Analyzing volatility shocks to Eurozone CDS spreads with a multicountry GMM model in Stata

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Motivation and strategy

- Credit default swaps (CDS) of Eurozone sovereign borrowers provide a direct indication of market participants' evaluation of default risk associated with the underlying securities.
- Challenges to the stability of the Euro from threats of default by several Eurozone countries have raised serious concerns and led to unprecedented policy responses.
- We model the time series of CDS spreads on sovereign debt in the Eurozone allowing for stochastic volatility and examining the effects of country-specific and systemic shocks.
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Literature review

- As in Tauchen and Zhou (2011), we estimate our model using the moment conditions of realised volatility.
- As in Zhang, Zhou and Zhu (2009), we focus on the very liquid five-year CDS contracts, aggregating daily data in order to compute weekly CDS spreads and their realised volatility. We model the shocks as unobservable random variables.
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The model

- We model CDS returns as follows:

$$dp_{it} = \sqrt{V_{it}}dW_{1it}$$
$$V_{it} = V_{1it} + \gamma_i V_{2t}$$
$$dV_{1it} = \kappa_{1i}\left(\theta_{1i} - V_{1it}\right)dt + \sigma_{1i}\sqrt{V_{1it}}dW_{2it}$$
$$dV_{2t} = \kappa_2\left(\theta_2 - V_{2t}\right)dt + \sigma_2\sqrt{V_{2t}}dW_{3t}$$

where p_{it} is the logarithm of CDS spreads and dW_{1it} is the Wiener shock affecting CDS spreads for the specific country.

- V_{1it} is the *idiosyncratic volatility*: this time-varying volatility is affected by sovereign-specific shocks dW_{2it} that can potentially cause the default of an individual country;
- V_{2t} is the *systemic volatility:* (with exposure γ_i): this time-varying volatility is subject to shocks dW_{3t} that can potentially affect all the countries in the Eurozone, capturing spillover effects from one country to another.

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Data description

- We focus on six members of the Eurozone for which we have complete data for Jan. 2009–June 2016: Austria, Germany, Spain, France, Germany, Italy, and Portugal. For each sovereign borrower, we have daily CDS spread quotations sourced from Bloomberg.
- We aggregate daily quotations of the liquid 5-year tenor in order to derive composite weekly quotations for 381 weeks.
- This allows us to have a measure of the weekly realized volatility and study the behavior of the weekly CDS returns.
- We build a panel Generalized Method of Moments (GMM) estimator where we analyze the effects of two different sources of volatility: *idiosyncratic volatility* and *systemic volatility.*

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Descriptive statistics

Table : Summary statistics for five-year CDS spreads

	mean	sd	min	p50	max
AUS	70.88	52.52	19.63	53.82	268.98
DEU	38.67	24.70	11.23	31.50	119.17
ESP	203.44	132.99	53.69	151.39	641.98
FRA	75.06	51.43	19.66	60.15	249.63
ITA	202.79	124.56	57.60	155.63	591.54
PRT	392.63	323.49	44.53	279.66	1526.95

- In terms of either mean or median values, there are two distinct groups among the Eurozone sovereign borrowers: those with relatively low quoted spreads, lower than 80bp, and those with considerably higher spreads: three of the infamous PIIGS (Portugal, Italy, and Spain), which we will describe as 'troubled borrrowers'.
- Even within this taxonomy, there are subdivisions: for instance, Austrian and French spreads are considerably higher than those of Germany.

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Correlations of changes in CDS spreads

- We now consider a rudimentary measure of spillover among the sovereign borrowers: the simple contemporaneous correlations of changes in CDS returns.
- These correlations of spread returns are positive and quite substantial, indicating that even the most creditworthy borrowers are likely to experience some market adjustments in their spreads when riskier borrowers' spreads increase.
- The highest correlations are those among the troubled borrowers: ITA, ESP, PRT.
- Although this is not a formal test of association, it is suggestive of the existence of meaningful spillover effects.

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Correlations of changes in five-year sovereign CDS returns

	retAUS	retDEU	retESP	retFRA	retITA	retPRT
retAUS	1.00					
retDEU	0.49	1.00				
retESP	0.53	0.48	1.00			
retFRA	0.60	0.60	0.58	1.00		
retITA	0.61	0.50	0.82	0.62	1.00	
retPRT	0.44	0.39	0.64	0.49	0.63	1.00

- These correlations, computed for the full sample period, may not tell the whole story. The linkages between sovereign borrowers' perceived risk may vary considerably over time as political and economic circumstances change.
- We have computed moving-window correlations, using a window of 26 weeks for the troubled borrowers' CDS returns changes at the five-year tenor.
- We present correlations of changes in the five-year quoted spread for Portugal and Spain versus those of Italy.

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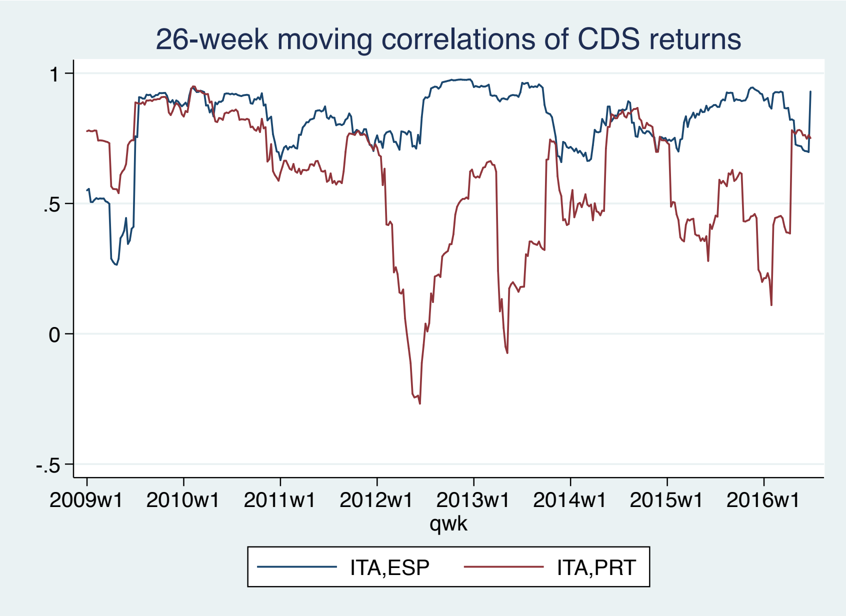
26-week moving correlations of CDS returns
1
.5
0
-.5
2009w1
2010w1
2011w1
2012w1
2013w1
2014w1
2015w1
2016w1
qwk
ITA,ESP
ITA,PRT

- Changes in the Italian returns are highly correlated with changes in the Spanish returns throughout the period.
- The correlations with Portuguese returns are much more variable, falling to near zero on two occasions, but often exceeding $+0.5$.

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Moving-window volatility estimates

- Another focus of interest might be the volatility exhibited by these spreads, for a given borrower and tenor, that reflects market participants' uncertainty about the riskiness of the underlying sovereign debt.
- We have computed moving-window standard deviations of the CDS spread series for each borrower.
- We illustrate the moving-window volatility estimates (using a 26-week window) for the five-year tenor.

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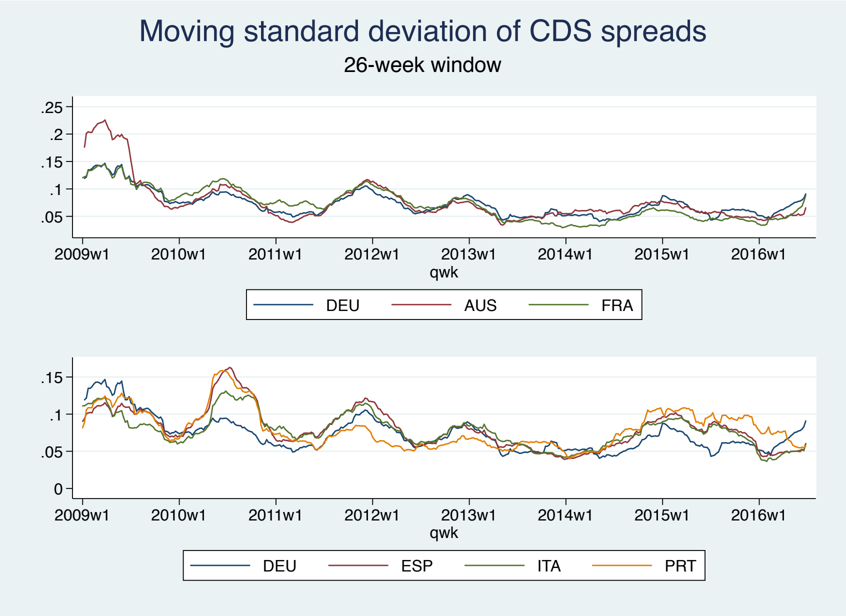
Moving standard deviation of CDS spreads
26-week window
.25
.2
.15
.1
.05
2009w1
2010w1
2011w1
2012w1
2013w1
2014w1
2015w1
2016w1
qwk
DEU
AUS
FRA
.15
.1
.05
0
2009w1
2010w1
2011w1
2012w1
2013w1
2014w1
2015w1
2016w1
qwk
DEU
ESP
ITA
PRT

The upper panel shows generally correlated changes in the volatility of the higher-quality borrowers' spreads. In the lower panel (on a different scale), we see wide divergences in 2010 between the volatility of German spreads (in blue) and the more troubled borrowers, corresponding to the Greek fiscal crisis. This divergence also appears in 2015 to a lesser degree.

Estimation methodology

- Although these descriptive measures are illuminating, they only provide evidence of comovement, representing spillover effects across sovereign borrowers.
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Empirical findings and forecast statistics

- Following Bollerslev and Zhou (2002), using weekly sovereign CDS returns, we build a conditional moment estimator for stochastic volatility models based on matching sample moments of Realized Volatility with population moments of the Integrated Volatility.
- Realized Variance is a nonparametric *ex post* estimate of the return variation as suggested by Andersen and Benzoni (2009). In this paper, the weekly Realized Variance is the sum of daily squared returns.
- The returns on CDS at time t, over the interval $[t-k, t]$ can be decomposed as:

$$r(t,k) = \ln CDS_t - \ln CDS_{t-k} = \int_{t-k}^{t} \mu(\tau)\, d\tau + \int_{t-k}^{t} \sigma(\tau)\, dW_\tau$$

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Financial modeling: CDS valuation

- The Quadratic Variation or Integrated Variance in this case is

$$QV(t,k) = IV(t,k) = \int_{t-k}^{t} \sigma^2(\tau)\, d\tau$$

- In discrete time, the corresponding sample Realized Variance (RV) can be described as:

$$RV(t,k,n) = \sum_{j=1}^{n \cdot k} r\left(t - k + \frac{j}{n}, \frac{1}{n}\right)^2$$

$$RV(t,k,n) \xrightarrow{p} IV(t,k) \text{ as } n \longrightarrow \infty$$

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Computation of the estimator

- The model presented above is estimated simultaneously for each of the six sovereign borrowers.
- Each country's estimation problem contributes two equations for expected QV and expected QV^2.
- Each country's volatility is evaluated vis-à-vis the average volatility for 'Europe', this set of six Eurozone members, which adds two equations to the problem.
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- We build a panel Generalized Method of Moments (GMM) estimator for the January 2009–June 2016 weekly data using the `gmm` facility of Stata version 14.1, with a HAC estimator for the GMM weight matrix with automatic bandwidth selection.
- Instruments used in the GMM specification include various lags of the cross-sectionally aggregated CDS spread series for the whole group and their squares.
- A total of 56 moment conditions are defined for the 14 equations, versus 27 parameters.
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Empirical findings

- Systemic effects are computed controlling for idiosyncratic volatility.
- In all six countries' equations we find significant impact of the idiosyncratic volatility on the CDS spreads.
- The parameter $\hat{\gamma}$, which captures the impact of the systemic volatility on individual borrowers' CDS returns, is significantly positive at the 90% or 95% level for all countries.

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GMM estimates for SV model using weekly data, January 2009–June 2016: "Europe" and selected countries

Parameters	estimate	p-value
κ_{EUR}	-0.002	0.970
θ_{EUR}	0.232	0.970
σ_{EUR}	0.166	0.000
κ_{AUS}	0.334	0.005
θ_{AUS}	0.003	0.000
$\log \sigma_{AUS}$	-0.523	0.000
γ_{AUS}	0.072	0.065
κ_{DEU}	0.788	0.075
θ_{DEU}	0.003	0.022
$\log \sigma_{DEU}$	-0.306	0.454
γ_{DEU}	0.276	0.060

GMM estimates for SV model using weekly data, January 2009–June 2016: "Europe" and selected countries

Parameters	estimate	p-value
κ_{ESP}	0.351	0.024
θ_{ESP}	0.000	0.920
$\log \sigma_{ESP}$	0.305	0.000
γ_{ESP}	0.342	0.016
κ_{FRA}	0.329	0.076
θ_{FRA}	-0.000	0.964
σ_{FRA}	.531	0.000
γ_{FRA}	0.291	0.004

GMM estimates for SV model using weekly data, January 2009–June 2016: "Europe" and selected countries

Parameters	estimate	p-value
κ_{ITA}	0.259	0.000
θ_{ITA}	0.005	0.014
$\log \sigma_{ITA}$	0.100	0.000
γ_{ITA}	0.165	0.009
κ_{PRT}	1.138	0.001
θ_{PRT}	0.007	0.000
$\log \sigma_{PRT}$	−0.873	0.003
γ_{PRT}	0.175	0.092

Conclusions

- We make use of daily data on sovereign CDS spreads within the Eurozone over the last 7+ years to analyze the effects of systemic and country-specific shocks on their returns at a weekly frequency.
- Estimation of these relationships as a system of GMM equations allows us to evaluate the relative magnitudes and importance of these effects across the set of sovereign borrowers.
- Systemic effects are computed controlling for idiosyncratic volatility. The parameter $\hat{\gamma}$, which captures the impact of the systemic volatility on specific CDS returns, is significantly positive for all sovereign borrowers.
- Although the computational problem is complex and highly nonlinear, GMM estimation of the system is feasible and preferred to a more restrictive maximum likelihood framework.

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