

Sovereign Debt and Systemic Risk: A Financial Approach

Work in progress. First Draft.



Christophe Hurlin
Alexandra Popescu
Camelia Turcu

Université d'Orléans, LEO

Outline

1. Introduction
2. Methodology
3. Data and Results
4. Conclusions

1. Introduction - Timeline: the unfolding Eurozone crisis

- **2007 - 2009** – Global financial crisis that requires large rescue plans to support the banking sector.
- **December 2009** - Greece admits that its debts amount to 113% of GDP - nearly double the Eurozone limit of 60%. Ratings agencies start to downgrade Greek bank and government debt.
- **2010 & 2011** – Bailout plans for **Greece, Ireland and Portugal**. Austerity measures are taken in all these countries.
- **During 2012** – Greece receives a second bailout. Italy and Spain sovereign bond yields increase sharply. Spain requests help in loans from Eurozone funds to try to help shore up its banks.
- **July 2012** - Mario Draghi: "The ECB is ready to do whatever it takes to preserve the euro."
- **March 2013** – Cyprus needs bailout, but the negotiated package implies an unprecedented measure: a bank levy on bank deposits. What happens next?

1. Introduction - Aim of the paper

- In crisis periods, what would be the consequences of a potential default of an EMU country on the capacity of other European countries to finance their debt?
 - *In stress period, how can we identify the contribution of an EMU country to the Eurozone debt crisis?*
- The question of identifying the contribution of a financial institution to systemic risk has already been raised [Brownlees and Engle (2011)].
 - *This issue can also be addressed at country level...this is the first attempt to do it!*
- One of the most popular systemic risk measures is the Systemic Risk Index (SRisk) advanced by Brownlees and Engle (2011) and uses financial returns.
 - *Our goal is to transpose this to the sovereign debt risk measured on government bond yields.*

1. Introduction - Before starting...

Market returns :

$$r_{mt} = \sum_{i=1}^N w_{it} r_{it}$$

Expected shortfall – ES

- the expected downside loss in case a negative shock is observed.

$$ES_{t-1} = E_{t-1}(r_{mt} | r_{mt} < C)$$

Marginal Expected Shortfall – MES [Brownlees and Engle (2011)]

- “the expected loss an equity investor in a financial firm would experience if the overall market declined substantially”.

$$MES_{i,t-1} = \frac{\partial ES_{t-1}}{\partial w_i} = E_{t-1}(r_{it} | r_{mt} < C)$$

1. Introduction

Macroeconomic approach based on publicly available data

- Countries (*not firms*)
- Government bond yields (*not financial returns*)
- Government bond index (*not market index*) using public debt (*not market capitalization*) weights.

1. Introduction - SRisk vs. SsRisk

SRisk

- Measures the expected *capital shortfall* of a *financial institution* in a crisis.
- Obtained from the *capital constraints* imposed on banks, SRisk is based on two elements: (i) the MES – the expected equity loss of a firm when the overall market declines beyond a given threshold; (ii) the leverage of the firm.

SsRisk

- Measures the expected *debt shortfall* of a *country* in a crisis.
- Obtained from the *government budget constraint*, SsRisk is based on: (i) the MES – the expected bond yield of a country when the overall market experiences a crisis; (ii) structural factors of each country (primary deficit, public debt level and growth rate)

2. Methodology: A simple theoretical idea

- Identify and measure the financing requirements of a country by using the standard government budgetary constraint.
- The evolution of the government debt-GDP ratio:

$$\frac{B_{it}}{Y_{it}} = (r_{it} - \pi_{it} - g_{it}) \frac{B_{i,t-1}}{Y_{i,t-1}} + \frac{def_{it}}{Y_{it}} + \frac{B_{i,t-1}}{B_{i,t-1}}$$

- The increase in the real debt stock at time t for country i :

$$B_{it} - B_{i,t-1} = [(1 + g_{it})(r_{it} - \pi_{it} - g_{it} + 1) - 1]B_{i,t-1} + def_{it}$$

- Debt Shortage = the expected increase in debt of country i conditional on the emergence of a European debt crisis

$$DS_{i,t-1} = E_{t-1}(B_{it} - B_{i,t-1} | Crisis)$$

2. Methodology: Some remarks

- **The crisis event:** the whole area faces a difficulty to raise funds *i.e.* high bond rates.
- **First remark** - no 'market index' as Eurobonds are not yet in place -> construct a virtual index:

$$r_{mt} = \sum_{i=1}^N w_{it} r_{it} = \frac{\sum_{i=1}^N r_{it} B_{it}}{\sum_{i=1}^N B_{it}}$$

- **Second remark** - the dynamics of sovereign bond yields follow random walks:

$$r_{it} = r_{i,t-1} + z_{it} \quad \text{and} \quad r_{mt} = r_{m,t-1} + z_{mt}$$

- Thus, the crisis event: $z_{mt} > C$, where the threshold is the VaR (95%).

2. Methodology

- Thus, assuming that growth and primary deficit are predetermined, the debt shortage becomes:

$$DS_{i,t-1} = \left[\underbrace{(1 + g_{it}) \left(1 + E_{t-1}(r_{i,t} | Crisis) - E_{t-1}(\pi_{it} | Crisis) - g_{it} \right) - 1}_{\text{Dynamic MES}} \right] B_{i,t-1} + def_{it}$$

$\xrightarrow{\text{Historical MES}}$

- Interpretation of DS:** the capital that a country would need to raise, if the European bond market experienced a crisis.
- The countries with the highest DS are the greatest contributors to systemic risk!

$$SsRisk_{i,t-1} = \max(0, DS_{i,t-1}) \quad SsRisk\%_{it} = \frac{SsRisk_{it}}{\sum_{i=1}^N SsRisk_{it}}$$

2. Methodology: Some econometrics

- Compute ‘**Dynamic MES**’ on bond yields:

$$\begin{aligned} E_{t-1}(r_{it}|Crise) &= E_{t-1}(r_{i,t-1} + z_{it} | z_{mt} > C) \\ &= r_{i,t-1} + \sigma_{it} \rho_{it} E_{t-1}\left(\varepsilon_{mt} \mid \varepsilon_{mt} > \frac{C}{\sigma_{mt}}\right) + \sigma_{it} \sqrt{1 - \rho_{it}^2} E_{t-1}\left(\xi_{it} \mid \varepsilon_{mt} > \frac{C}{\sigma_{mt}}\right) \end{aligned}$$

- Garch (1,1) to get conditional volatilities, σ_{it} .
- DCC (1,1) to get conditional correlations, ρ_{it} .
- Non-parametric approach to get tail expectations.

2. Methodology: Some econometrics

- Compute '**Historical MES**' on inflation:

$$MES_{it}^{hist} = \frac{\sum_{\tau=t-W}^{t-1} \pi_{i\tau} \mathbb{I}(z_{m\tau} > C)}{\sum_{\tau=t-W}^{t-1} \mathbb{I}(z_{m\tau} > C)}$$

3.1 Data

- 11 Eurozone countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain)
 - Daily nominal government bond yields for a 10-year maturity
 - Time span : May 2000 – December 2011
 - Monthly inflation
 - Annual country public debt
 - Annual GDP to get the growth rate
 - Annual primary deficit
- Data source : Datastream & Eurostat

3.1 Data

- Aggregation

$$DS_{i,t-1} = [(1 + g_{it})(1 + E_{t-1}(r_{i,t}|Crisis) - E_{t-1}(\pi_{it}|Crisis) - g_{it}) - 1]B_{i,t-1} + def_{it}$$

↓ ↓ ↓ ↓ ↓ ↓

quarterly annually daily daily annually annually

- Stock: constant value
- Flow: linear depreciation
- Growth rate: equivalent period rate
- MES: average over the period

3.2 Results

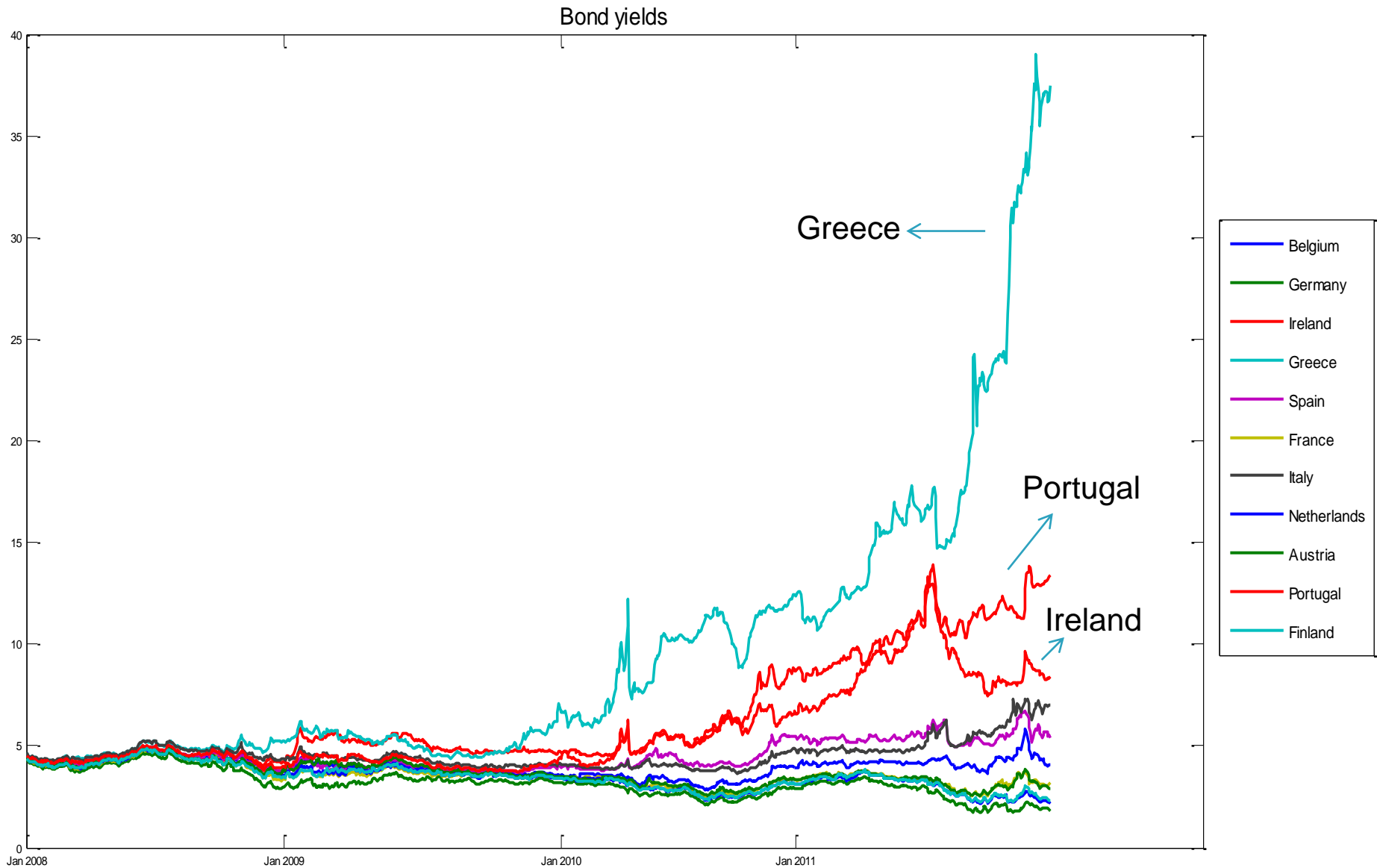
Table 1: Country weights

Country	Germany	France	Italy	Spain	Ireland	Greece	Portugal	Belgium	Netherlands	Austria	Finland
Weight (2011)	25,39%	20,88%	23,18%	8,95%	2,06%	4,32%	2,25%	4,40%	4,79%	2,65%	1,13%

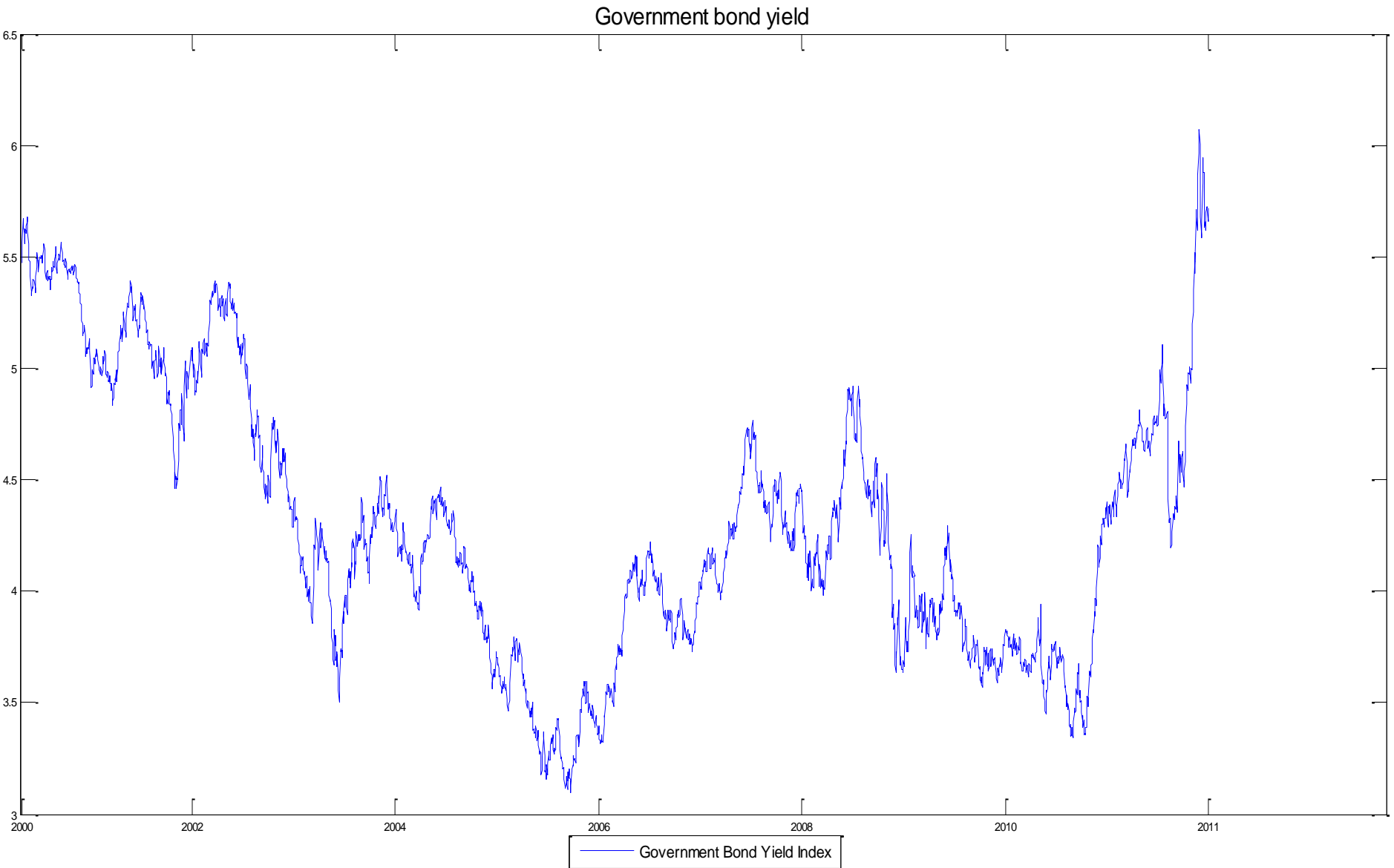
Table 2: Descriptive statistics of the series

	Market index	Belgium	Germany	Ireland	Greece	Spain	France	Italy	Netherlands	Austria	Portugal	Finland
Avg. Yield	4,29	4,25	3,88	4,92	6,25	4,41	4,05	4,53	4,03	4,11	4,97	4,02
Max	6,07	5,84	5,49	13,90	38,99	6,71	5,65	7,31	5,60	5,77	13,80	5,63
Min	3,10	2,82	1,69	3,04	3,21	3,03	2,48	3,21	2,16	2,53	3,00	2,21
Vol.	0,61	0,64	0,80	1,62	4,77	0,68	0,69	0,65	0,75	0,72	1,82	0,76
Corr.	-	0,94	0,60	0,42	0,32	0,92	0,77	0,95	0,67	0,76	0,51	0,70
Skw	0,42	0,43	-0,29	2,22	3,90	0,41	0,23	0,75	-0,06	0,28	2,74	0,11
Kur	2,43	2,51	2,68	8,33	20,80	2,39	2,41	4,06	2,57	2,45	10,68	2,49

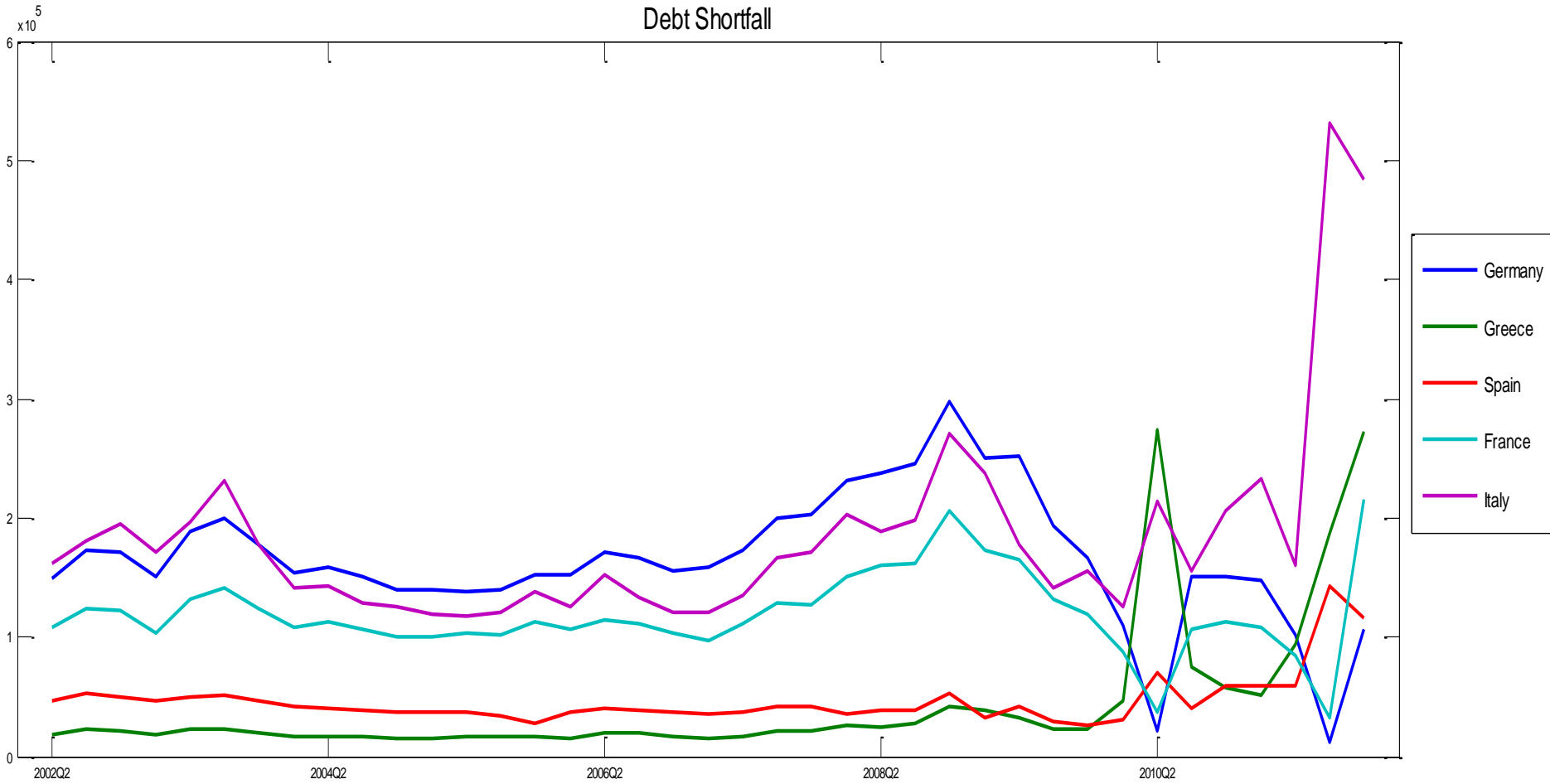
3.2 Results – Bond yields by country



3.2 Results – Bond yield index



3.2 Results– Debt Shortfall time series



3.2 Results – SsRisk Index

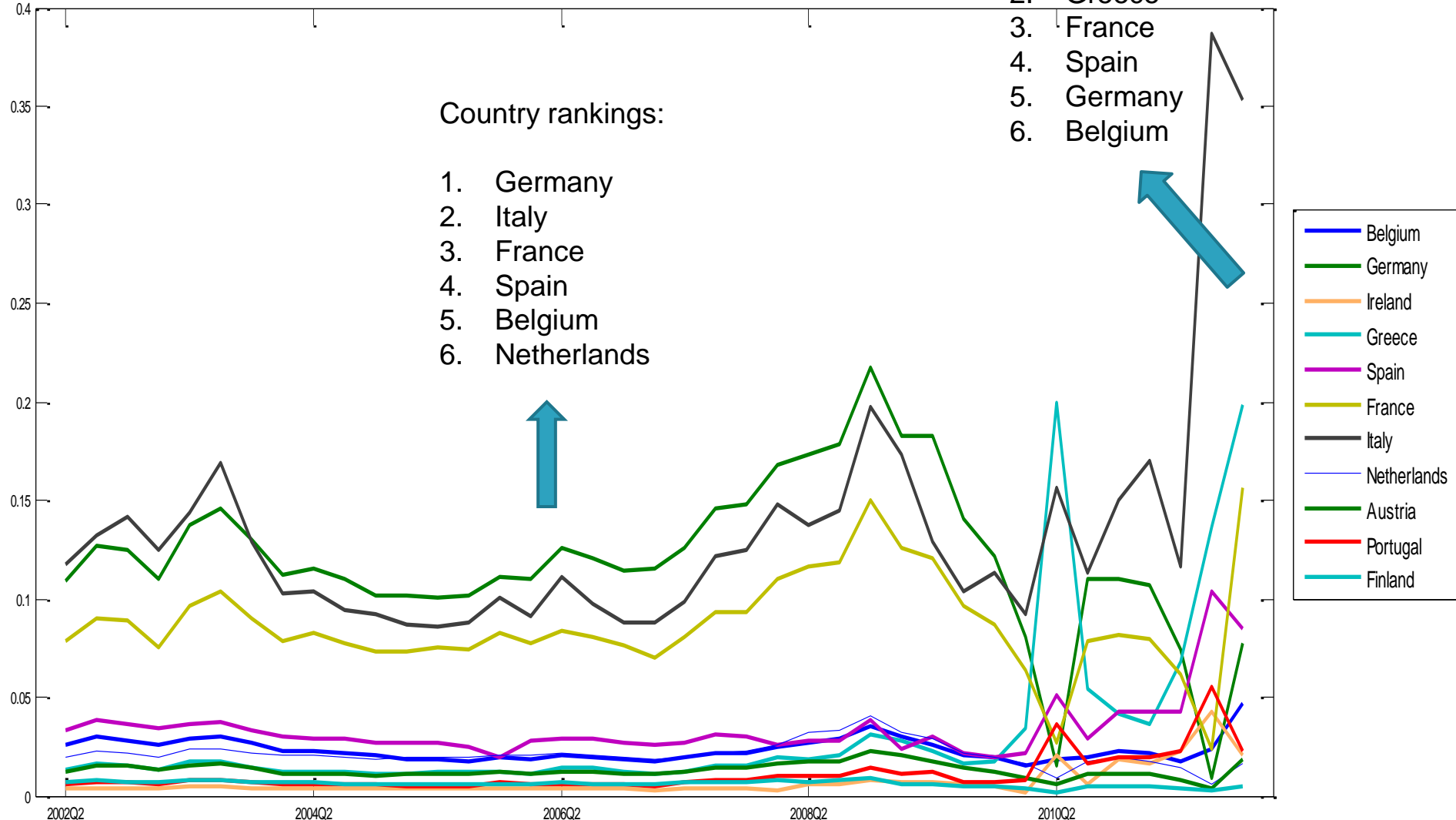
Country rankings:

SsRisk%

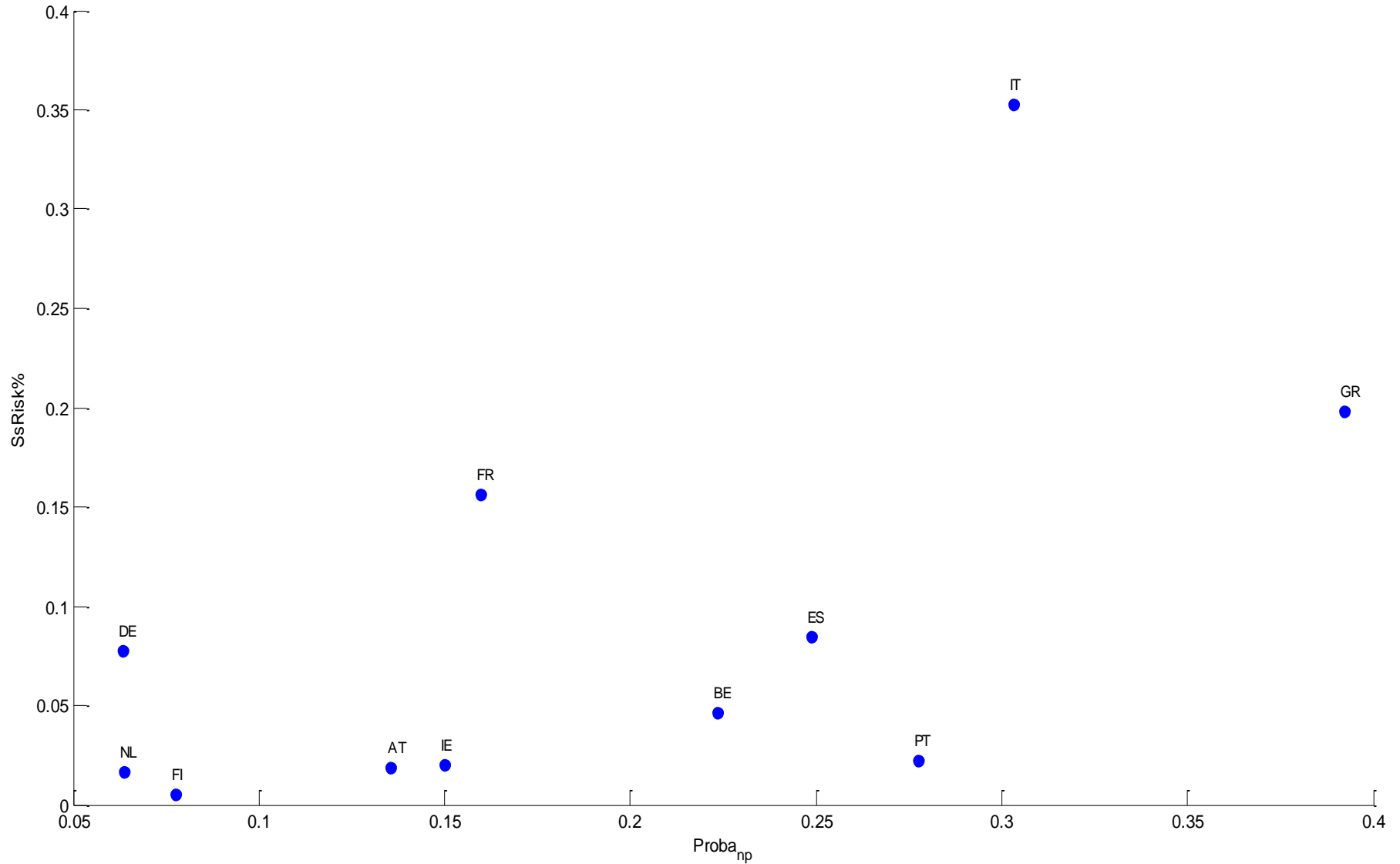
1. Italy
2. Greece
3. France
4. Spain
5. Germany
6. Belgium

Country rankings:

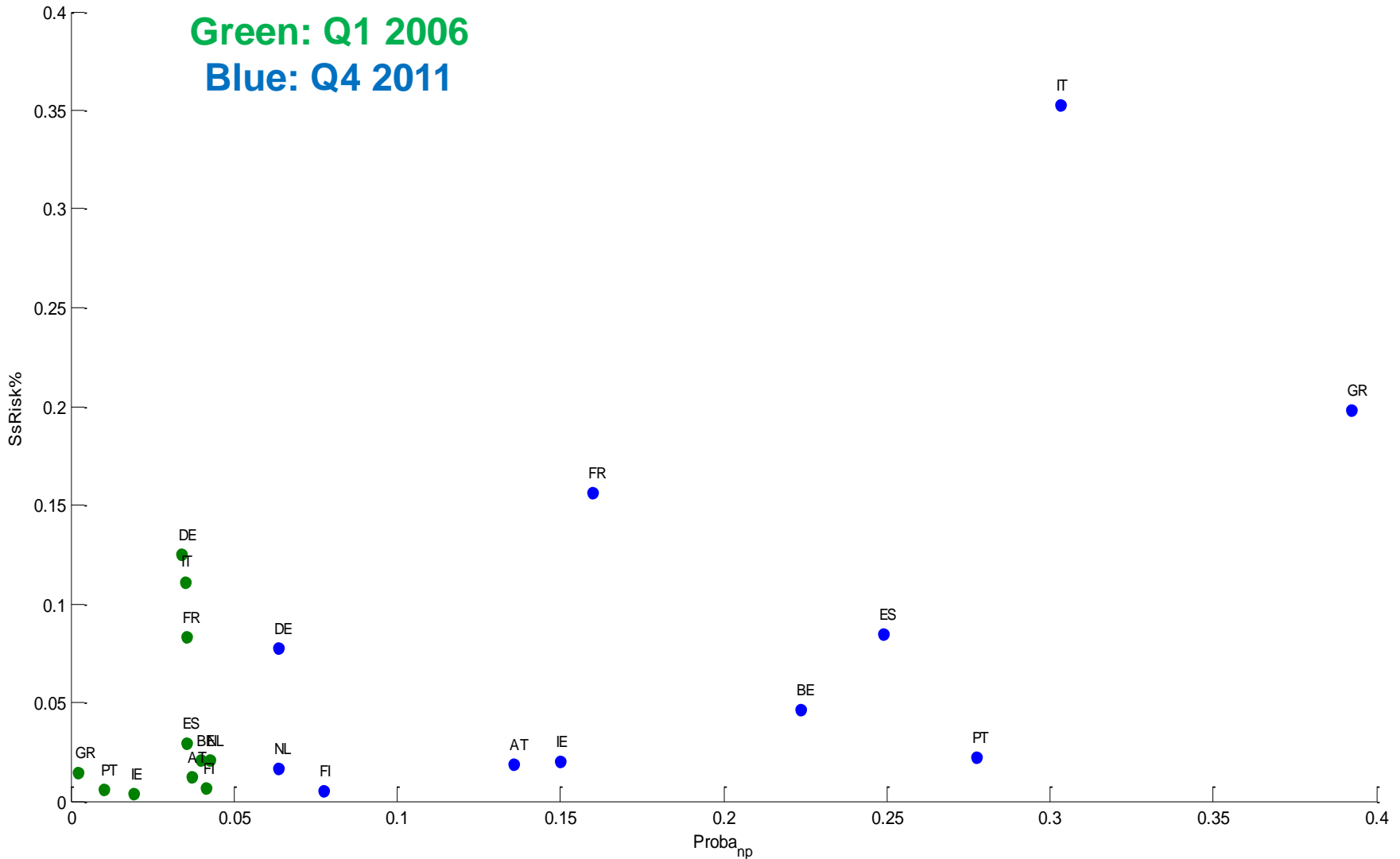
1. Germany
2. Italy
3. France
4. Spain
5. Belgium
6. Netherlands



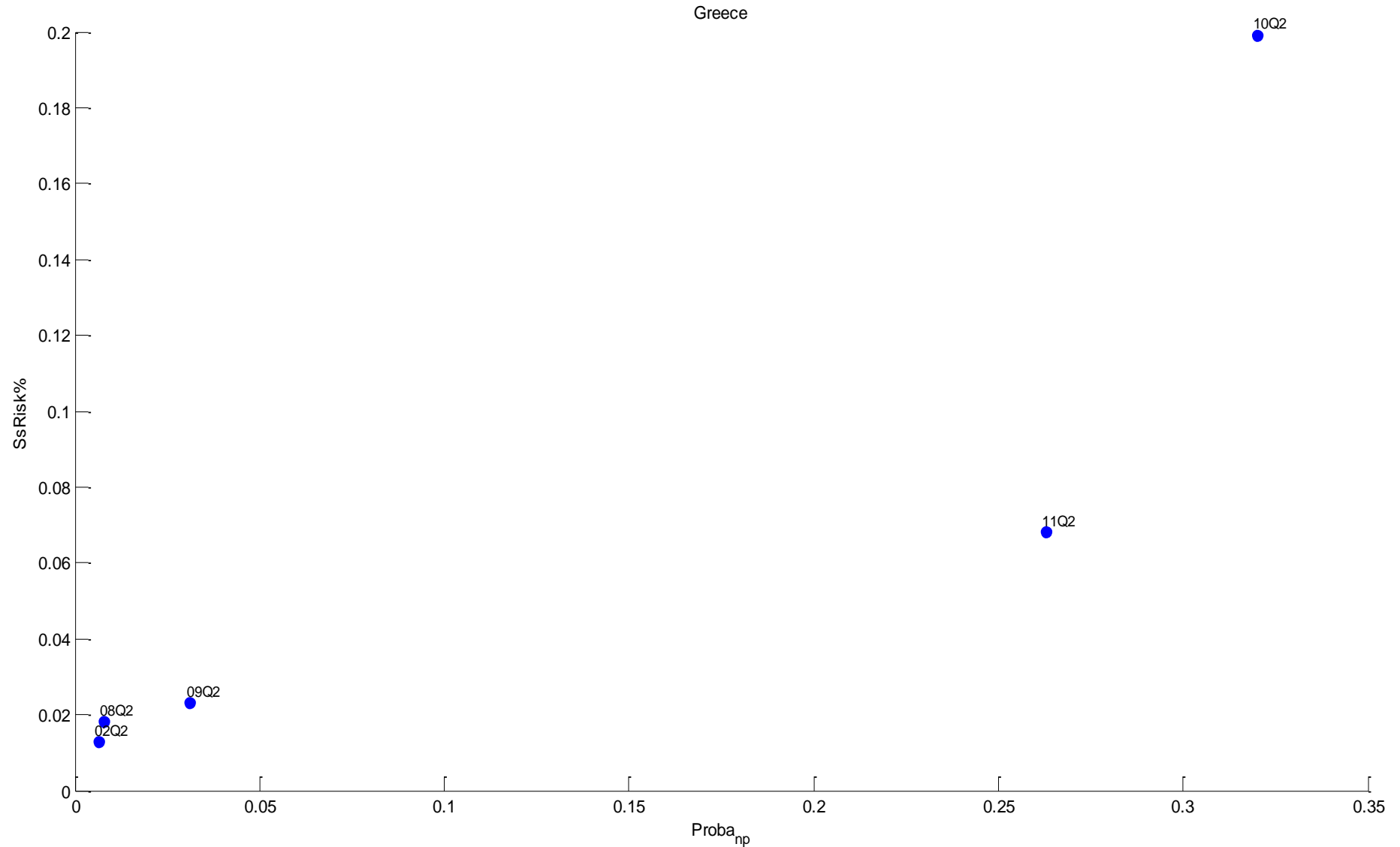
3.2 Results – Torino Scale – as of Q4 2011



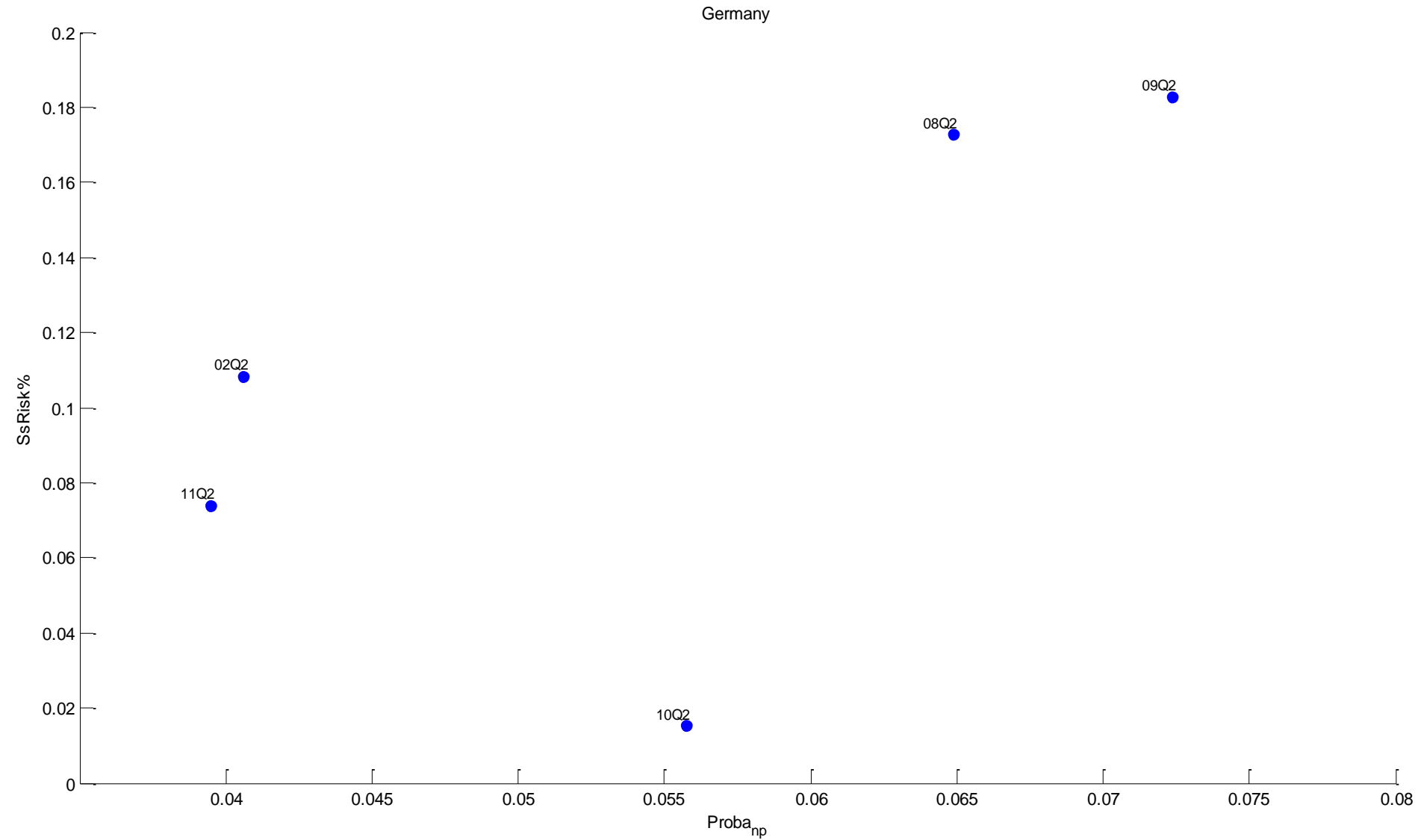
3.2 Results – Before and during the crisis



3.2 Results - Greece



3.2 Results - Germany



4. Preliminary conclusion and further research

- MES and the SRisk% are two systemic risk measures that can successfully be applied not only to financial crises, but also to the sovereign debt crisis.
- Our findings confirm the fact that countries with deteriorated public finances, sanctioned by investors with high yields, have experienced in recent years an important increase in their (marginal) contribution to systemic risk.
- These measures give some information about which countries need more monitoring and provide a ranking of systemically important countries relative to their probability of default.
- Nevertheless, in order to use these measures as a warning signal, **an Ssrisk index** needs to be used and an out-of-sample analysis needs to be undertaken => future research (work in progress)
- Also, the relationship with the banking system should be taken into account (??)

- Thank you for your attention!