Measuring sovereign contagion in Europe

Massimiliano Caporin
University of Padova

Loriana Pelizzon
University of Venice & MIT

Francesco Ravazzolo
Norges Bank & BI

Roberto Rigobon
MIT

September 27, 2012
2002 Introduction of Euro

Measuring sovereign contagion in Europe
Euro debt crises: 2009, Ireland
Euro debt crises: 2010, Greece

Greece is going to ruin us!!

Modern Greek ruins
Euro debt crises: 2011, Spain
Euro debt crises: Italy, Contagion?

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Measuring sovereign contagion in Europe
Debt Restructuring and Contagion

- How much contagion to countries in the European Monetary Union could be expected as a result of a possible credit event in Greece or Italy or Spain?

- How much France and Germany are going to be affected?

- How about countries outside the European Union?

- Through which channel is the shock going to be transmitted?

Clearly these are important questions for economists, policy makers, and practitioners. The empirical challenges to address these questions are extraordinary!

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Measuring sovereign contagion in Europe
First challenge: What is exactly contagion?

Is it the ‘normal’ or ‘usual’ propagation of shocks, or is it the transmission that takes place under unusual circumstances?

Contagion:

- the comovement that takes place under extreme conditions – or tail events.

- how different the propagation of shocks is after normal and rare events.
Second challenge: the empirical one.

If the correlation between two variables is different in normal and crisis times, how can we be sure that this is the outcome of a shift in the propagation and not the result of the fact that correlations are not neutral to shifts in volatility?

Crisis times are usually associated with higher volatility and simple correlations are unable to deal with this problem.
Our contributions: measuring spillovers in (European) cds’s and bonds

▶ We investigate contagion in the cds’s of 8 EU countries: seven countries within the Euro area, PT, GR, IE, IT, ES, DE, FR, and UK (in the slides results only for FR and DE).

▶ **Objective**: Measure the risk of contagion of a Debt Restructuring!

▶ **First challenge**, definitions of contagion:
  - comovements that take place under tail events;
  - differences in the propagation of shocks after normal and rare events.

▶ We follow the second approach and focus on European sovereign debt through CDS and bond spreads.
Our contributions: measuring spillovers in (European) cds’s and bonds

- **Second challenge**, problem of measuring contagion in cds’s:
  - Correlation is not a good measure.
  - Contagion as a non-linear event.
  - Adjustments in the literature need strong assumptions about the source of shock.

- Parametric methods:
  - Focus on a reduced-form approach
  - Non-linear regressions.
  - Frequentist quantile regression.
  - Bayesian quantile regression with heteroscedasticity.

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CDS results

- No change in the intensity of the transmission of shocks among European countries during the onset of the current fiscal crisis.

- Sovereign risk contagion is largely a linear phenomenon:
  - linearity cannot be rejected;
  - non-linear regressions give statistically significant outcomes but they are economically irrelevant;
  - quantile estimates are similar among different quantiles.

- Thus, risk spillover among countries is not affected by the size of the shock (see quantile estimates).

- This does not mean that the situation might not change, but the common shift in CDS spreads that we have observed in the data is the outcome of interdependence that has been present all the time.
Bond results

- Extend the analysis using bond returns over the sample 2003-2011.

- Evidence of breaks during the Great financial crisis:
  - Change in the intensity of the propagation of shocks in the pre-crisis period (2003-2006) and the post-Lehman one (2008-2011).

  - The coefficients actually come down, not up!

  - Were bonds from different country perfect substitutes in the pre-crisis period?

<table>
<thead>
<tr>
<th>Country</th>
<th>Mean</th>
<th>Std</th>
<th>Min</th>
<th>Max</th>
<th>Med(Abs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>0.15</td>
<td>3.12</td>
<td>-17.66</td>
<td>22.19</td>
<td>1.00</td>
</tr>
<tr>
<td>Germany</td>
<td>0.04</td>
<td>2.28</td>
<td>-13.89</td>
<td>19.02</td>
<td>0.63</td>
</tr>
<tr>
<td>Greece</td>
<td>6.53</td>
<td>64.70</td>
<td>-462.83</td>
<td>764.06</td>
<td>6.36</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.96</td>
<td>16.93</td>
<td>-137.21</td>
<td>101.18</td>
<td>5.00</td>
</tr>
<tr>
<td>Italy</td>
<td>0.46</td>
<td>9.35</td>
<td>-79.98</td>
<td>63.91</td>
<td>2.98</td>
</tr>
<tr>
<td>Portugal</td>
<td>1.30</td>
<td>20.76</td>
<td>-199.91</td>
<td>174.71</td>
<td>4.00</td>
</tr>
<tr>
<td>Spain</td>
<td>0.37</td>
<td>10.14</td>
<td>-75.24</td>
<td>48.80</td>
<td>3.50</td>
</tr>
<tr>
<td>U.K.</td>
<td>0.03</td>
<td>3.25</td>
<td>-18.89</td>
<td>18.00</td>
<td>1.01</td>
</tr>
</tbody>
</table>
Correlation with IT increases after July 2011. In general, correlations with Greece and Ireland show larger movements.
Non-parametric inference: 60-days rolling correlations, DE
Parametric inference: linear model

- The Delta-CDS volatility might differ during market turbulence compared to the volatility during less volatile market periods.
- The dependence between the changes in the CDS indices of any two countries could be estimated with a simple linear model:

\[
\Delta CDS_{i,t} = \beta_0 + \beta_1 \Delta CDS_{j,t} + \gamma' X_{t-1} + \epsilon_t \\
\epsilon_t | I^{t-1} \sim D(0, \sigma_t^2) \\
\sigma_t^2 = \theta_0 + \theta_1 \epsilon_{t-1}^2 + \theta_2 \sigma_{t-1}^2
\]

where \( i \) and \( j \) are two country identifiers.
We include the following covariates in $X_{t-1}$: the change in the Euribor rate; the change in a Liquidity Risk proxy (Euribor minus EONIA); and the change in a Risk Appetite index (VSTOXX minus the GARCH(1,1) volatility of the VSTOXX).

However, such model assumes linearity and this might be problematic when talking about contagion.
Parametric inference: non-linear models

We extend the previous model such as:

\[ \Delta CDS_{i,t} = \beta_0 + \beta_1 \Delta CDS_{j,t} + \gamma' X_{t-1} + \sum_{l=2}^{p} \phi_l (\Delta CDS_{j,t})^l + \varepsilon_t \]

\[ \varepsilon_t | I^{t-1} \sim D (0, \sigma_t^2) \]

\[ \sigma_t^2 = \theta_0 + \theta_1 \varepsilon_{t-1}^2 + \theta_2 \sigma_{t-1}^2 \]

where \( \sigma_t^2 \) follows a GARCH(1,1) process. The linearity is associated with the null hypothesis \( H_0 : \phi_l = 0 \forall l = 2, \ldots p \). We evaluate the null hypothesis using a Likelihood Ratio test (similar results when using a Ramsey (1969) test, \( (\Delta CDS_{j,t})^l \) replaced by \( (\Delta CDS_{i,t})^l \).
The coefficients are statistically significant in many cases, but they are extremely small.
Parametric inference: non-linear models

<table>
<thead>
<tr>
<th>Country</th>
<th>France quadratic $\phi_2 * X^2$</th>
<th>France cubic $\phi_3 * X^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Greece</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>Italy</td>
<td>0.008</td>
<td>0.000</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Spain</td>
<td>0.010</td>
<td>-0.001</td>
</tr>
<tr>
<td>UK</td>
<td>-0.002</td>
<td>0.059</td>
</tr>
</tbody>
</table>

The economic values are very small.
### Measuring sovereign contagion in Europe

<table>
<thead>
<tr>
<th>$i$</th>
<th>$j$</th>
<th>P-value</th>
<th>$X$</th>
<th>$X^2$</th>
<th>$X^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>GERMANY</td>
<td>FRANCE</td>
<td>0.000</td>
<td>0.539</td>
<td>0.002</td>
<td>-0.001</td>
</tr>
<tr>
<td>GERMANY</td>
<td>GREECE</td>
<td>0.000</td>
<td>0.018</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>GERMANY</td>
<td>IRELAND</td>
<td>0.004</td>
<td>0.059</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>GERMANY</td>
<td>ITALY</td>
<td>0.001</td>
<td>0.144</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>GERMANY</td>
<td>PORTUGAL</td>
<td>0.000</td>
<td>0.063</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>GERMANY</td>
<td>SPAIN</td>
<td>0.050</td>
<td>0.119</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>GERMANY</td>
<td>UK</td>
<td>0.955</td>
<td>0.370</td>
<td>-0.001</td>
<td>0.000</td>
</tr>
</tbody>
</table>
During large market movements, the relation between the Delta-CDS of the selected European countries might not follow a linear relation. We consider Quantile Regressions between the CDS changes of any two countries.

\[
\min_\Theta \sum_{t=1}^{T} \rho_\tau (\Delta CDS_{i,t} - \beta_0 - \beta_1 \Delta CDS_{j,t} - \gamma' X_{t-1})
\]

where \( \rho_\tau (a) \) is the *check* function for quantile \( \tau \) defined as \( \rho_\tau (a) = a \times (\tau - \mathbf{1}(a < 0)) \) and \( \Theta = \{\beta_0, \beta_1, \gamma'\} \). The minimization problem results in:

\[
Q_t(\tau) = \hat{\beta}_{\tau,0} + \hat{\beta}_{\tau,1} \Delta CDS_{j,t} + \hat{\gamma}_{\tau} X_{t-1}
\]
Absence of variability across quantiles suggests a linear relation.
Parametric inference: GERMANY

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The previous regression assumes time-invariant coefficients and, in particular, homoscedasticity.

Estimation could be repeated over different samples and regression windows, such as rolling window.

Estimates might, however, be biased or at the least inefficient.

Inefficiency might be higher for low at high quantile levels.
As in Hiemstra and Jones (1994) and Chen, Gerlack and Wei (2010), we allow for heteroscedasticity

\[
\min_{\Theta} \sum_{t=1}^{T} \left( \rho_\tau \left( \frac{\Delta CDS_{i,t} - \beta_0 - \beta_1 \Delta CDS_{j,t} - \gamma' X_{t-1}}{\sigma_t(\tau)} \right) + \log(\sigma_t(\tau)) \right)
\]

where the term \(\sigma_{t,\tau}^2\) is modeled with a GARCH(1,1) representation:

\[
\sigma_{t,\tau}^2 = \theta_{0,\tau} + \theta_{1,\tau} \varepsilon_{t-1,\tau}^2 + \theta_{2,\tau} \sigma_{t-1,\tau}^2 \quad \text{(1)}
\]
Linearity is confirmed!
Parametric inference: GERMANY

- D(FRANCE)
- D(GREECE)
- D(IRLAND)
- D(ITALY)
- D(PORTUGAL)
- D(SPAIN)
- D(UK)
Government bond spreads

- Define bond spreads: bond yields on 5 years minus 5-year swap rate (risk-free rate as in Beber et al. (2009)).

- Repeat the analysis for three subperiods:
  - the pre crisis period (2003-2006);
  - the post crisis one (2008-2011);
  - full the sample (2003-2011).
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French bond spreads, 2003-2006

Coefficients assume higher values.
## Government bond spreads

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>0.800</td>
<td>0.800</td>
<td>0.800</td>
</tr>
<tr>
<td>Greece</td>
<td>0.800</td>
<td>0.020</td>
<td>0.015</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.600</td>
<td>0.050</td>
<td>0.100</td>
</tr>
<tr>
<td>Italy</td>
<td>0.900</td>
<td>0.200</td>
<td>0.220</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.900</td>
<td>0.020</td>
<td>0.060</td>
</tr>
<tr>
<td>Spain</td>
<td>0.900</td>
<td>0.230</td>
<td>0.200</td>
</tr>
<tr>
<td>UK</td>
<td>0.600</td>
<td>0.200</td>
<td>0.350</td>
</tr>
</tbody>
</table>

**Table:** Average daily bond spreads
French bond spreads, 2003-2011

Evidence of instability!
Conclusions

- Sovereign risk contagion is largely a linear phenomenon.

- Risk spillover among countries is not affected by the size of the shock.

- The common shift in CDS spreads that we have observed in the data is the outcome of interdependence that has been present all the time.

- Results for bond spread support findings and highlight a change in the intensity (reduction) of the propagation of shocks in the 2008 and not during the fiscal crisis.