	0.013***	0.016***	0.016***
*(debt_ratio$_{it}$)*Dummy_Jul2012*	-0.011***	-0.011***	-0.013***	-0.013***
*(log_reer$_{it}$)*Dummy_Sep2009*	0.051***	0.050***		
*(log_reer$_{it}$)*Dummy_Jul2012*	-0.060***	-0.064***		
*(Risk aversion 3$_{t}$)*Dummy_Sep2009*	0.129***	0.135***	0.216***	
*(Risk aversion 3$_{t}$)*Dummy_Jul2012*	-0.104**	-0.083**	-0.168***	
*(log_vix$_{t}$)*Dummy_Sep2009*				0.001***
*(log_vix$_{t}$)*Dummy_Jul2012*				-0.001**
*(spreads_2pc$_{t}$)*Dummy_Sep2009*	0.165***	0.165***	0.225***	0.158**
*(spreads_2pc$_{t}$)*Dummy_July2012*	-0.085	-0.133**	-0.193***	-0.159***
*N*T*	1700	1700	1760	1840
Adj_R^2	0.98	0.98	0.98	0.98
SE or regression	0.44	0.44	0.44	0.44

Note: The regression models are estimated over the time period Jan 1999-Jun 2017 (number of observations *TxN* = 2,220). The panel members include Greece, Portugal, Spain, Belgium, Netherlands, Austria, Italy, Ireland, France and Finland (number of cross-sections=10). The models are estimated with Two-Stage Least Squares with cross-section weights. The instruments used are the second and third lag of the dependent variable and the first and second lag of the independent variables. The asterisks ***, **, * indicate significance at the 1, 5 and 10% confidence level, respectively.

Source: Eurobank Economic Research

Empirical results (*selective EMU periphery countries*)

Models A-C (dependent variable: 10yr sovereign spread$_{it}$)

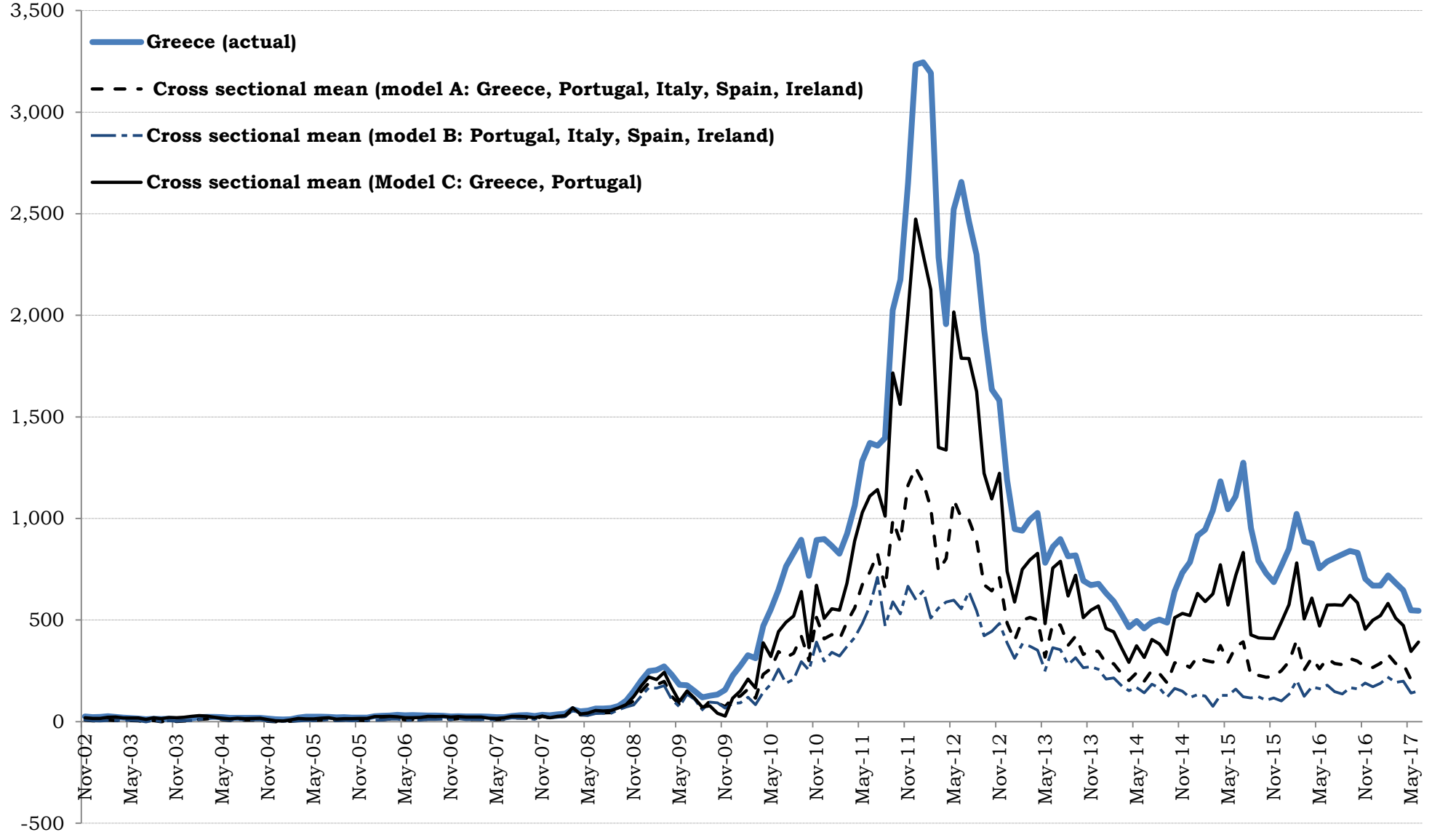
Variable	Model A (Greece, Portugal, Italy, Spain & Ireland)	Model B (Portugal, Italy, Spain & Ireland)	Model C (Greece & Portugal)
Constant	0.065	0.035**	-0.041
10yr sovereign spread$_{it-1}$	0.934***	0.939***	0.870
budget_balance$_{it}$	-0.004	-0.007	-0.043
debt_ratio$_{it}$	-0.001	-0.001	0.002
Risk aversion 3$_t$	0.021	**0.025**	**0.045**
spreads_2pc$_t$	0.009	**0.017**	**0.026**
*(budget_balance$_{it}$)*Dummy_Sep2009*	-0.038***	**-0.029****	**0.012**
*(budget_balance$_{it}$)*Dummy_July2012*	0.029*	**0.024****	**0.040**
*(debt_ratio$_{it}$)*Dummy_Sep2009*	0.005***	**0.002****	**0.021****
*(debt_ratio$_{it}$)*Dummy_Jul2012*	-0.003**	**-0.001**	**-0.014****
*(Risk aversion 3$_t$)*Dummy_Sep2009*	**0.081****	**0.077***	**0.442*****
*(Risk aversion 3$_t$)*Dummy_Jul2012*	**-0.070**	**-0.073***	**-0.399****
*(spreads_2pc$_t$)*Dummy_Sep2009*	**0.187*****	**0.171*****	**0.384****
*(spreads_2pc$_t$)*Dummy_July2012*	**-0.230*****	**-0.221*****	**-0.422****
*N*T*	880	704	352
Adj_R^2	0.98	0.98	0.98
SE or regression	0.50	0.28	0.80

Note: The regression models are estimated over the time period Jan 1999-Jun 2017. The panel members include selective groups of the following EMU periphery countries: Greece, Portugal, Spain, Italy, Ireland (number of cross-sections=5, 4 and 2, respectively). The models are estimated with Two-Stage Least Squares with cross-section weights. The instruments used are the second and third lag of the dependent variable and the first and second lag of the independent variables. The asterisks ***, **, * indicate significance at the 1, 5 and 10% confidence level, respectively.

Source: Eurobank Economic Research

How Greece compares with the cross sectional means of Models A, B & C

(see empirical results in previous page)



Source: Eurobank Economic Research

Empirical results: interpretation & policy implications

Models 1-6

Lagged dependent variable (*10yr sovereign spread*$_{it-1}$): The coefficient of the lagged dependent variable is positive and highly significant in all specifications (models 1-6). This indicates a strong persistence of sovereign bond yield spreads in monthly frequencies (similar results documented in other relevant studies see e.g. Afonso at al., 2015).

Fiscal variables (*budget_balance*$_{it}$ & *debt_ratio*$_{it}$): The coefficient of the expected (one-year-ahead) fiscal performance of country *i* vs. that of Germany has the correct theoretical sign (negative) and is mostly significant. This confirms the significance of expected fiscal fundamentals in the determination of sovereign debt yield spreads i.e., expectations for an improvement in the general government fiscal balance tend to reduce bond yield spreads (and vice versa). On the other hand, the coefficient of the expected debt ratio differential of country *i* relative to that of Germany is mostly insignificant and has the wrong theoretical sign (negative). Same result applies to the square of the aforementioned variable $(debt\_ratio_{it})^2$.

Economic activity & competitiveness variables (*ip_yoy*$_{it}$ & *log_reer*$_{it}$): The coefficient of the relative economic performance variable, ip_yoy_{it} (first difference of contemporaneous year-on-year industrial production growth of country *i* relative to that in Germany), is strongly significant, but has the wrong expected sign in all estimated specifications (models 2-4). On the other hand, the relative price competitiveness variable, log_reer_{it}, (logarithmic difference of the CPI-based REER of country *i* relative to Germany) has the correct expected sign (positive) and is mostly significant (models 3-5). The *expected* theoretical signs cited above align with the notion that improved competitiveness and macroeconomic conditions support public finances and market perceptions for the outlook of a country (and thus, tend to reduce sovereign risk premia), especially in periods of reduced investor appetite for risk.

Risk aversion variables (*Risk_aversion*$_{1t}$, *Risk_aversion*$_{2t}$, *Risk_aversion*$_{3t}$): The coefficients of the risk aversion variables (each one of them is extracted as the first principal component of different groups of risk-sentiment metrics) are all found to be statistically significant and to have the correct theoretical sign (positive). The rationale of this relationship is based on a standard "flight-to-quality" argument in periods of generalized risk-aversion by international investors (and vice-versa during periods of increased investor appetite for risk). Similar results are documented in earlier empirical studies.[1]

[1] Among others, Attinasi, Checherita and Nickel (2009) use a dynamic panel approach to explain the determinants of sovereign bond yield spreads in a sample of selected euro area countries during the period July 2007-March 2009. They find that international risk aversion explains as much as 55.6% of the daily change in sovereign spreads over Germany. The study also shows that the remainder of the corresponding cumulative change in spreads over the said period can be attributed to i. the expected fiscal balance and government debt over Germany (7.7% and 13.6%, respectively) ii. bond market liquidity conditions relative to Germany (13.9%) and iii. the bank support packages announced by many Eurozone governments in the months following the Lehman collapse (9.2%).

Source: Eurobank Economic Research

Empirical results: interpretation & policy implications

Models 7-10

In order to examine whether and to what extent the determination of sovereign bond yield spreads has changed after the outbreak of the global financial crisis (as well as during the different phases of the euro area sovereign debt crisis), we follow Afonso et al. (2015) and others and introduce a number of slope dummies, which enter our model specifications (models 7-10) in multiplicative form i.e., they are multiplied by the *macro-fiscal*, *liquidity* and *risk aversion* variables under examination.

These dummy variables aim to capture different points in time corresponding to major events that may have caused structural shifts in the bond yield spread series, such as the outbreak of the global financial crisis (August 2007); the beginning of the transformation of the global credit crisis into the euro area sovereign debt crisis (March 2009); the outbreak of the Greek crisis (September 2009); M. Draghi's "Whatever it takes" verbal intervention (July 2012); and the inception of the ECB's extended asset purchase programme (January 2015).

Generally, the majority of *credit risk*, *liquidity risk* and *risk aversion* variables under examination are strongly significant and have the correct theoretical/expected signs when multiplied by the slope variable *Dummy_Sept2009,* which captures the point in time when the Greek crisis erupted. The same result applies for our *core-periphery heterogeneity* variable, $spreads\_2pc_t$ (extracted as minus the 2nd principal component of the sovereign bond yield spreads under study), which aims to capture the dichotomy observed between core and periphery EMU countries at the height of the global financial crisis. Note that increases in this variable indicate higher periphery risk.

On the other hand, when most of the aforementioned *credit risk*, *liquidity risk* and *risk aversion* variables are multiplied by the slope dummy, *Dummy_Jul2012,* which marks the point in time when Mario Draghi committed to do "whatever it takes" to contain the deepening euro area sovereign debt crisis, the respective coefficients mostly reverse in sign and are strongly significant. We interpret this result as providing empirical support to the effectiveness of the ECB's "whatever it takes" verbal intervention (as well the relevant policy measures taken afterwards) to contain and reduce the contagion effects of the crisis in the euro area periphery.

All in all, our empirical results broadly indicate that the determinants of sovereign bond yield spreads in the euro area have changed significantly across time, with the macroeconomic/fiscal, liquidity and global risk sentiment fundamentals playing a much greater role in market pricing, especially at the height of the EMU crisis and for the so-called euro-area periphery economies. This compares with the period before the outbreak of the global crisis, which saw a significant disconnect between domestic macro/fiscal fundaments and the pricing of sovereign debt markets in the euro area (as suggested by our empirical results as well as numerous earlier empirical studies).

Source: Eurobank Economic Research

Part III

A fundamentals-based valuation framework for Greek sovereign bond yield spreads

Fundamentals-based valuation model for Greek sovereign bond yield spreads

Baseline specification

Empirical framework: Time series analysis to explain the evolution of 10-year Greek government bond yield spreads vs. Germany.

Estimation methodology: Least Squares (to control for potential endogeneity, the baseline model has also been estimated with Two-Stage Least Squares with the first two lags of independent variables used as instruments – no serious endogeneity problems have been detected and thus, the regression results shown on page 16 correspond to Least Squares estimation).

Model specification – general form:

$$\Delta(Greek\_Spread_t) = c + \beta_1 * \Delta(Portuguese\_Spread_t) + \beta 2 * \Delta(Greek\_macro/fiscal_t) + \beta 3 * (Global\_Risk\_Aversion_t) + \varepsilon_t$$

Where,

t is time subscript & ***Δ*** is the first difference operator

Greek_Spread & ***Portuguese_Spread*** denote the respective 10-year government bond yield spreads to Germany

The ***Greek_macro/fiscal*** variables include:

- ***D(LOG(ESI_GR)):*** first logarithmic difference of the Economic Sentiment Index
- ***D(LOG(REER_GR)):*** first logarithmic difference of the CPI-based Real Effective Exchange Rate of Greece vs. 37 trade partners
- ***D(DEBT_RATIO_GR):*** first difference of the public debt to GDP ratio
- ***D(LOG(RS_GR)):*** first logarithmic difference of the Retail Sales index (volume, seasonal & calendar days adjusted)

The Global_Risk_Aversion *variable* (acronym: *INTRISK3(-1)*) represents the (first lag of) of the *Risk_Aversion* variable used in the panel study (see page 6 & Appendix)

The slope dummy variables ***D_Sept2011*** & ***D_Jun_2012*** *(=1.0 from Sep. 2011 and Jun. 2012 onwards and zero otherwise)* enter our regression in multiplicative form i.e., they are multiplied by the respective Greek macro/fiscal variables.

Data frequency & time span: monthly observations, mostly spanning the period January 2009 to June 2017

Regression outcome: see page 16

Source: Eurobank Economic Research & relevant data sources

Fundamentals-based valuation model for Greek sovereign bond yield spreads

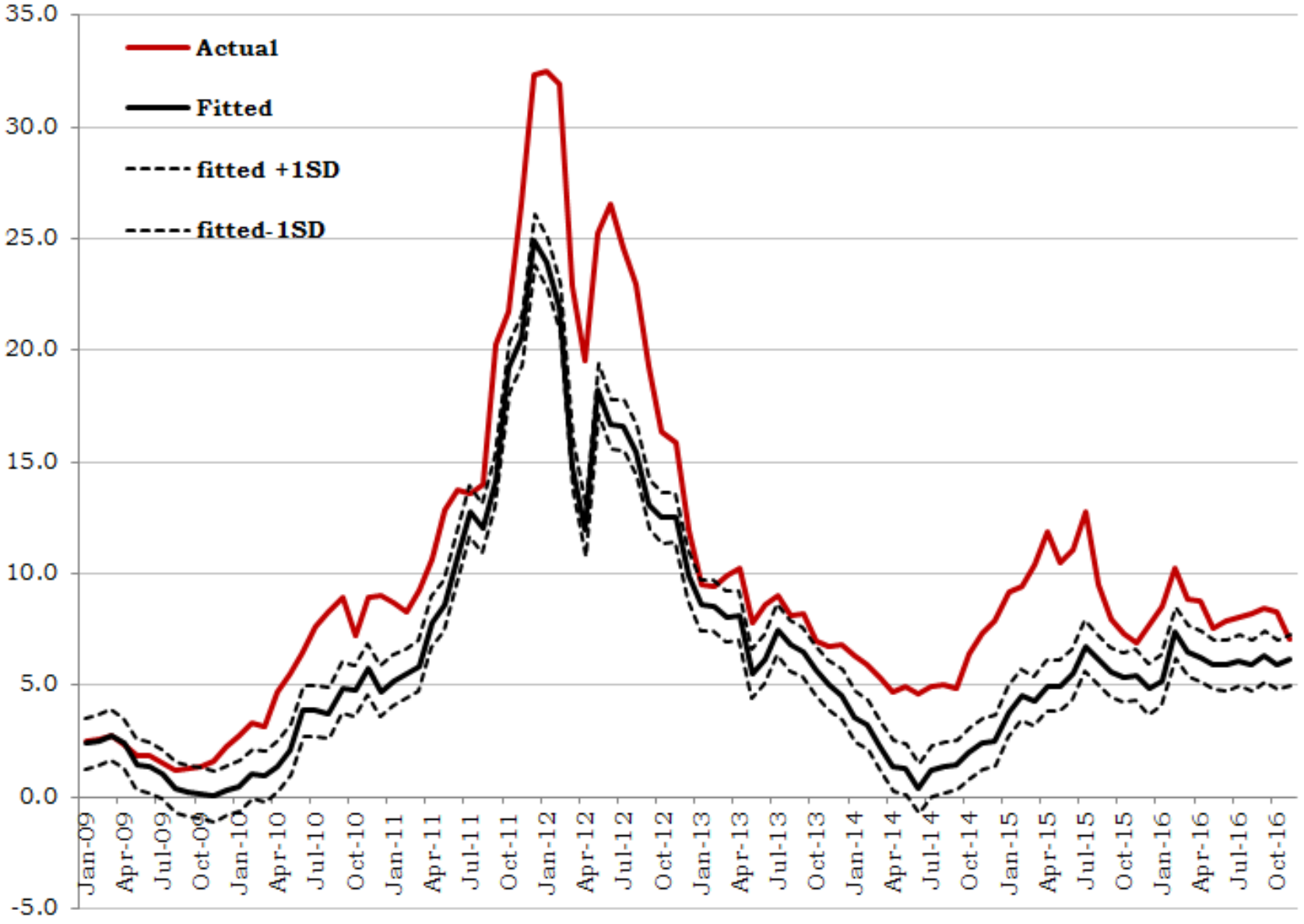
Baseline model estimates

Dependent Variable: D(SPREADS)				
Method: Least Squares				
Date: 01/07/11 Time: 23:27				
Sample (adjusted): 2009M01 2017M04				
Included observations: 100 after adjustments				
White Heteroskedasticity-Consistent Standard Errors & Covariance				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(SPREAD_PORTUGAL)	1.390	0.258	5.387	0.000
D(INTRISK3(-1))	0.421	0.227	1.852	0.067
D_SEPT2011*D(LOG(ESI_GR))	-0.973	0.587	-1.658	0.098
D_JUN2012*D(LOG(ESI_GR))	0.911	0.590	1.543	0.101
D_SEPT2011*D(LOG(REER_GR))	-1.833	0.555	-3.305	0.001
D_JUN2012*D(LOG(REER_GR))	1.667	0.565	2.949	0.004
D_SEPT2011*D(DEBT_RATIO_GR)	0.433	0.089	4.888	0.000
D_JUN2012*D(DEBT_RATIO_GR)	-0.620	0.178	-3.474	0.001
D_SEPT2011*D(LOG(RS_GR))	-0.404	0.158	-2.553	0.012
D_JUN2012*D(LOG(RS_GR))	0.323	0.168	1.927	0.057
C	0.056	0.110	0.508	0.612
Adjusted R-squared	0.609	S.D. dependent var		1.873
S.E. of regression	1.171	Akaike info criterion		3.258
Sum squared resid	122.110	Schwarz criterion		3.544
Log likelihood	-151.881	Hannan-Quinn criter.		3.374
F-statistic	16.406	Durbin-Watson stat		2.283
Prob(F-statistic)	0.000			

Source: Eurobank Economic Research & relevant data sources

Fundamentals-based valuation model for Greek sovereign bond yield spreads

Actual & model-fitted spreads to Germany (in percentage points)



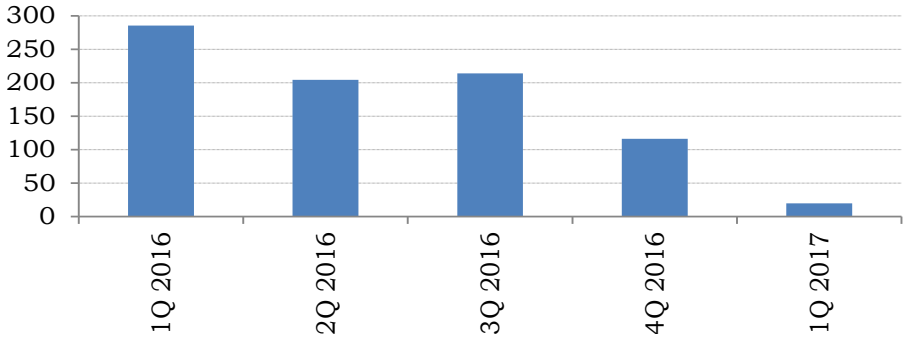
Source: Eurobank Economic Research & relevant data sources

Model-based valuation of Greek 10yr sovereign bond yield spreads

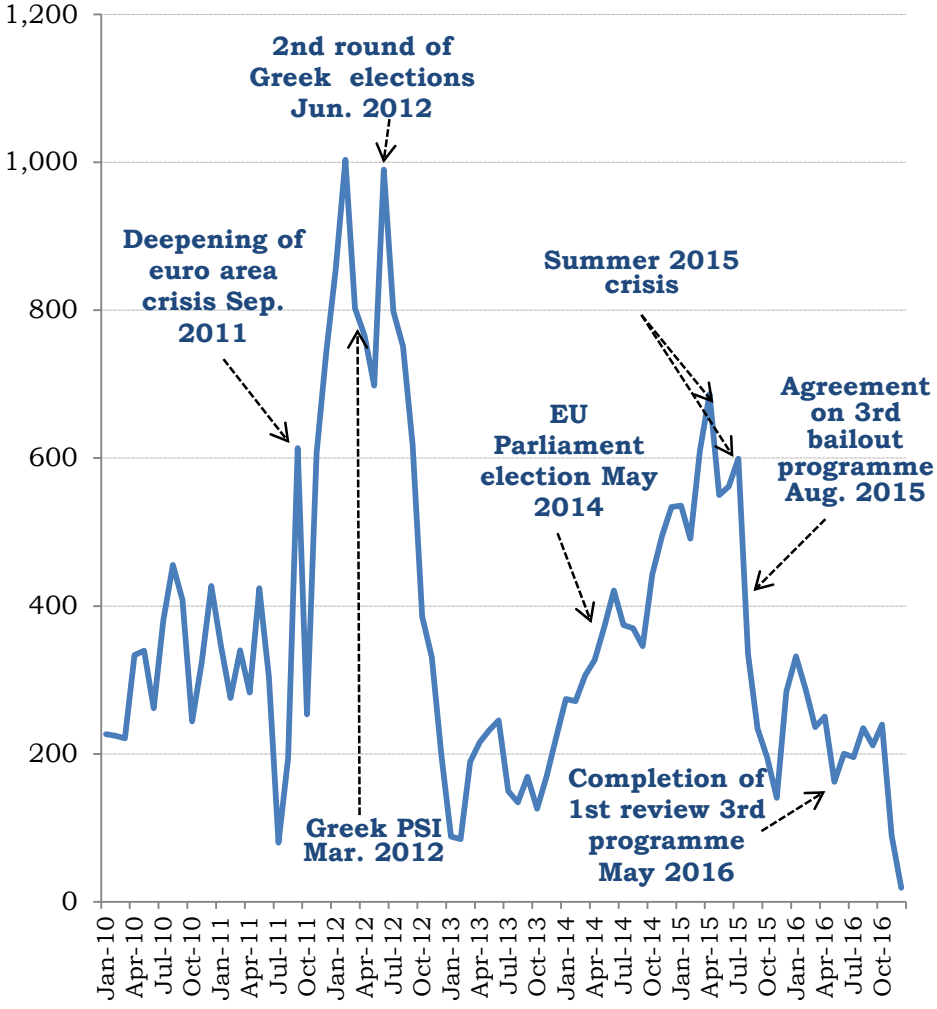
Degree of undervaluation estimated as the difference between fitted and actual values

- As indicated by the empirical results shown on page 16, our fundamentals-based valuation model explains around 60% of the volatility in the monthly series of Greek 10yr government bond yield spreads over the period Jan. 2009 to Apr. 2017.
- Apparently, other factors (not accounted for in our empirical estimates) have been influencing the evolution of Greek sovereign debt spreads over the aforementioned period.
- Arguably, such factors may include: market liquidity conditions, increased political and macroeconomic uncertainty as well as periods of heightened investor fears over Greece's euro membership and the outlook of the agreed stabilization programmes.
- Taking these caveats and model limitations into account, the charts presented herein show the time evolution of the degree of misalignment of the Greek bond yield spreads (in our case, undervaluation of respective prices) relative to the underlying fundamentals analyzed in our study.

10-yr Greek bond yield spread over Germany: degree of misalignment relative to fundamentals
Positive spread values indicate prices are undervalued relative to fundamentals
(quarterly average in bps)



10-yr Greek bond yield spread over Germany: degree of misalignment relative to fundamentals
Positive spread values indicate prices are undervalued relative to fundamentals
(monthly average in bps)



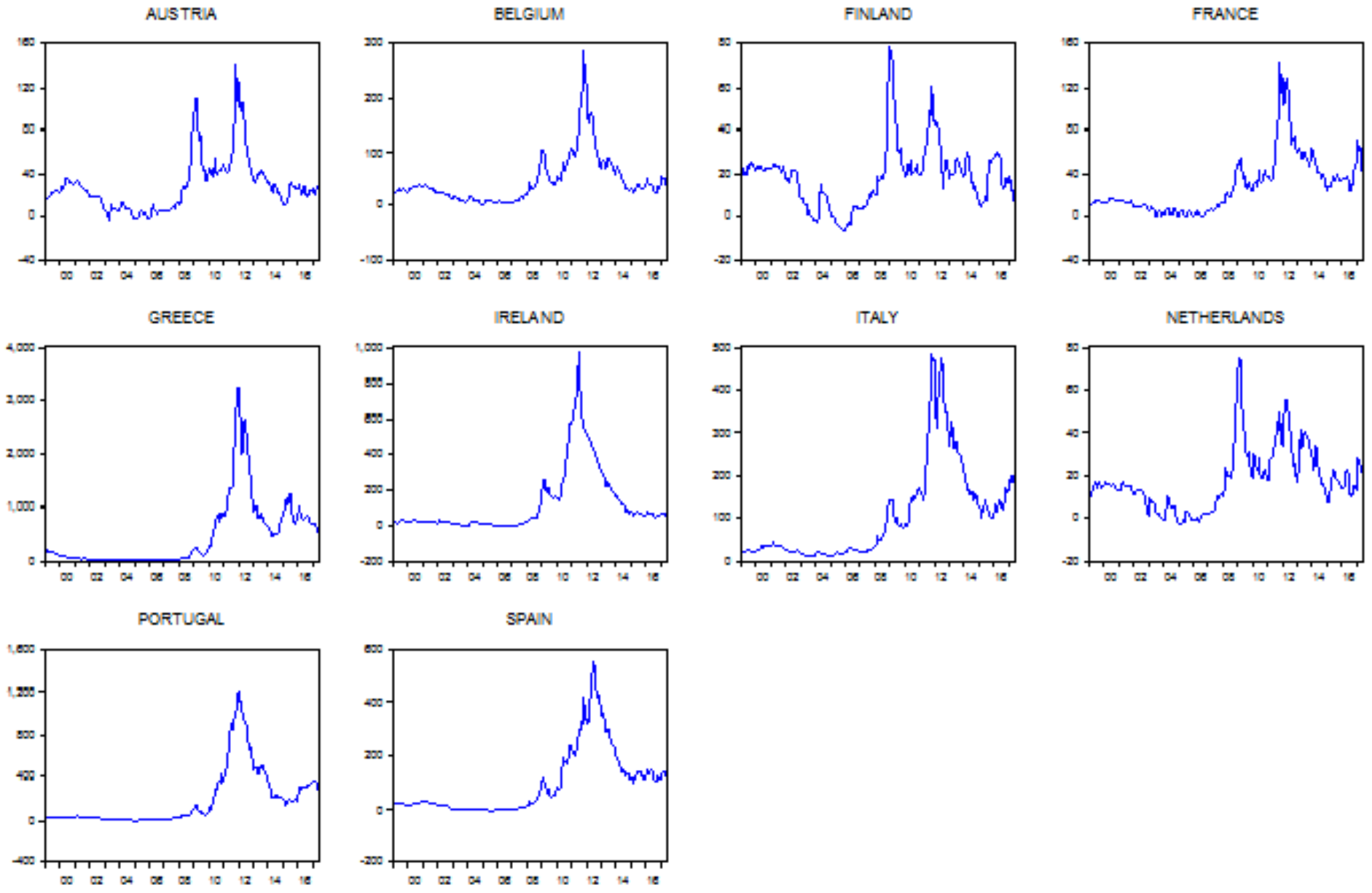
Source: Eurobank Economic Research & relevant data sources

Appendix

Descriptive statistics & principal components analysis

Evolution of 10-year government bond yield spreads, Jan 1999-Jun 2017

Graphical depiction



Source: Eurobank Economic Research, Bloomberg

10-year government bond yield spreads, Jan 1999-Jun 2017 (in bps)

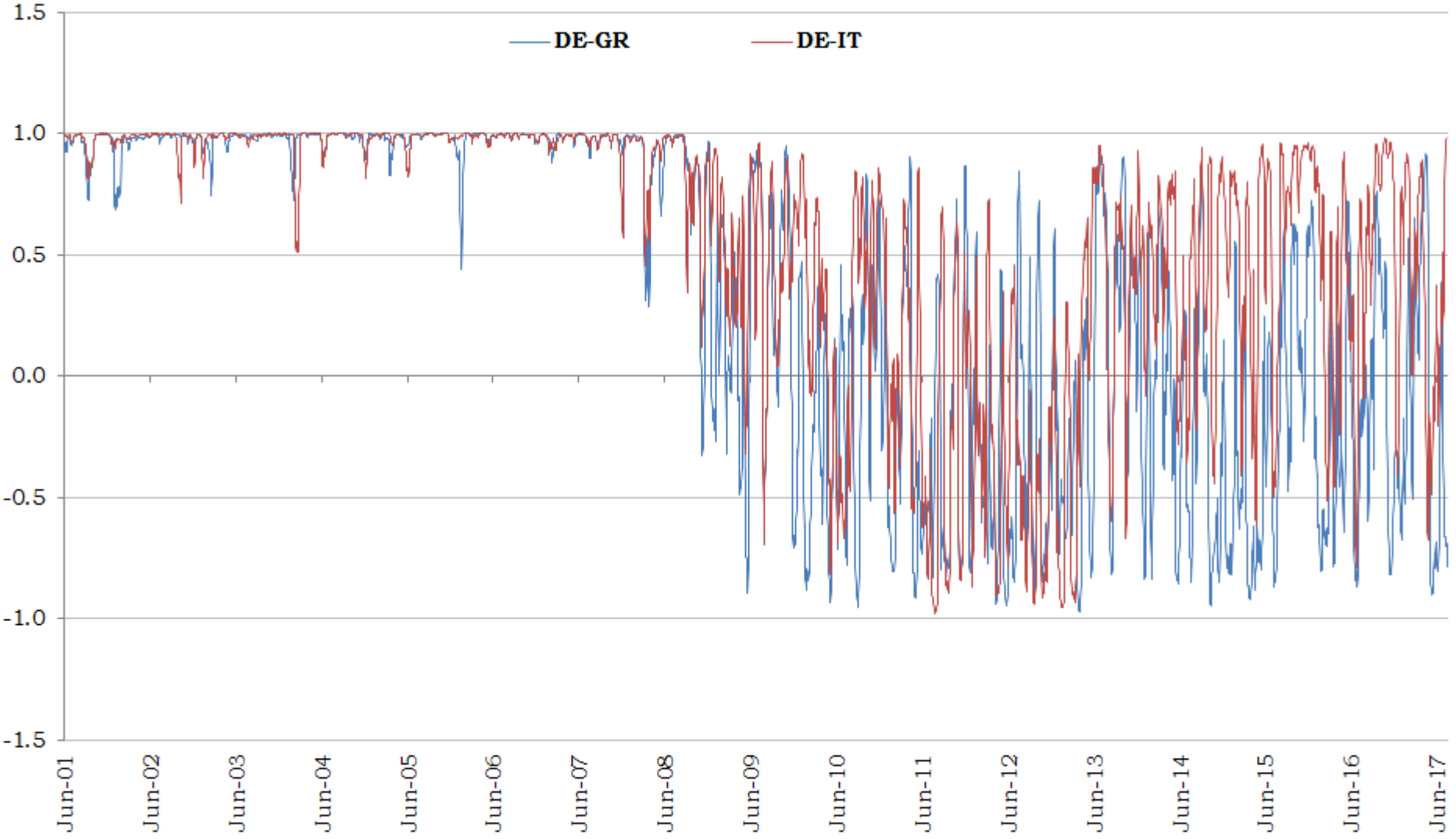
Descriptive statistics

	AUSTRIA	BELGIUM	FINLAND	FRANCE	GREECE	IRELAND	ITALY	NETHERL.	PORTUGAL	SPAIN
Mean	28.1	45.1	18.3	27.8	470.6	121.0	105.4	17.9	195.5	99.3
Median	23.8	31.3	19.5	18.4	150.0	36.8	46.5	15.2	42.2	33.1
Maximum	142.6	288.9	78.7	146.0	3,245.5	971.8	484.7	74.4	1,223.0	555.4
Minimum	-3.6	-0.8	-7.5	-0.6	10.2	-4.5	9.8	-2.7	-2.1	-2.1
Std. Dev.	25.8	46.8	14.9	27.8	651.8	182.5	110.4	14.6	268.8	122.5
Skewness	1.7	2.2	1.1	1.7	2.1	2.1	1.6	1.2	1.9	1.6
Kurtosis	6.5	9.0	5.7	6.2	7.8	7.3	5.0	4.8	6.1	4.9
Observations	222	222	222	222	222	222	222	222	222	222

Source: Eurobank Economic Research, Bloomberg

Increased heterogeneity between core and periphery sovereign debt markets at the height of the euro area debt crisis

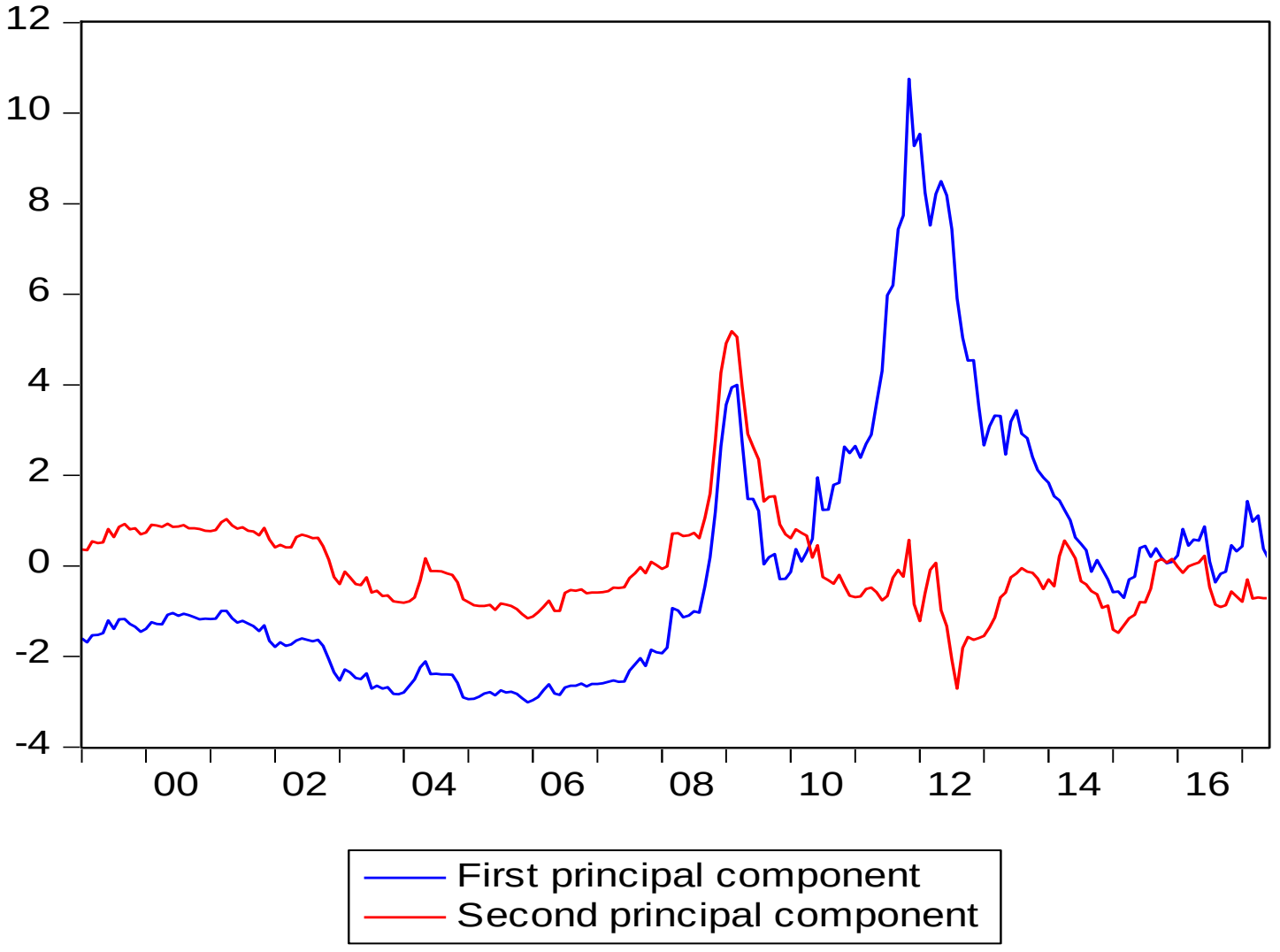
10yr Greek/German & Italian/German government bond yields
21-day rolling correlations



Source: Eurobank Economic Research, Bloomberg

First & second principal component of government bond yield spreads

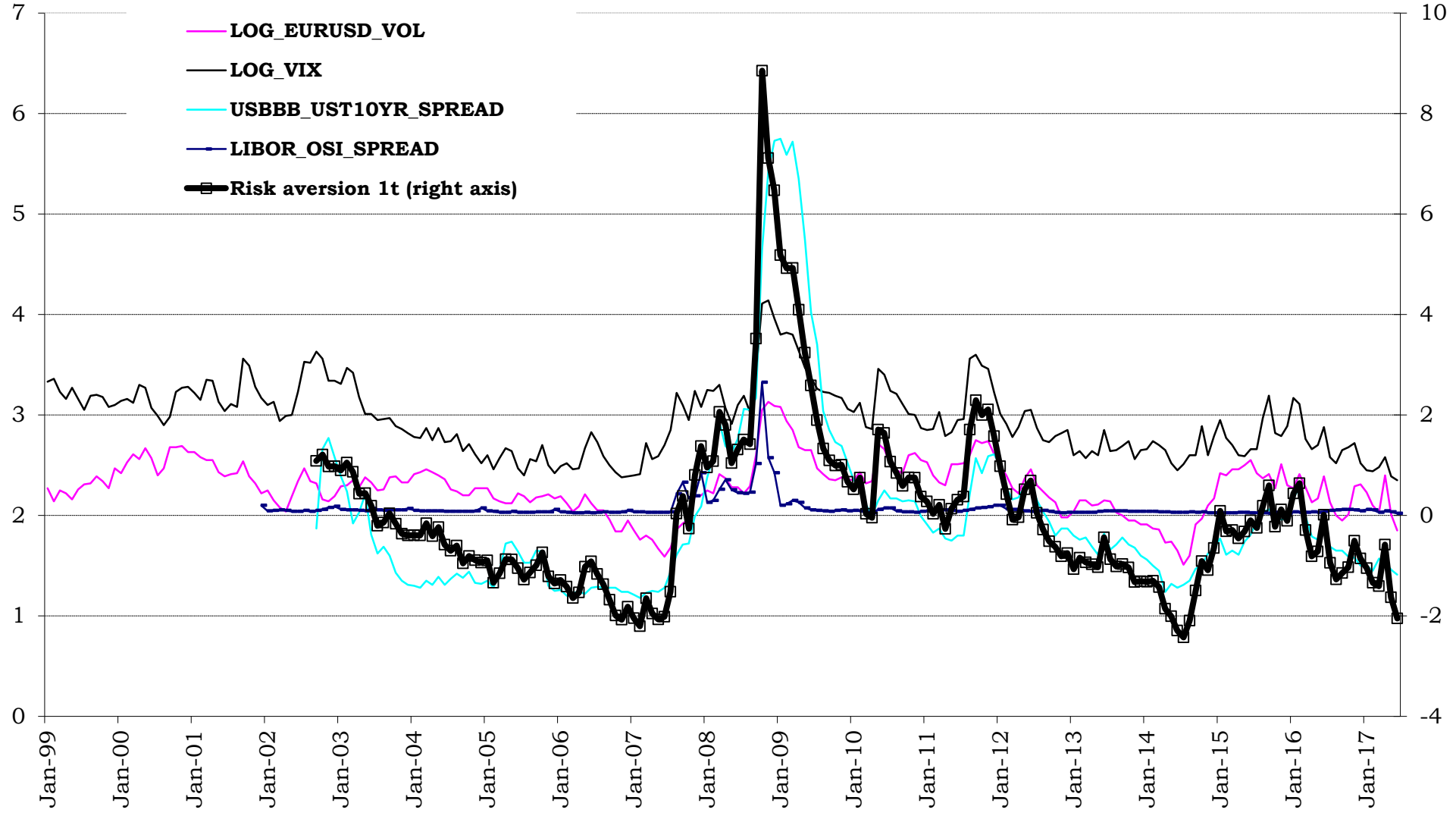
Graphical depiction



Source: Eurobank Economic Research, Bloomberg

Variable - *Risk aversion 1*

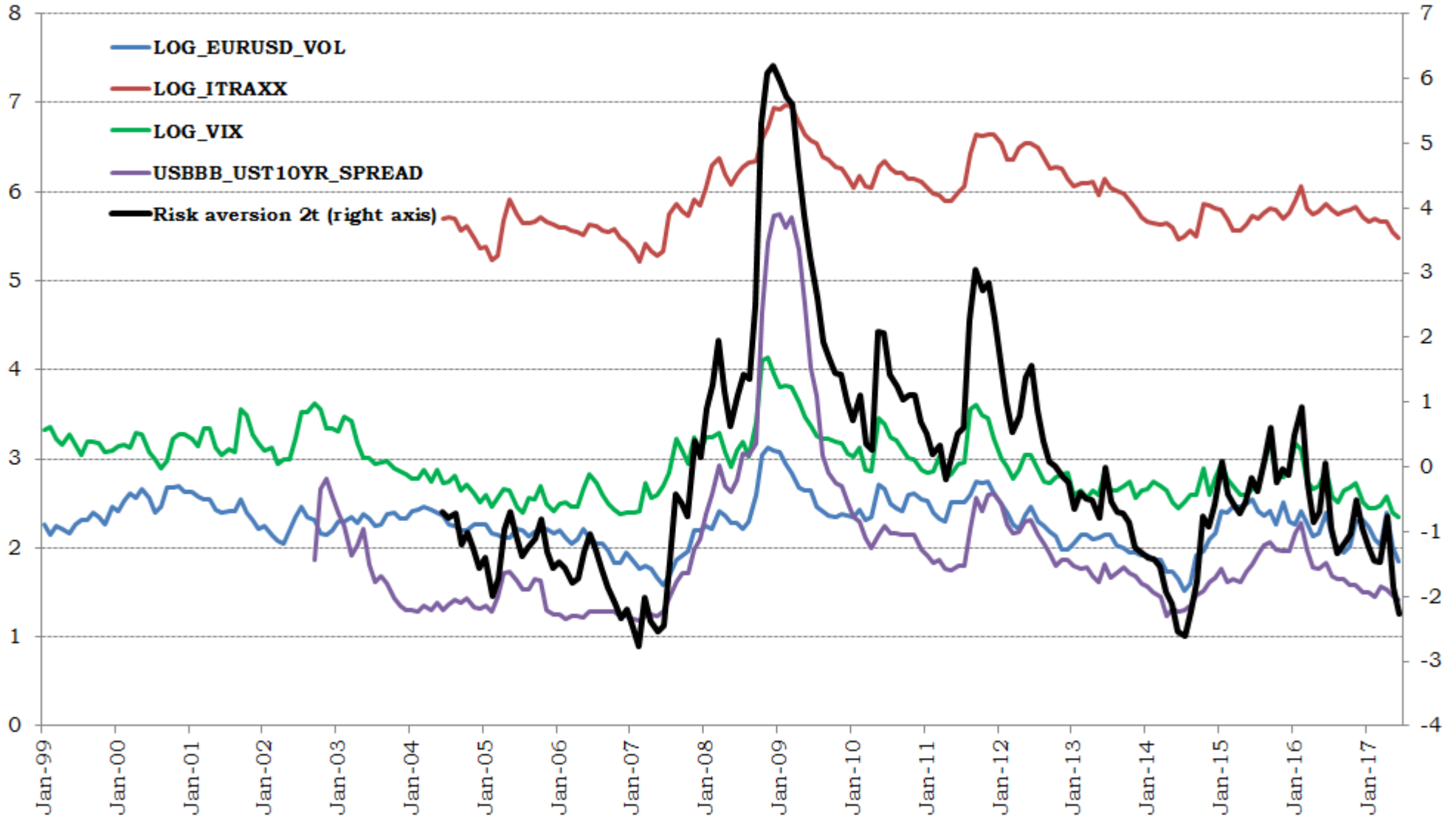
Extracted as1st principal component of the four (4) risk aversion metrics shown below



Source: Eurobank Economic Research, Bloomberg

Variable - *Risk aversion 2*

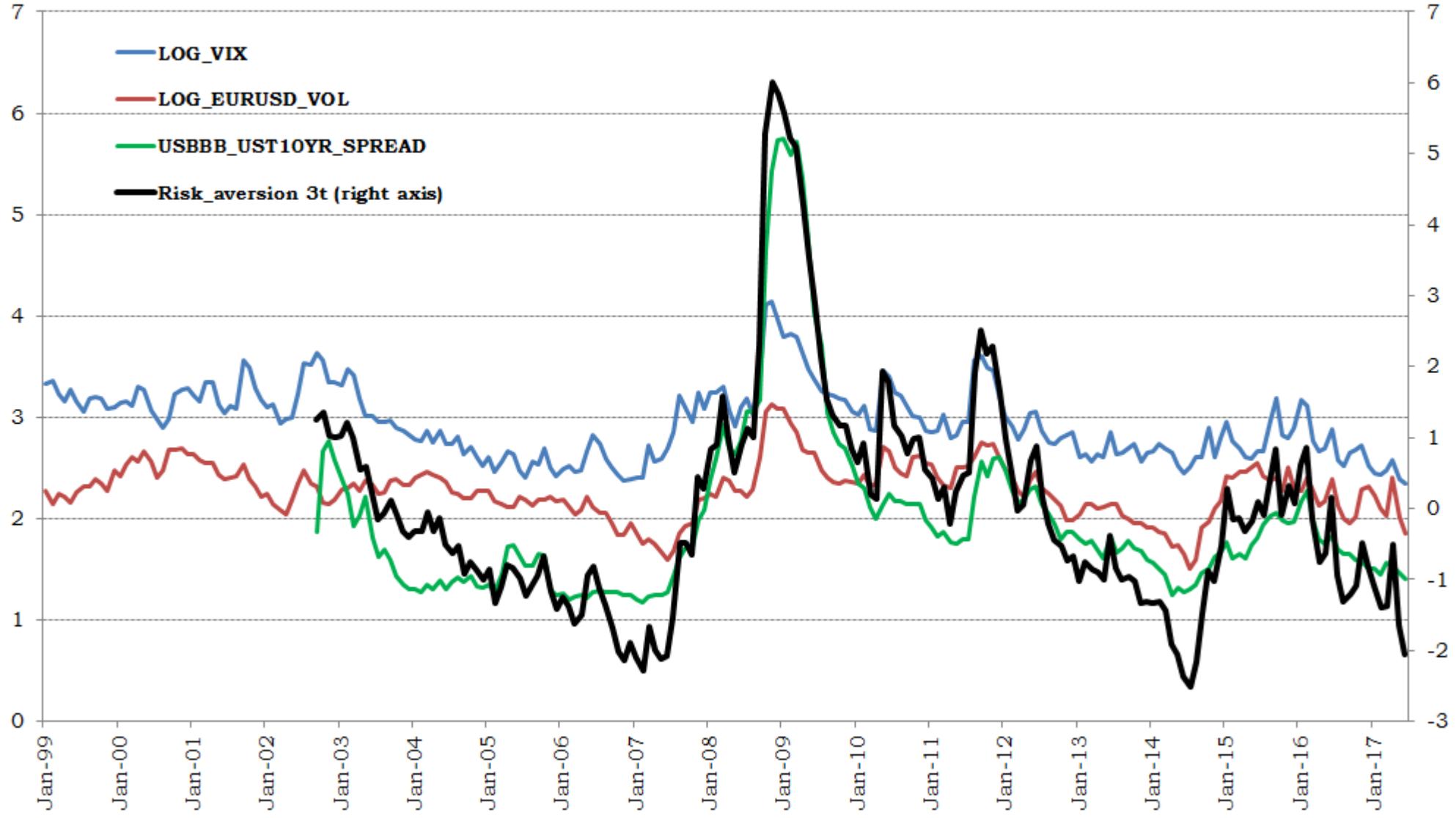
Extracted as1st principal component of the four (4) risk aversion metrics shown below



Source: Eurobank Economic Research, Bloomberg

Variable - *Risk aversion 3*

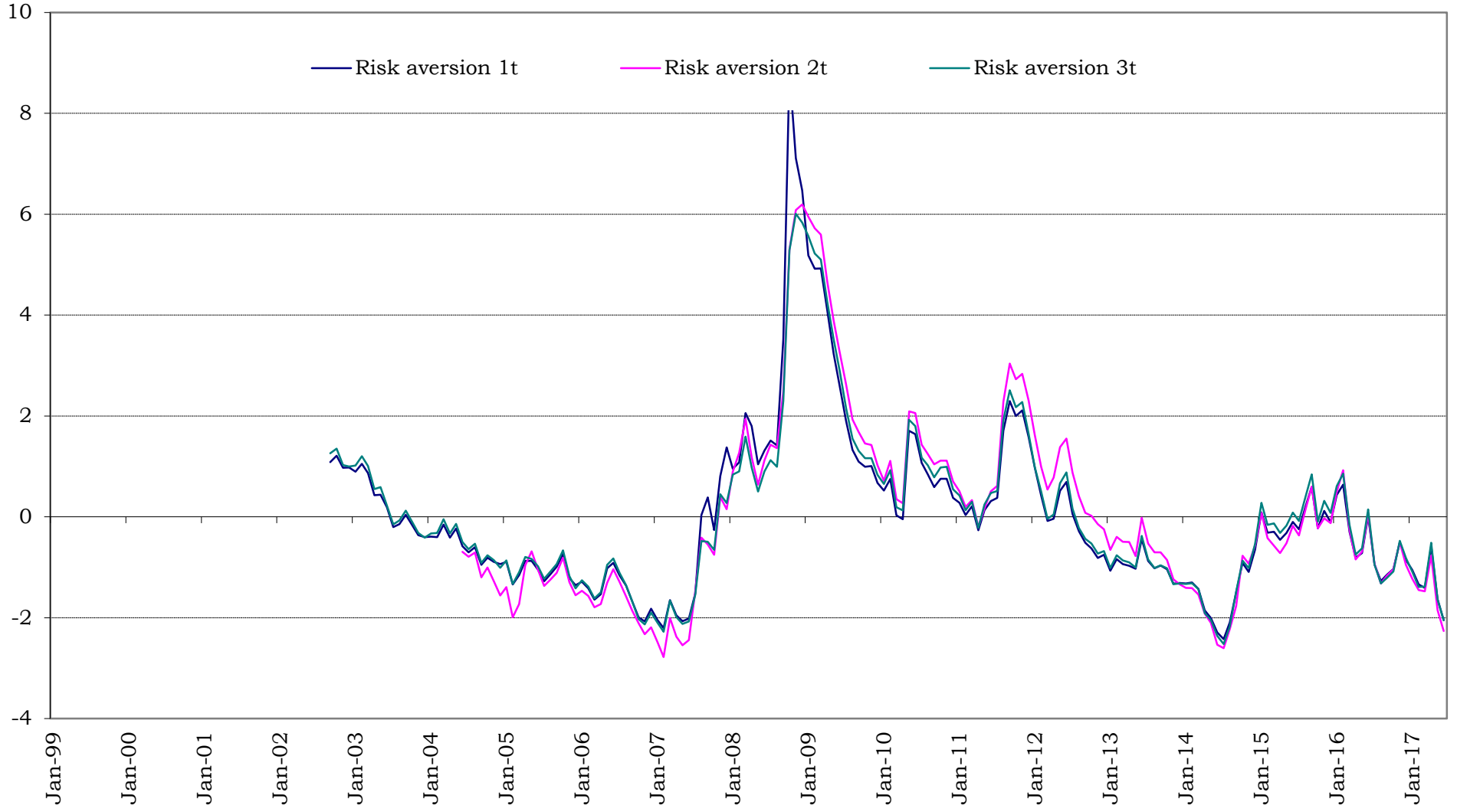
Extracted as1st principal component of the three (3) risk aversion metrics shown below



Source: Eurobank Economic Research, Bloomberg

Variables - *Risk aversion 1, Risk aversion 2 & Risk aversion 3*

Graphical depiction



Source: Eurobank Economic Research, Bloomberg

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