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

Christopher F Baum and Paola Zerilli

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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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The model

We model CDS returns as follows:

\[ dp_{it} = \sqrt{V_{it}} dW_{1it} \]

\[ V_{it} = V_{1it} + \gamma_i V_{2t} \]

\[ dV_{1it} = \kappa_1 i (\theta_1 i - V_{1it}) \, dt + \sigma_1 i \sqrt{V_{1it}} dW_{2it} \]

\[ dV_{2t} = \kappa_2 (\theta_2 - V_{2t}) \, dt + \sigma_2 \sqrt{V_{2t}} dW_{3t} \]

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 $\gamma_i$): 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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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

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<td>57.60</td>
<td>155.63</td>
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<tr>
<td>PRT</td>
<td>392.63</td>
<td>323.49</td>
<td>44.53</td>
<td>279.66</td>
<td>1526.95</td>
</tr>
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</table>
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 borrowers’.

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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.
Correlations of changes in CDS spreads

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Correlations of changes in five-year sovereign CDS returns

<table>
<thead>
<tr>
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<th>retAUS</th>
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<td>retDEU</td>
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<td>1.00</td>
<td></td>
<td></td>
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<tr>
<td>retESP</td>
<td>0.53</td>
<td>0.48</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>retFRA</td>
<td>0.60</td>
<td>0.60</td>
<td>0.58</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>retITA</td>
<td>0.61</td>
<td>0.50</td>
<td>0.82</td>
<td>0.62</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>retPRT</td>
<td>0.44</td>
<td>0.39</td>
<td>0.64</td>
<td>0.49</td>
<td>0.63</td>
<td>1.00</td>
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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.

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An initial analysis of the data

Moving-window correlations of CDS returns

26-week moving correlations of CDS returns
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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.

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Moving standard deviation of CDS spreads
26-week window

An initial analysis of the data
Moving-window volatility estimates
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.
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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:

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

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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:

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

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where \( n \) is the sampling frequency.
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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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

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<td>$\gamma_{DEU}$</td>
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<td>$\kappa_{ITA}$</td>
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<td>$\kappa_{PRT}$</td>
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<tr>
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<tr>
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<tr>
<td>$\gamma_{PRT}$</td>
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<td>0.092</td>
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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.
Conclusions

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