




# Systemic Risk Tomography

Edited by Monica Billio

Loriana Pelizzon and Roberto Savona

*Signals, Measurement  
and Transmission Channels*

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# Introduction

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## Systemic Risk: Measures and Warnings<sup>1</sup>

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### 1.1. Introduction

In April 2010, Europe was shocked by the Greek financial turmoil, when the global financial crisis, which started in the summer of 2007 and reached systemic dimensions in September 2008 with the Lehman crash, took a new course.

What we observed was an adverse feedback loop between sovereign and bank risks reflected into bubble-like spreads, as if financial markets were received a wake-up call from disregarded structural vulnerability of economies at risk.

These events inspired a project to “think and rethink” the economic and financial system conceived as an “ensemble” of Sovereigns, Banks with other Financial Intermediaries and Corporations (S-BFI-C). The main aim was to propose a novel way to explore the financial system by sectioning each part of it and understand how they are interrelated. The mission was to inspect the financial system as a biological entity identifying the main risk signals and providing the right measures of prevention and intervention.

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Chapter written by Monica BILLIO, Loriana PELIZZON and Roberto SAVONA.

<sup>1</sup> The research leading to the results contained in this book has received funding from the European Union Seventh Framework Program (FP7-SSH/2007-2013) under grant agreement n° 320270 - SYRTO. This acknowledgment thus relates to all the chapters of this book.

This is why the project was called SYstemic Risk TOMography, or simply SYRTO.

The SYRTO project<sup>2</sup> was next selected and funded in 2013 by the European Union under the Seventh Framework Programme. It has been developed over the course of 3 years and some of the main results of this research inspired the research reported in the chapters of this book.

The objectives of the research project were conceived as a concrete response to the dramatic events which occurred in 2008 with the global financial crisis and in 2010 with the European sovereign debt crisis. Specifically, SYRTO proposed the following:

- 1) assembling an early warnings system (EWS) to be used as risk barometer for each sector and countries alike, identifying potential threats to financial stability;
- 2) realizing a SYRTO Code in order to detect a series of recommendations, also expressed in terms of EWS prescriptions, on: (i) the appropriate governance structures for EU to prevent and minimize systemic risks and (ii) the best mechanisms for ensuring an effective interplay between, and coordination of, macro- and micro-prudential responsibilities.

The realization of these targets was conceived in a step-by-step process in which:

- first, we inspect idiosyncratic risks within the financial system thereby making clear the more important risk predictors and how these are related to: (i) sovereign risk, (ii) banks and other financial intermediaries risk and (iii) non-financial corporates risk;
- second, we explore both the two-way and multi-way risk connections among macrosectors (sovereign, bank and other financial intermediaries, corporates), by elucidating the risk linkages and related transmission channels;

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<sup>2</sup> The SYRTO project included the following universities: University of Brescia; CNRS & University of Paris 1 Panthéon-Sorbonne; Athens University of Economics and Business; Cà Foscari University of Venice; VU University of Amsterdam.

– third, we assemble an overall EWS and suggested possible normative superstructure for a better EU economic governance including monetary and policy coordination as well as financial market supervision.

This book offers a complete overview of the major results and contributions achieved during the lifetime of the SYRTO project<sup>3</sup>.

## 1.2. The new systemic risk context

During the second half of 2011, sovereign and banking risks increased in the Eurozone in an environment of weakening macroeconomic growth prospects. Contagion effects become substantial, also accelerated by the interplay between vulnerability of public finances and financial sector. Furthermore, bank funding pressures increased markedly, thus feeding the fear of the Euro collapse.

While the EU's response to the economic downturn was swift and decisive (e.g. the European Economic Recovery Plan – EERP – launched in December 2008 and ECB monetary interventions in 2011), the future of macroeconomic and monetary conditions in Europe was seen as strictly dependent upon the following building blocks:

– *prediction and prevention of systemic crises*, implying an in-depth understanding of the principal causes of the crisis and how changes in macroeconomic, monetary, regulatory and supervisory policy frameworks could help in preventing their recurrence;

– *risk mitigation*, to minimize the impacts of systemic risks and thus stabilizing the financial system and the real economy in the short run by adopting policy interventions and financial supervision;

– *crisis resolution*, by adopting (i) financial policies, in order to contain banking problems; (ii) macroeconomic policies, in the form of macroeconomic stimulus both monetary and fiscal having in mind the interplay between macro prudential instruments; (iii) structural reforms, by boosting potential growth and productivity then positively reflecting on

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<sup>3</sup> Please refer to SYRTO website [www.syrtoproject.eu](http://www.syrtoproject.eu) to get all the deliverables of the project in terms of publications, conferences materials, policy briefs, technical documents and online systemic risk platform.

fiscal burden, on deleveraging and balance sheet restructuring, and on cross-country imbalances.

Within this new and complex economic context, the main need was to develop core conceptual frameworks, models and tools to handle the three blocks having a system-wide perspective on financial and economic stability. The lesson learned with the global financial crisis was indeed that the financial and economic community neglected such a perspective.

Since the microprudential approach to financial stability ignores the multidimensional nature of risks, the challenging task was to develop formal measures of system-wide risk, in order to capture the linkages and vulnerabilities of the financial system, and regulate the overall level of risk of the system and the real economy's exposure to such a risk.

To put into perspective this new way of thinking about the financial system, a stylized macrofinancial architecture in which sovereigns, financial intermediaries and corporations are intricately connected through balance sheets, as well as real and financial links, is a pragmatic way of mapping what we should monitor.

Together, these links form a complex system of many risk dimensions, translating into systemic risk, namely, "the risk that financial instability impairs the functioning of the financial system to the point where economic growth and welfare materially suffer"<sup>4</sup>.

In this perspective, relationships between sovereign – banks and other financial intermediaries (BFIs) – corporations of the European Union needed to be explored with the following objectives:

- Identify the common (fundamental) and the sector-specific (idiosyncratic) risks, and assemble an EWS to be used:
- as risk barometer for each sector and countries alike, in order to identify potential threats to financial stability;

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4 From: Constancio V., "Macro-prudential supervision in Europe", ECB-CFS-CEPR Conference, Frankfurt am Main, 2010, available at <https://www.ecb.europa.eu/press/key/date/2010/html/sp1009273.en.html>.

- as a system of rules of thumb by monitoring a series of leading indicators so as to minimize the possible negative impacts from systemic crises, preventing contagion effects also including the appropriate mechanisms to restore systemic crisis problems.

– Explore monetary policy and macroprudential issues relative to systemic risk developing a series of recommendations, also expressed in terms of EWS prescriptions, on:

- the appropriate governance structures for EU to prevent and minimize systemic risks;

- best mechanisms for ensuring an effective interplay between, and coordination of, macro- and microprudential responsibilities.

The path toward a better macroeconomic and monetary integration in Europe should focus on:

– the EU economic governance including monetary and policy coordination as well as financial market supervision, taking into account the complex institutional and economic integration in the Eurozone;

– the prediction, prevention and mitigation of systemic risks providing an EWS to be next used as the *trait d'union* between institutional and quantitative features of systemic risk.

In doing this, the concept of systemic risk assumes a pivotal role, being the main focus to be inspected in terms of *measurements, transmission channels and policy intervention*. Chapters in this book report some of the thoughts and results that the project has developed on this perspective.

### **I.3. Systemic risk objectives**

The research activity within the new challenging context has been articulated in a step-by-step process conceived with the end to lead findings toward the two main tangible objectives, namely, the EWS and a SYRTO Code.

The first objective has been to inspect the idiosyncratic risks within the financial system thereby making clear the main risk predictors and how these are related to:

– sovereign risk;



- banks and other financial intermediaries risk;
- non-financial corporates risk.

Once the idiosyncratic risks have been identified and scrutinized, the following step has been to connect them by clarifying:

- the two-way and multi-way risk connections among macrosectors (sovereign, bank and other financial intermediaries, non-financial corporates);
- the main risk linkages and related transmission channels;
- proposing novel systemic risk measures.

Finally, based on major achievements of the previous steps, we focused on the two major objectives:

- to assemble an overall EWS to be used as risk barometer for each sector and countries alike, identifying potential threats to financial stability;
- to realize a SYRTO Code, namely, a series of recommendations and prescriptions on: (i) how to prevent and minimize systemic risks and (ii) the best coordination of macro- and microprudential responsibilities.

### **1.3.1. *Idiosyncratic risks***

Detecting the fundamental risk sources of the financial system depends on the following risk categories:

- *sovereign risk*, both considering economic fundamentals and market prices in order to make clear the relationship between risk perceptions, especially during times of market turmoil, and “fundamental” risk inherent to macroeconomic vulnerabilities;
- *banks and other financial intermediaries risk*, exploring how financial and macroeconomic risks change over time due to the strong interconnectedness between financial intermediation, macroeconomic environment and asset price dynamics;
- *corporate risk*, showing how financial sector risks transmit to real business cycle fluctuations using a balance-sheet risk perspective.

### **1.3.2. Two-way and multi-way risk connections**

Risk connections among the system S-BFI-C have been explored by focusing on, first, the bivariate relationships, and second, on the joint determination of risks:

1) *two-way risk connections*, monitoring the feedback between sovereign debt and bank risks as well as spillover effects between banks and the corporate sector also considering interconnections between sovereign and corporate risks;

2) *multi-way risk connections*, exploring the main financial and economic linkages as a channel for propagation of shocks through recent advanced econometric/statistical techniques such as network analysis, data-mining techniques and latent variable modeling approaches.

### **1.3.3. Systemic risk measures**

Different systemic risk indicators have been developed using different methodologies thereby offering a list of potential battery of measures using financial and economic data. These measures helped the realization of the Early Warning and NowCasting indicators, to analyze:

- linkages and vulnerability of the financial system;
- bi-variate risk relationship among sovereign debts, BFIs and corporate.

### **1.3.4. Early warning system and SYRTO Code**

The EWS is the first main systemic risk operational objective, which allows us to put into practice what we learned during research and offers an effective monitoring risk system for sovereigns, BFIs and the corporate sector. It provides a comprehensive risk analysis covering countries and sectors and aggregating the individual risk dimensions.

The second main systemic risk objective regards the possible framework for systemic risk regulation in terms of policy/monetary recommendations and prescriptions, leading toward a formal SYRTO Code, in order to detect possible rules of thumb to limit the triggers, the shock transmission of systemic risks and *ex post* policy interventions to stabilize the Euro area

financial system. The Code we propose in this book (Chapter 9) comprises three main actions:

- 1) *prevention*: Identification of a series of rules of thumb in order to limit the triggers of systemic risk;
- 2) *mitigation*: Limiting systemic shocks transmission and prevent conflicts of interest and ineffective policy interventions;
- 3) *stabilization*: *Ex post* policy interventions to stabilize the Euro system.

## **1.4. Some lessons we learned in studying systemic risks: the book content**

The book reports some of the main results of the SYRTO project and is structured into three parts.

### **1.4.1. Risk connections and systemic risk measures**

The two-way risk connections can be studied moving in many directions with different statistical and econometric procedure, including linear and nonlinear approaches to inspect time-varying and nonlinear relationships.

We have detected the main financial and economic *multi-way risk connections*. What we implemented in our research agenda includes the following approaches: (i) multi-equation system with latent variables, (ii) network analysis, (iii) data-mining techniques, (iv) latent-based systemic risk measurement approach and (v) agent-based models.

All these approaches can be put together to develop novel systemic risk measures also proposing a new taxonomy based on a micro-macroperspective as well as according to mapping procedure, which can take the form from micro to macro and vice versa. Specifically, we could articulate the entire computation in three building blocks:

– First, we analyze the time evolution of systemic risk in Europe using the WorldScope lists of the financial industry for the European countries. The analysis can be based on the cross-sectional distribution of systemic risk measures such as Marginal Expected Shortfall, Delta CoVaR, SRISK, SES and network connectedness measures. These measures are indeed conceived

at a single institution level for the financial industry in the Euro area and capture different features of the financial market during the period of stress.

– Second, we extract business and financial cycles from economic and financial time series including informative variable such as GDP, credit, credit to GDP, credit to disposable personal income and residential property prices. These cycles vary stochastically over time and can be identified by multivariate linear Gaussian state space models.

– Third, new ranking methods have been developed using average pairwise stock correlations and turn out to be nearly identical to the more sophisticated network-based systemic risk rankings such as Google PageRank.

Chapters 1–5 provide evidence of risk connections under different perspectives, detailing and developing part of the results obtained in the SYRTO project.

#### **1.4.2. Early warning system for systemic risk(s)**

The development of an EWS for systemic risk is at the core of the SYRTO project. We started from the three building blocks of risk connections and systemic risks and we developed a systemic risk taxonomy for EWS:

##### *1) Micro systemic risk measures – single financial institution:*

– standard systemic risk measures: (i) Equity side (CoVaR, MES, SES, SRISK and Granger Causality) and (ii) Bond side (CoRisk and Distressed Insurance Premium);

– new systemic risk measures: (i) PageRank, (ii) CorrRank, (iii) BetaRank and VaRRank, (iv) Markov switching models and (v) multivariate stochastic volatility model.

##### *2) Macro systemic risk measures – financial system:*

– standard macro systemic risk measures: (i) Dynamic Granger Causality Index and (ii) principal component analysis (PCA);

– new macro systemic risk measures: (i) normalized rank reflection symmetry, (ii) sovereign joint default probabilities, (iii) business and

financial cycles, (iv) dynamic PCA, (v) dynamic factor models and (vi) leading indicator (LI) of the Euro area IP growth.

3) *Aggregation/disaggregation* – mapping micro and macro (from micro to macro and vice versa):

– single institutions  $\rightarrow$  financial system (aggregation): (i) entropy measures, (ii) stress indices and (iii) panel regressions;

– single institutions  $\leftarrow$  financial system (disaggregation): (i) graphical models and (ii) network analysis.

The development and testing of these measures among others are reported in Chapters 6–8 and used to develop the web-based systemic risk platform available at <http://syrtoproject.eu/results/>.

### **1.4.3. SYRTO Code**

The SYRTO Code<sup>5</sup> contains the policy implications and recommendations for the measurement and management of systemic risk. Specifically, it explores the challenges for governance and coordination of macroprudential policies aimed at systemic risk. The code draws on a wide body of academic research on systemic risk, such as has been done under the SYRTO project, but not limited to it.

The Code, summarized in Chapter 9, starts with “six take aways” that give the most important policy lessons that we can deduce from systemic risk research:

- 1) models give useful early warning signals;
- 2) low financial stress levels are not synonymous to high financial stability;
- 3) the challenge is to make hard decisions based on soft information;
- 4) manage the complexity of the financial system;
- 5) there is evidence for a country-specific financial cycle;
- 6) systemically important institutions are correctly identified.

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<sup>5</sup> The complete document is available at: <http://syrtoproject.eu/wp-content/uploads/2016/02/Syrtocodefinal.pdf>

The lessons learned are structured as an introduction with policy challenges, followed by sections on prevention, mitigation and stabilization.

## **1.5. Conclusion**

We aim to underline once more that this book is a selection and a re-elaboration of some of the results that the SYRTO project developed. A detailed description of all our efforts, and in particular the web-based systemic risk platform, is available on the SYRTO website (<http://syrtoproject.eu/results/>).

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