INSTITUTE FOR ADVANCED STUDIES LUCCA

#01
2015

ISSN 2279-6894
IMT LUCCA EIC WORKING PAPER SERIES 01
January 2015

RA **Economics and institutional change**

Systemic Risk and Banking Regulation: Some Facts on the New Regulatory Framework

Michele Bonollo
Irene Crimaldi
Andrea Flori
Fabio Pammolli
Massimo Riccaboni

ISSN 2279-6894
IMT LUCCA EIC WORKING PAPER SERIES #01/2015

Piazza San Ponziano 6, 55100 Lucca

Research Area
Economics and institutional change

Systemic Risk and Banking Regulation: Some Facts on the New Regulatory Framework

Michele Bonollo
Credito Trevigiano;
IMT Institute for Advanced Studies Lucca

Irene Crimaldi
IMT Institute for Advanced Studies Lucca

Andrea Flori
IMT Institute for Advanced Studies Lucca

Fabio Pammolli
IMT Institute for Advanced Studies Lucca

Massimo Riccaboni
IMT Institute for Advanced Studies Lucca;
Department of Managerial Economics, Strategy and Innovation, K.U. Leuven

Systemic Risk and Banking Regulation: Some Facts on the New Regulatory Framework[1]

Michele Bonollo*, Irene Crimaldi†, Andrea Flori‡, Fabio Pammolli§, Massimo Riccaboni¶

January 10, 2015

Abstract

The recent financial crisis highlighted the relevant role of the systemic effects of banks' defaults on the stability of the whole financial system. In this work we draw an organic picture of the current regulations, moving from the definitions of systemic risk to the issues concerning data availability. We show how a more detailed flow of data on traded deals might shed light on some systemic risk features taken into account only partially in the past. In particular, we analyse how the new regulatory framework allows regulators to describe OTC derivatives markets according to more detailed partitions, thus depicting a more realistic picture of the system. Finally, we suggest to study sub-markets illiquidity conditions to consider possible spill over effects which might lead to a worsening for the entire system.

JEL Codes: G01, G18 G21

Keywords: Systemic Risk, OTC Derivatives Market, Basel Regulations, European Market Infrastructure Regulation, Trade Repositories.

*CreditoTrevigiano and IMT Institute for Advanced Studies Lucca, Italy, michele.bonollo@imtlucca.it.
† IMT Institute for Advanced Studies Lucca, Italy, irene.crimaldi@imtlucca.it. Irene Crimaldi is a member of the Italian Group "Gruppo Nazionale per l'Analisi Matematica, la Probabilità e le loro Applicazioni (GNAMPA)" of the Italian Institute "Istituto Nazionale di Alta Matematica (INdAM)".
‡ IMT Institute for Advanced Studies Lucca, Italy, andrea.flori@imtlucca.it.
§ IMT Institute for Advanced Studies Lucca, Italy, fabio.pammolli@imtlucca.it.
¶ IMT Institute for Advanced Studies Lucca, Italy, and K.U. Leuven, Leuven, Belgium, massimo.riccaboni@imtlucca.it.

[1] Financial support from Consiglio Nazionale delle Ricerche – Programma Nazionale della Ricerca, Project "CRISIS Lab".

1 Introduction

The outbreak of financial systems in 2007 underlines the weaknesses of international regulations concerning banking risk supervision. In particular, past regulation on capital requirements was focused on a *micro-prudential* approach in which bank was assessed on the basis of its own portfolio and its own risk, while regulatory capital had to be large enough to face bank's risk level. Conversely, the collapse of financial systems stresses the importance of measuring the risk contribution of each bank to the financial stability, thus suggesting to replace the classical principle "too big to fail" with a "too interconnected to fail" perspective (see for instance Bastos et al., 2009 and Strahan, 2013).

The banking sector represents a cornerstone in the analysis of systemic risk due to its important role in the propagation of shocks to global markets and wider economy. As emphasized by the current crisis, bank failures weaken the financial system and spread financial distress. Therefore, institutions whose bankrupt may trigger the default of other banks need more rigorous supervision by regulators and should in principle fulfil higher levels of capital requirements. Hence, the need to set up an effective regulatory capital also for the systemic risk motivates the new Basel 3 framework to address these points (BCBS, 2013). Nevertheless, a huge debate over systemic risk measurement methodologies, capital requirements and effectiveness of the rules is taking place in the banking and academic community.

Although systemic risk has been largely studied in recent times, literature is still trying to propose a widespread quantitative definition. In particular, the effective application of any systemic risk indicator requires that its notion should be clearly set forth. Therefore, its definition should be widely accepted by the financial community and implemented in the effective risk management practices. This leads to a growing literature concerning the identification of the key features of financial stability useful to disentangle bank's systemic risk contribution.

One of the most promising attempts concerns the exploitation of the network theory approach to construct and analyse financial systems. This perspective has been widely adopted in many other fields, such as the web, the social networks, the airport design, the traffic flows and so on. Therefore, once the relationships among banks (e.g. inter-banking market, OTC derivatives, etc.) are modelled as a network, where banks are the nodes and their bilateral exposures are the oriented links, we could exploit network theory tools and indicators in some way in order to estimate and possibly prevent systemic risk. In the international debate the word *resilience* of the banking system had been largely scrutinized. Thus, what happens to the remaining institutions of the system when a large bank fails? This question leads naturally to a *Loss Given Default* approach. Hence, the systemic features of a bank are related to the losses that it can cause by some *contagion* mechanism determined by its default. Therefore, by introducing new capital constraints the banking system should be more resilient to such a shock, exactly as an hydric network damaged by a hole in its structure. This motivates the investigation of which structures are more prone to spread financial distress. Literature usually indicates two potential candidates: a network with a small number of large banks with a "hub & spoke" topology or a network with a large number of small banks and a more uniform distribution of exposures.

These issues and many others cannot be managed, or at best may receive a partial answer in the current state of the art. In fact, the lack of a complete data set regarding bilateral exposures does not allow an accurate and granular description of the network. In particular, at a local level practitioners (banks) can exploit their peer-to-peer links of all available bilateral data, while the scientific community can typically use the aggregate global statistics and some partial network information in order to investigate the network features and/or behaviours. Hence, the introduction of new regulations, such as the *European Market Infrastructure Regulation* (EMIR) and the *Trade Repository* implemented by the *European Securities and Markets Authority* (ESMA) in Europe and the *Dodd-Frank Act* in US, could give new relevant insights on the financial system structure.

Despite the hardness of this field, the paper aims to give an up-to-date overview[2] of the systemic risk definitions, trying to build a bridge among academy, supervisors and practitioners perspectives. The work is structured as follows. Section 2 shows how the various types of actors involved in the debate stress different aspects and give greater emphasis to some features rather than others. In particular, Section 2 attempts to bring out the common points proposed in literature in order to identify a level playing field. Section 3 discusses the impact of new regulations on the structure of the system. Basically, due to the lack of data and the difficulty to match information, often related to cross-jurisdiction situations, it is quite difficult to measure the amount and type of bilateral exposures, netting agreements, and collateral positions between two counterparties. Therefore, regulators are proposing ways to solve the issue of scarce availability of data. In particular, this Section presents the pillars that compose the EMIR, providing details on the effective banking sector practices. Section 3 addresses systemic risk from several points of view. Firstly, it describes the rules concerning the provision of data and the implementation of the trade repositories. Secondly, it underlines how public dissemination of transaction derivatives data might contribute to depict a much clearer picture of the financial systems. Finally, it reflects upon how the assessment of systemic risk could benefit from more granular data availability provided by the new regulatory framework, thus suggesting to investigate the potential relationship between liquidity risk and the emergence of systemic criticalities. Section 4 provides conclusions.

2 Looking for the Definition of Systemic Risk and its Sources

In the last fifty years, quantitative approaches applied to banking activity have grown rapidly. The view of different types of risk was not so clear at the beginning. It is worthwhile to recall that the *financial* (or *market*) *risk*, with the VaR-quantile definition, was the first to get a systematic treatment, while only in the last twenty years the same improvement has been observed for credit and operational risk. The need of risk management techniques and risk measures allowed a very successful path for both applied and theoretical research. Among others, we recall the developments in the extreme value theory (Embrecht et al., 1999) and the theory for coherent risk measures (Acerbi and Tasche, 2002).

In the previous cases, it was relatively simple to distinguish and hence to define the different risks. Basically, the risk was defined as the *loss that the bank could face due to some event in a given class of instruments*, e.g. financial instruments (*market risk*), loans (*credit risk*), and banking broad sense processes and systems (*operational risk*). In particular, the analysis of credit risk belongs to a vast strand of literature which includes also the study of *counterparty risk*. This type of risk is defined as the risk that the counterparty to a transaction involving specific financial instruments may not respect its payment obligations. Therefore, counterparty risk is a credit risk, since the loss is due to the counterparty's insolvency. However, it presents two specific features: the uncertainty of the value of the exposition, which is related to the market behaviour, and the bilateral nature of the risk. From a systemic perspective, the counterparty risk plays an important role in the interbank market where bilateral exposures imply a densely interconnected system. These connections represent a significant source of *systemic risk* as they become a channel in the spreading of shocks, thus causing contagion and domino effects.

The systemic risk concept is well known, but its quantitative study started about only a decade ago (De Bandt et al., 2009). Thus, it is not surprising that only in the forthcoming Basel 3 framework it receives a set of rules as concerns the equivalent capital requirement. The application of any systemic risk indicator requires that the notion of systemic risk should be clearly set forth. Therefore, the definition of systemic risk should be widely accepted by the financial community and implemented in the effective risk management practices.

---

[2] For a deepening on some of these aspects, the interested reader can refer to Bonollo et al. (2014a,b).

In the *Financial Stability Board* (FSB) recommendations (FSB, 2010) several points are strongly stated to face the systemic risk of *Global Systemically Important Financial Institutions* (G-SIFIs). The most relevant recommendation is related to a higher loss absorbency capacity required to G-SIFIs to avoid the *moral hazard* (to accept too much risk) implicit in the "too big to fail" or "too interconnected to fail" principles. In order to prevent that some banks could misbehave since they are unlikely to fail thanks to public support, it is therefore necessary to require them more capital useful to absorb potential losses: *financial institutions should be subject to requirements commensurate with the risks they pose to the financial system.* However, no explicit systemic risk definition is provided. Moreover, the introduction states the following preliminary remark:

This report recommends a policy framework for addressing the systemic and moral hazard risks associated with systemically important financial institutions (SIFIs) whose disorderly failure, because of their size, complexity and systemic interconnectedness, would cause ***significant disruption*** *to the wider financial system and economic activity*[3].

To get a definition of the systemic risk, we refer to the recent paper on the systemic risk capital requirement by the Basel Committee (BCBS, 2013):

The Committee is of the view that global systemic importance should be measured in terms of the impact that a bank's failure can have on the global financial system and wider economy, rather than the risk that a failure could occur. This can be thought of as a global, system-wide, loss-given-default (LGD) concept rather than a probability of default (PD) concept.

Obviously, this definition does not allow to perform any calculation of the systemic risk of a bank, but it still provides a sharp clear perspective. The rationale of the regulation is that a bank is systemic if its "systemic" LGD is very large, hence its default probability must be reduced by a higher loss absorbency capacity. Furthermore, an enforced supervision has to be addressed along with resolution programs. To avoid misunderstanding, we also point out that the above definition is referred to the single bank, i.e. to its contribution to the risk of the system. This is different from the risk of the banking system as a whole, that we call global systemic risk.

In particular, the concept of *resilience* of a system is helpful to describe the network of financial institutions analyzing what happens to the other participants of the system when a large institution fails. This allows us to distinguish between the topological properties of the network computed to describe the systemic risk as a whole and the contribution to systemic risk that the single node determines. Hence, from the regulatory point of view, the purposes concern the design of a banking system more resilient to shocks and the identification of which nodes have a greater systemic contribution.

Surprisingly, most of the papers by regulators and policy groups do not define at all the systemic risk, as if it were an obvious, trivial concept or an "axiom". Hence, most of the works investigate the sources of systemic risk, or the tools to hedge it: corporate governance, accounting principles, collateral management, capital requirement, and so on. In those papers where a systemic risk measure is given, the risk indicator embodies a semantic definition. In particular, after the 2007-2008 crisis, a first attempt to design a global framework for the systemic risk is discussed in the joint paper by the *International Monetary Fund* (IMF), the *Bank for International Settlements* (BIS), and the *Financial Stability Board* (FSB) (see IMF-BIS-FSB, 2009). In the introduction section, we have the following statement:

Establishing what constitutes systemic importance has proved difficult, and most G-20 members do not have a formal definition. *Nonetheless, in practice G-20 members consider an institution, market or instrument as systemic if its*

[3] Note that we put in bold (not present in the original document) the reference to the "significant disruption", since it seems to be very broad, almost ambiguous, for a practical implementation.

failure or malfunction causes widespread distress, either as a direct impact or as a trigger for broader contagion. The interpretation, however, is nuanced in that some authorities focus on the impact on the financial system, while others consider the ultimate impact on the real economy as key.

Despite the first statement (in bold), where the difficulty of a general meaning of systemic risk is pointed out, we note that a LGD approach is implicitly given. Furthermore, the *contagion effect* becomes explicit. Basically, if the bank i defaults and the bank j has a positive exposure to the bank i, say E_{ji}, its credit exposure disappears, unless the recovery rate R_i. If the magnitude of the loss $(1-R_i)E_{ji}$ is relevant with respect to a given threshold, say the capital level of j, than j could itself default. This is what we call a *contagion or cascade default*. Note that, in the case of a positive exposure (i.e. a credit position) of j to i, the default of i implies a capital reduction for j. If the exposure is negative (i.e. a funding position) for j, the default of i might still have bad consequences on j due for instance to liquidity effects whenever i is an usual funding source for j. Hence, a withdrawal of liquidity by a bank can cause critical and systemic effects on the whole available liquidity of the system.

The *European Central Bank* perspective is that *(systemic risk is) so widespread that it impairs the functioning of a financial system to the point where economic growth and welfare suffer materially* (ECB, 2010). Similarly, a *Bank of England* paper (Nier et al., 2008) does not provide any strict interpretation of systemic risk. In a broad sense, it claims that *systemic risk arises when there is the potential for multiple banks to fail and to impose costs on the financial system and ultimately on the economy as a whole*.

With regard to the academic literature, as a definition of systemic risk, let us recall the one by Billio et al. (2012), i.e. systemic risk is any *set of circumstances that threatens the stability of or public confidence in the financial system*. Cont et al. (2010) underpin the role of *systemic risk, defined as macro-level risk which can impair the stability of the entire financial system. Bank failures have led in the recent years to a disruption of the financial system and a significant spill over of financial distress to the larger economy*. Despite definitions provided in the scientific literature tend to be more rigorous, they are also too general for a straight application.

Finally, an interesting approach is offered by the private sector perspective. For instance, the *Counterparty Risk Management Policy Group* (CRMPGIII) comprised of some leading financial institutions (e.g. JPMorgan, Morgan Stanley, Citigroup, etc., see CRMPGIII, 2008) does not provide an explicit definition for systemic risk in its 2008 annual paper. On the other hand, the paper stresses some points:

- the complexity of financial markets makes very hard to detect the systemic risk;
- the credit concentration is the most important source;
- some high-level precepts could reduce ex-ante the systemic risk (e.g. corporate governance, risk monitoring, risk appetite estimation, contagion focus, enhanced oversight).

As for the industrial standpoint, for the purpose of brevity, let us only recall a recent *Depository Trust & Clearing Corporation* (DTCC) white paper (DTCC, 2013). The emphasis and the main contribution to the debate is in the attempt to give an exhaustive taxonomy of the systemic risk sources, namely: cyber security, new regulations, high frequency trading, counterparty risk, collateral, market quality, CCPs (central counterparties), business continuity risk. This list is very interesting, as it moves from the classical financial networks (OTC, inter-banking) or liquidity flows to some more general risk factors and risk drivers.

For the sake of conciseness, we omit several other definitions and explanations of systemic risk (see for instance Billio et al., 2012 and Bisias et al., 2012), and we try to summarize in a more useful way some stylized facts about systemic risk, i.e. all the "coordinates" that allow to set up a reliable framework.

- *Perimeter*: The systemic risk concerns both the whole system in a macro-prudential approach and the single bank risk contribution from a capital requirement point of view. As a useful (non mathematical) parallelism, it can be conceived in a broad sense as a portfolio of balance sheets where the linkages between them define the dependence structure. In other words, exactly as the VaR and the Component VaR in a financial or lending portfolio.
- *Definition*: From both global and local perspective, systemic risk is close to a LGD definition. To this end, one should well define the loss propagation flows, the default mechanism and the indirect effects on liquidity.
- *Tools to manage and mitigate*: In an ex-ante step, to reduce the default probability of SIFIs, via a higher loss absorbency. Once the default occurs, a safety net with a recovery and resolution program (e.g. the deposit guarantee scheme). Finally, a network topology modification to get lower systemic risk figures, e.g. the introduction of central counterparties as robust hubs for the OTC derivative markets.
- *Main gaps and needs*: High granularity (i.e. the detailed knowledge of any peer to peer deal), high frequency data, high quality data are not yet fully available. Furthermore, also the granularity level and the list of the multidimensional attributes of nodes and edges are not yet clear. Their comprehension is a requirement for any successful implementation of network theory in this field.

3 The New Systemic Risk Regulatory Framework

3.1 The European Market Infrastructure Regulation (EMIR) and the *Trade Repositories*

While the Basel 3 regulation for the systemic risk refers to some heuristic indicators[4], a more quantitative approach could allow to have a deeper control of the financial system dynamics and related risks. For instance, if we refer to the OTC market, until now the reporting, e.g. from *Bank for International Settlements* (BIS), *International Swaps and Derivatives Association* (ISDA), *Commodity Futures Trading Commission* (CFTC), etc., is restricted to *aggregated* measures provided by national central banks or by some leading reporting dealers. Therefore, due to the lack of data or the difficulty to match information, mainly in cross-jurisdiction situations, it is quite hard to estimate the amount and type of actual bilateral exposures, netting agreements, and collateral positions between two counterparties.

This motivates regulators to set mechanisms to overcome the issue of the scarce availability of data. In US, prior to the *Dodd-Frank Act* (2010), financial institutions had less obligations regarding the amount of financial leverage, counterparty risk exposures, market share, and other data to be reported to any regulatory agency. Conversely, new rules introduce also requirements on OTC exposures and assign to specific agencies the role of collecting and sharing data. Similarly, in Europe the creation of the *European Securities and Markets Authority* (ESMA) and the *European Systemic Risk Board* (ESRB) are also motivated by the need to enforce the availability of data in order to improve the supervision and the restraint of the systemic risk. In addition, the *European Parliament* established the *European Market Infrastructure Regulation* (EMIR) with the Regulation No. 648/2012. Differently from the European directives (e.g. Basel 3, represented by the *Capital Requirement Directive IV*, CRDIV), a regulation does not require single countries national

[4] The proposed methodology is grounded on a measurement system based on five indicators: *Cross-jurisdictional activity, Size, Interconnectedness, Substitutability/Financial institution infrastructure* and *Complexity* (see BCBS, 2013).

laws to become effective. Moreover, the EMIR was enriched by the Commission Delegated Regulations from No148/2013 to No 153/2013 along with the ESMA Technical standards. Unfortunately, despite the EMIR officially came into force as of 2012, August 16, its effective implementation is still a work in progress.

Basically, the EMIR aims to reduce or to control the counterparty credit risk, the systemic risk and the market abuse. In order to reach these purposes, several new rules have been determined and new tools for authorities and regulators have been set up. Hereinafter, we give respectively a general overview of the pillars that compose the EMIR and we introduce the *Trade Repository* which represents the challenging tool that should allow all market players to get useful data to assess systemic risk. As a by-product of the new regulation, the trade repository should improve the quality of the international derivatives statistics[5].

The Pillars of the EMIR Architecture. In recent times, every new financial regulation is summarized in some pillars. This facilitates a top down overview of the contents of the new regulatory framework and makes possible a comparison between regulations in different countries (e.g. Basel vs Dodd-Frank). The EMIR may be synthesized in the following pillars:

- Pillar I: Every *eligible* OTC derivative must be cleared by some Central Counterparty (CCP).
- Pillar II: Every *non-eligible* OTC derivative deal must be collateralized by some suited cash or security guarantees by means of standard contracts.
- Pillar III: The required OTC and listed derivatives data must be reported to the Trade Repository (i.e. the reporting obligation).

Although the three pillars look very simple, some hundreds of FAQs have arisen (see ESMA, 2013) and several releases of QAs and technical standards have been published to clarify its applicability. First of all, which is the exact definition of "financial instruments" underlying the EMIR regulation? We do not refer to the exchange style (OTC vs. Listed), but to the *payoff* of the instrument. As a recent example, we recall that the MiFID directive does not include simple forex instruments, such as forward contracts. At the current state of the art, it seems that the EMIR perimeter considers all interest rates, equity, forex and commodities, while simple forward operations are included only in the case of differential settlement. Regarding the *scope* of the deal, in some cases the EMIR constraints are not applicable. For instance, a deal arranged for economic, commercial or business reasons (e.g. a forex forward instrument underwritten to hedge an import/export invoice) can be excluded by the various pillars obligations. Besides, *the inter-company* deals are excluded from the regulation. As concerns the *eligible* definition, the boundary is stated taking into account the complexity of the payoff, i.e. the algebra of the maturity terminal payment, and the complexity of the underlying. Although this issue has not yet been solved, it is very likely that *forward/future* style derivatives and *fix-float* interest rate swaps will be in the eligible category. Regarding the market players that must apply the EMIR, specific obligations are prescribed for different operators, namely: *Financial Institutions* (banks, asset managers, funds), *Non Financial Corporations Plus* (NFC+ in the EMIR definition), and the others *Non Financial Corporations* (NFC)[6]. The EMIR requires that Pillars I and II are mandatory only for financial institutions and NFC+, while Pillar III is compulsory for all the market players. Obviously, some retail or private operators do not report their contracts to the trade repository since the financial

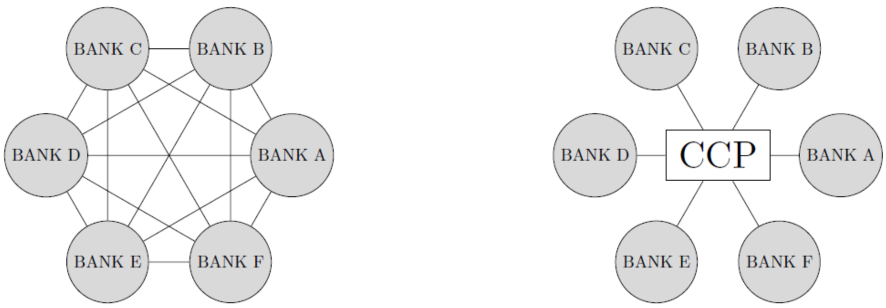
[5] See for instance: https://rtdata.dtcc.com/gtr/dashboard.do.

[6] The NFC+ are distinguished from the NFC according to a volume threshold; the volume is defined by the *gross notional value*, and it ranges from 1 to 3 billions of euros, separately for the different asset classes (equity, interest, Forex, credit, commodities).

institution, as counterpart in the contract, will submit both the deal data and the *mirrored* "customer side" data on behalf of him or her.

The Pillar I aims to reduce the credit counterparty risk of OTC derivatives by replacing the classical *peer-to-peer* relationships with the introduction of some robust *hubs*, such as the CCPs (see Fig. 1), which satisfy very strict requirements both in terms of capitalization and organizational constraints. In the EMIR regulation, the CCPs concept is broader than those of the traditional clearing houses hosted in the stock exchanges. However, all OTC clearing houses that match these requirements can ask for the registration[7].

Figure 1: From left to right the transition to a network with a CCP as a transaction hub



Moreover, one can wonder whether the new topology given by a CCP implies or not a decrease of the systemic risk. In fact a CCP reduces the default probability of the single exposure but it increases the loss given default effect. What happens when a CCP fails? What if one of its major clearing members defaults? Furthermore, if specific derivatives classes are cleared by many separate CCPs (see Duffie and Zhu, 2011), which is the impact on netting capacity and collateral demands?

The Pillar II aims to reduce the counterparty risk by collateral risk mitigation. Even though there are no doubts about to the effectiveness of the measure, from a business perspective a high collateral level with a frequent margining process could cancel the leverage effect. Hence, one of the main incentives to make a new deal might be hampered.

Finally, the Pillar III is meant to monitor the systemic risk, the market abuse, and to get more reliable derivatives statistics. This aspect will be discussed in the next paragraph.

The Trade Repository (TR). The trade repository aims to disseminate high quality data in order to depict a comprehensive picture of the market and to monitor the systemic risk and market abuse phenomena. The EU regulation 648/2012 states that this information is made available *"...to ESMA, the relevant competent authorities, the European Systemic Risk Board (ESRB) and the relevant central banks of the European System of Central Banks (ESCB)..."*. This means that these authorities are able to drill down any deal between counterparty A and counterparty B, exactly as reported by both counterparties A and B. Therefore, the Pillar III of the EMIR looks like the Pillar III of the Basel regulation, i.e. the *Disclosure* Pillar. Hence, regulators can access the highest level of granularity related to the exposures and the risks of the banks, depending on their mandates, while the other market participants can exploit only aggregated data by means of a set of standardized tables that banks are obliged to publish in their own website.

---

[7] Among them, in the IDEM (Italian Derivatives Market) in Milan the clearing house is the *Cassa Compensazione Garanzia*, while in the Eurexmarket in Frankfurt the clearing house is the *EC EurexClearing*, and so on.

From a practical point of view, the implementation of the TR is very detailed. First of all, banks and the others subjects do not report directly to the ESMA, as they are intermediated by some Trade Repository Services (TRs). In particular, the latter must register with the ESMA and the deadline for the activation of the reporting is 2014, February 12. Data are composed of two main categories: the specific *counterparty data* and the *common data* (e.g. trade date, notional, underlying data, collateral, etc.), i.e. a list of (26 + 59) = 85 variables (fields). Furthermore, existing contracts must be reported, along with all contracts with trade date after 2012, August 16 (when the EMIR came into force) as a *backload* process. Besides the EMIR regulation, the most important references for the TRs are the Delegated Regulations 148/2013 and 151/2013. By matching data provided by the two counterparties, the TRs will follow a *data quality* process to ensure the reliability of granular data as a preliminary requirement for the aggregated statistics.

Example 1 Given an equity option, if counterparty A reports a certain value for the *trade date* and for the notional *amount*, then for the same deal counterparty B should report the same values. If this is not the case, a warning will be issued, and the reporting entities could be penalized if they show a critical error rate.

Although the first step seems a trivial one, it is very hard to implement the “same deal” statement. Usually, each bank has its own position keeping system, and each deal receives in the system a progressive deal number *identifier*. In the past, no business reason suggested counterparties A and B to adopt the same identifier, as software and technological reasons made it very difficult and expensive.

Due to EMIR, in order to match and compare data before their publication, banks now must adopt several common identifiers and taxonomy codes. Among them, the most important are:

- *UTI, Unique Trade Identifier* (the deal identifier);
- *LEI, Legal Entity Identifier;*
- *UPI, Unique Product Identifier*.

The UTI allows the TR to match a deal between two counterparties: in principle, a given UTI value reported by A (where the counterparty is B) must exist in the data feed provided by B. Once the common UTI is detected, the TR verifies the other variables, most of them are not free text or numerical, although have to belong to a given domain. Regarding the LEI, there is the issue of managing the different branches of a group (i.e. it should be able to get the parental linkages) and of updating the reference data for counterparties in the internal bank database[8]. Therefore, it is very important to set up a cross reference integrity process. Finally, as concerns the UPI, a problem is related to the classification of deals with hybrid products, whose prevailing asset class is not always clear.

Example 2 The UPI defines a taxonomy of the derivative payoff. The financial industry has created over past decades a huge amount of clauses for the derivatives contracts. Banks have never applied the same classification, due to the different practices and position keeping platforms. For instance, does an *Asian option* written on an *equity basket* belong to the same family of an *Asian option* written on an *equity index*? Could an Asian strike option be included in the same category of an *Asian price option*?

[8] Banks have internal IDs for counterparties and often some external IDs, e.g. Bloomberg ticker, are linked to them.

The time frame of the report obligation to the TR is *daily*, i.e. any new deal is reported within one working day. In addition, the general 85-dimensions data requirement depends on the asset class of the deal, namely: interest, equity, forex, credit, commodity, and exchange traded derivatives (ETDs). To this extent, the inclusion of ETDs is a questionable issue. In fact, the ETDs data are already easily available from Stock Exchanges, indeed it is debatable their further transmission to the TRs.

More specifically, the European regulation 151/2013 designs three different levels of granularity: the *Transaction level*, the most detailed one, the *Position level*, with details by counterparty and product/underlying, and the *Aggregate level*, with details by product/underlying, but no counterparty information. The authorities and regulators can get the first two levels depending on their mandate, while the other market players will work only at the aggregate level.

Several TRs were registered to ESMA[9]. Consequently, a new layer of data management has to be created. To have an exhaustive picture of the derivatives market, one should extract the same data for a given category from all the registered TRs. Hence, some software vendors are developing tools and dashboards in order to collect different data sources in a homogeneous setting.

Anyway, in spite of the huge effort that the whole financial and ICT industry is performing to feed data, the TRs will undoubtedly give a lot of tractable empirical data along with new ideas and directions useful to define the systemic risk field. After a "phase-in period", we expect that the systemic risk research based on the TRs might slightly change the very heuristic approach to the systemic risk concerning the SIFIs Basel 3 regulation.

3.2 An Example on the Trade Repository Provision of Transaction Data

The introduction of TRs allows a wide audience of practitioners to work with more granular data. Typically, the BIS statistical reports constitute the reference for highlights of over-the-counter (OTC) derivatives markets[10], providing comprehensive and internationally consistent information on the size and structure of the largest OTC derivatives markets. In particular, since June 1998, semi-annual surveys focus on notional amounts outstanding and gross market values for forwards, swaps and options of foreign exchange, interest rate, equity and commodity derivatives, while as of end-December 2004 the BIS provides also data on credit default swaps for single and multi name instruments. From December 2011, the number of reporting countries is 13[11]. Although more information became available after the outbreak of financial markets, derivatives statistics arising from official releases underline the difficulty to depict a granular and up-dated picture of the system.

Both the EMIR in Europe and the Dodd-Frank Act in US aim to disclose a more detailed description of the derivatives markets. Even though only authorities are allowed to exploit the highest level of granularity provided by the TRs framework, market players still benefit from this flow of data through TRs services which collect deals from several platforms, leading also to the provision of public access to this information. In particular, in Europe the Commission Delegated Regulation No 151/2013 states in Art. 1 that TRs shall publish data (on a website or an online portal easily accessible by the public and updated at least weakly) showing a breakdown of the aggregate open positions, transaction volumes and values per derivatives classes (commodities, credit, FX, equity, interest rate, and other derivatives). In US,

---

[9] Six TRs are currently recognised by ESMA: *CME Trade Repository Ltd*., *DTCC Derivatives Repository Ltd*., *ICE Trade Vault Europe Ltd*., *Krajowy Depozyt Papierów Wartosciowych S.A*., *Regis-TR S.A*., and *UnaVista Ltd*. This list might be updated by any future registrations with ESMA.

[10] BIS statistics on derivatives markets are available at http://www.bis.org/statistics/derstats.htm. BIS provides also exchanged traded statistics from commercial data sources (see for instance: http://www.bis.org/statistics/extderiv.htm). Other sources of a wide range of statistics are ISDA and OCC. In particular, for the purposes of this section valuable references are available at http://www.swapsinfo.org/charts/derivatives/price-transaction and http://www.occ.gov/topics/capital-markets/financial-markets/trading/derivatives/derivatives-quarterly-report.html.

[11] Every three years addition jurisdictions participate in the *Triennial Central Bank Survey*. The latest survey took place at end-December 2013. Results are available at http://www.bis.org/publ/rpfx13.htm

the regulator (Part 43 of the CFTC's regulation) provides a mechanism for public access to real-time price information through *Swap Data Repositories* (SDRs) which are required to publicly disseminate swaps data *as soon as technologically practicable* after receiving the information (i.e. after execution), unless certain time delays[12]. Such rules cover any swap between two parties that determines a corresponding change in their respective market risk positions, as well as any amendments, assignment, novation, termination or other "price forming" life cycle event (see e.g. DTCC, 2014). This allows ICT industry to develop tools able to describe derivatives markets on a daily basis, thus providing risk dashboards for instruments, counterparty or maturity comparisons. In addition, since deals might be reported by means of different TRs, this in turns leads to the establishment of data services providers which collect information from many sources. Obviously, these tools do not allow to extract which banks are involved in the transactions as well as other confidential data since they represent exclusive information for authorities which are not provided for the general public. However, with respect to the BIS statistical releases, they introduce interesting improvements from several points of view: more frequent data, a more detailed partition of derivative instruments, information on netting agreements and collateral management, detailed data on market prices and volumes.

From a practical perspective, in US both market players and the general public can benefit from the provision of real-time data, while in Europe only aggregate information is publicly available. Both US and EU regulations require a wide set of contractual information by counterparties, but provide different levels of details for public statistics. As concerns systemic risk, in both cases authorities can exploit the highest level of granular data for assessing this risk. However, since we are interested in showing how the new regulatory framework on trade repositories strengthens the derivatives market description, we believe it is more valuable to focus on an example of the US public dissemination of transaction data. For the following analysis, we rely on data from the *GTRAnalytics* tool[13] (hereinafter GTRA). In particular, in our study we restrict the analysis to the interest rates derivatives market which at the end of June 2014 accounts for respectively the 81% and 77% of the global OTC derivatives market in terms of notional amount outstanding and gross market value. Finally, since the swaps market was worth $421 trillion compared with $563 of the total notional amount outstanding of the interest rate market[14], this motivates our choice to study the swaps segments as representative for the global OTC derivatives market.

Official statistics classify the OTC interest rate derivatives market according to reporting counterparties, residual maturities and currencies[15]. The implementation of TRs provides a detailed classification of swaps derivatives based on the types of contractual legs and maturities, thus allowing to analyse the swaps sub-markets separately. In particular, for each deal (identified by an ID) GTRA informs whether it is a new contract or a change of an existing one. It also specifies the asset class of the instrument and reports a set of information regarding contractual terms including: the execution time, the effective date and the contract expiry of the deal, the settlement and both the underlying assets currencies, payment frequencies, day count convention, and, obviously, the notional and the price. Moreover, GTRA gives useful information on clearing agreements and collateral positions which enrich the description of market trends and improve risk assessment. Finally, it is worthwhile to outline that we refer to prices and volumes of actual trade deals in the market which consequently extend the traditional use of indicative (bid/ask quotes showed by brokers or data providers) and consensus

[12] Actually, deals that would be subject to a time delay are block trades and large notional off-facility swaps.

[13] *GTRAnalytics* is a software developed by the consulting firm *IASON ltd*. Basically, this tool collects trades' information from several TRs and for many types of contracts, cleans up the database of manifest inconsistencies and errors and aggregates according to asset classes and deal types. This allows us to curtail potential biases due to data misreporting and fragmentation which arise from merging datasets of different TRs and among different regulations. Corrections on existing deals which amend or modify contractual terms are taken into account. For references see http://www.financial-machineries.com/gtr-analytics.htm.

[14] Data refer to BIS statistics and to single currency contracts only. For further references, see http://www.bis.org/statistics/derstats.htm.

[15] Reporting counterparties are: reporting dealers, other financial institutions and non financial customers; residual maturities are: up to 1 year, between 1 and 5 years, over 5 years; currencies are: US dollar, Euro, Yen, Sterling, Swiss franc, Canadian dollar, Swedish krona, other. Moreover, BIS provides also Herfindahl indices for all OTC interest rate derivatives contracts.

(quotes/prices submitted by market contributors) data.

The following descriptive statistics present a simple example of the information available thanks to the new regulatory framework. For simplicity, we run a daily trade analysis only for clusters of derivatives based on *Fix-to-Floating* swaps[16] from January to November 2014.

Tab 1: Percentage of deals grouped by settlement currency and contract expiry
(Source: our estimates based on GTRA data)

Contract Expiry	USD	EUR	MXN	GBP	JPY	Others
1y	18%	7%	22%	1%	2%	50%
2y	37%	8%	16%	3%	2%	35%
3y	55%	5%	14%	2%	1%	22%
5y	63%	6%	9%	3%	2%	17%
7y	61%	6%	16%	2%	6%	9%
10y	58%	9%	15%	4%	4%	10%
20y	49%	14%	7%	5%	21%	4%
30y	78%	13%	0%	6%	1%	1%

Tab 2: Monthly notional amounts (in billion of the respective currency) for selected settlement currencies
(Source: our estimates based on GTRA data)

Currency	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Ago-14	Sep-14	Oct-14	Nov-14
USD	1397.49	803.98	1486.38	1219.56	1218.38	1103.89	1108.82	1162.88	1714.17	1739.30	1100.16
EUR	346.78	175.21	277.10	143.34	143.39	196.48	116.50	124.59	242.60	189.82	134.09
GBD	69.51	50.32	54.23	33.79	39.48	41.62	36.23	33.91	55.06	49.45	31.90

Tab 3: Percentage of deals grouped by indication of clearing agreements and collateralization based on different contract expiry
(Source: our estimates based on GTRA data)

Contract Expiry	Clearing Agreements		Indication of Collateralization				
	Cleared	Un-Cleared	FC	OC	PC	UC	Null
1y	39%	61%	6%	4%	22%	27%	41%
2y	63%	37%	4%	4%	15%	21%	55%
3y	74%	26%	4%	4%	12%	17%	62%
5y	77%	23%	3%	6%	12%	16%	63%
7y	76%	24%	4%	5%	11%	15%	65%
10y	79%	21%	3%	6%	12%	14%	65%
20y	83%	17%	2%	3%	10%	14%	72%
30y	92%	8%	1%	8%	9%	13%	70%

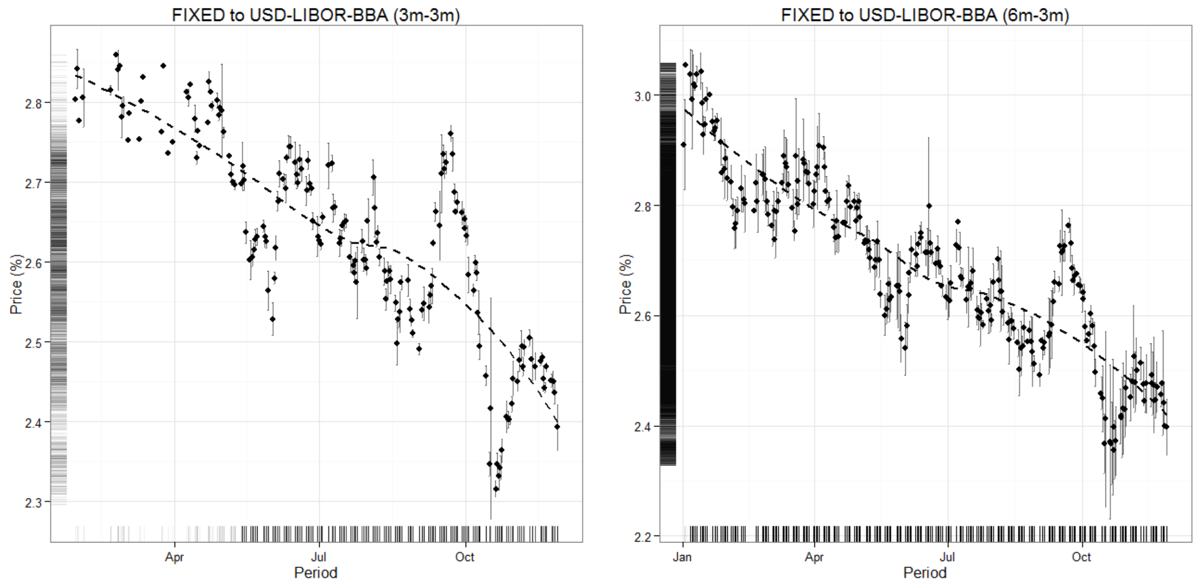
In the previous tables, we show how a swaps sub-market can be partitioned according to contractual terms. In addition, other classifications could combine these features or focus on the several underlying assets which characterise the swaps market. Since official statistics are usually collapsed in few basic classifications, a more detailed representation might contribute to detect which parts of the market shows critical patterns. Moreover, since gross market values indicate that contracts with positive and negative replacement values with the same counterparty are not netted, then the introduction

[16] In order to focus only on the new effective operations, we consider deals for which "*Action*" is equal to "*New*" and "*Price Forming Continuation Data*" is "*Trade*". For conciseness, we report only deals for which "*Contract Start*" is equal to "*Spot*" and we omit similar statistics for other types of swaps such as *OIS*, *Basis* and *Fix-to-Fix* instruments (GTRA provides also detailed information on *FRAs*, *CAPs* and *FLOORs*, and *SWAPTIONS* which go beyond our scope here). Finally, in this part we do not make distinctions among the possible underlying assets.

of clearing agreement might shed light on the actual exposures. Similarly, the presence of collateral information might enforce the overall perception of risk positions, thus providing a more realistic description. Finally, it is worth emphasizing that we can further refine the research with respect to daily or intra-daily deals. Therefore, since the recent financial crisis underlines the importance of derivatives market as a channel for the spread of trigger effects, these simple examples contribute to claim how a more detailed picture might improve on an almost real-time basis the awareness of which swaps sub-markets present systemically important patterns, thus facilitating risk assessment.

In particular, the use of traded prices and volumes allows to measure market liquidity for categories of instruments and expiry dates. For instance, although market participants always need some reference fixings for actively traded contracts, in some cases they are only based on indicative prices shown on brokers' pages. Indeed, TRs data might reveal that some markets are quite scant and that indicative quotes give a false sense of liquidity. As regards systemic risk, TRs might therefore provide information on whether OTC derivatives market are locally (where locally does not refer to regional classifications, but to clusters based on type of instrument, maturity, underlying, etc.) illiquid, thus for instance pointing to fire sale issues that represent a mechanism through which contagion effects propagate (see e.g. Diamond and Rajan, 2011). In the following example, we use basic statistics to show how swaps sub-markets can differ in terms of liquidity. We limit the analysis on the set of *Fix-to-Floating* swaps with underlying asset equal to *USD-LIBOR-BBA* which represents the most significant subset in our dataset. Below, we focus on the most relevant legs frequencies partitions[17]. In particular, for each date we plot both the average price[18] and the respective error bar of the traded deals, while along the axes we show the rug plots for both the number of deals and prices. Hence, in order to facilitate the representation of prices dispersion around the average values, for each date we compute the upper and lower levels of the error bar by respectively adding and subtracting the corresponding standard deviation from the mean value.

Figure 2: Daily mean prices and their respective dispersions for Fixed to USD-LIBOR-BBA swaps with different leg frequencies (left plot 3m-3m,right plot 6m-3m) (Source: our estimates based on GTRA data)

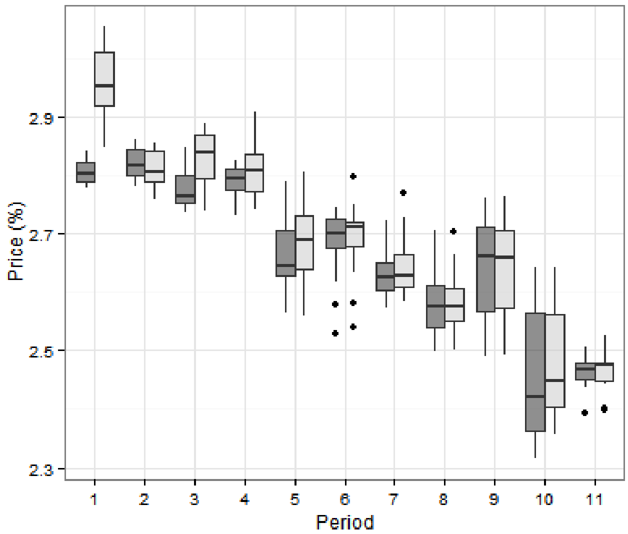


[17] Although one could perform the same study using a wide range of contractual terms, we limit our analysis on instruments with "*Contract Expiry*" equal to "*10y*". In order to limit potential biases due to outliers, for each instrument we cut off 0.025 of the area in each tail of the reference sample distribution.

[18] In a plain vanilla interest rate swap two counterparties, a floating-rate payer and a fixed-rate payer, agree to exchange net payments, computed with respect to a notional principal amount, at a series of future points of time. In the examples, we refer as *price* as the *fixed* rate at which counterparties find fair to exchange net flows.

Previous examples aim to show swaps sub-markets liquidity differences. Although it represents a simple way to investigate prices dispersion, the use of the mean-standard deviation framework still allows market players to disentangle which parts of the swaps market show critical patterns. In both cases, prices' dispersions undergo significant changes during the reference sample, with periods of relative concentrated prices alternated by more volatile intervals. In addition, the following plot show how their prices' behaviours can be compared to study swap sub-markets' peculiarities. Although both instruments present a similar trend, the provision of detailed transaction data reveals monthly differences. Therefore, by combining the information from prices' volatility with the amount of traded deals one might investigate market stress scenarios for specific swaps sub-markets. This might suggest a relationship between the emergence of illiquidity conditions in specific and important markets and the risk of spill over effects which ultimately might lead to a worsening for the entire system.

Figure 3:Box plot of monthly mean prices for Fixed to USD-LIBOR-BBA swaps with different leg frequencies (grey = 3m-3m, light grey = 6m-3m) (Source: our estimates based on GTRA data)



From a risk management perspective, the provision of detailed data helps banks to perform properly portfolio valuation and manage the *model risk*. In the recent market practice a new acronym was created, i.e. *XVA*, to indicate all the *valuation adjustments* in the OTC derivatives markets. More explicitly, XVA stands for CVA (credit counterparty risk adjustment), DVA (debt valuation adjustment, the same of CVA but with the opposite sign), FVA (the *funding-liquidity* valuation adjustment), and KVA when it indicates the CVA Basel III capital requirement. Indeed, a more detailed flow of data might support banks to satisfy the upcoming requirements related to the *additional valuation adjustment* (AVA), which introduce a prudential assessment for those positions measured following a fair value approach. Moreover, the integration with internal databases allows banks to compute their relative competitive levels for types of instruments, facilitating therefore concentration measurement. In particular, the availability of detailed transaction data improves historical and market activity analysis useful to assess the parameter risk arising from the revaluation process of the derivatives book. Finally, the use of traded data prevents market manipulation phenomena, thus enhancing a realistic description of financial systems. Indeed, from our point of view, it seems that this flow of information is of a higher level of detail and quality than that of some risk dashboards utilized by supervisors to measure systemic risk on the basis of aggregate variables[19].

[19] See for instance the *Composite Indicator of Systemic Risk* (CISS) developed by the *European Systemic Risk Board* (ESRB) which includes 15 raw, mainly market-based financial stress measures.

4 Conclusion

The financial crisis in 2007-2008 highlighted the relevant role of the systemic effects of the single entities' defaults on the stability of the whole financial system. For this reason, the new regulatory framework adopted a methodology in order to face this risk, called systemic risk. However, in spite of the large amount of literature on this topic, the approach proposed by the scientific community is still heuristically based on some indicators and quite far from being a proper quantitative technique.

In this work, we draw an organic picture of the current regulations, moving from the definitions of systemic risk to the issues concerning data availability. In particular, we discuss how the implementation of *Trade Repositories* improves data collection and makes available more granular information useful to measure systemic risk. We are confident that the provision of more detailed transaction data will support regulators' risk assessment and facilitate market players' observance of regulatory requirements. In addition, we believe that a more detailed flow of data on traded deals might contribute to enhance some systemic risk features taken into account only partially in the past. Our analysis shows how the new regulations allow to describe OTC derivatives markets according to detailed partitions, thus depicting a more realistic picture of the system. Therefore, this might motivate the study on whether sub-markets illiquidity conditions determine the risk of spill over effects which ultimately might lead to a worsening for the entire system. Consequently, since the recent financial crisis generated from the derivatives markets was due to both credit and liquidity drivers, the capability to exploit jointly prices' and volumes' liquidity effects gives a new powerful tool to analyse the systemic features of these markets.

Acknowledgment

Authors wish to thank *Iason ltd* for having made the dataset available. Special thanks go to A. Castagna for his precious collaboration.

References

Acerbi, C., and Tasche, D., (2002), "On the coherence of expected shortfall", *Journal of Banking and Finance*, 26 (7), 1487-1503.

Bastos, E., Cont, R., Minca, A., and Moussa, A., (2009), "Too interconnected to fail: measuring systemic risk in financial networks", *Proceedings of the Conference on Quantitative Risk Management*, Paris VII University.

BCBS (Basel Committee on Banking Supervision), (2013), "Global systemically important banks: updated assessment methodology and the higher loss absorbency requirement", BCBS paper 255, Bank of International Settlements.

Billio, M., Getmansky, M., Lo, A. W., and Pelizzon, L., (2012), "Econometric measures of connectedness and systemic risk in the finance and insurance sectors", *Journal of Financial Economics*, 104, 535-559.

Bisias, D., Flood, M., Lo, A.W., and Valavanis, S., (2012), "A Survey of Systemic Risk Analytics", *Office of Financial Research*, Working Paper 0001.

Bonollo M., Crimaldi I., Flori A., Pammolli F., Riccaboni M. (2014a), "Systemic Importance of Financial Institutions: regulations, research, open issues, proposals", *EIC working* paper series #2/2014, IMT Institute for Advanced Studies, Lucca.

Bonollo M., Crimaldi I., Flori A., Pammolli F., Riccaboni M. (2014b), "Systemic Importance of Financial Institutions: From a Global to a Local Perspective? A Network Theory Approach", *EIC working* paper series #9/2014, IMT Institute for Advanced Studies, Lucca. (Available Italian version, forthcoming in *Bancaria*).

Cont, R., Moussa, A., and Bastos e Santos, E., (2010), "Network structure and systemic risk in banking systems", Working Paper available at SSRN: http://ssrn.com/abstract=1733528

CRMPGIII (Counterparty Risk Management Policy Group), (2008), "Containing Systemic Risk: The Road to Reform", Annual Report.

De Bandt, O., Hartmann, P., and Peydro, J.L., (2009), "Systemic risk in banking: An update", In: Berger, A.N., Molyneux, P., Wilson, J., et al. (Eds.), *Oxford Handbook of Banking*, Oxford University Press, Oxford.

Diamond, D. W., and Rajan, R. G., (2011), "Fear of Fire Sales, Illiquidity Seeking, and Credit Freezes", The Quarterly Journal of Economics, 126 (2), 557-591.

DTCC (Depository Trust & Clearing Corporation), (2013), "Beyond the Horizon, A White Paper to the Industry on Systemic Risk", DTCC white paper.

DTCC (Depository Trust & Clearing Corporation), (2014), "DTCC Data Repository (U.S.) LLC Rulebook", Rulebook revised as of 10/03/2014.

Duffie, D., and Zhu, H., (2011), "Does a Central Clearing Counterparty Reduce Counterparty Risk?", *The Review of Asset Pricing Studies*, 1 (1), 74-95.

ECB (European Central Bank), (2010), "Financial networks and financial stability", Financial Stability Review.

Embrecht, P., Resnick, I., and Samorodnitsky, G. (2013), "Extreme Values Theory as a Risk Management Tool", *North American Actuarial Journal*, 3(2).

ESMA (European Security Market Authority), (2013), "Questions and Answers on EMIR", ESMA paper 2013/1080.

European Commission, (2013), "Delegated Regulation on the minimum details of the data to be reported to trade repositories", Delegated Regulation 148/2013.

European Commission, (2013), "Delegated Regulation on the data to be published and made available by trade repositories and operational standards for aggregating, comparing and accessing the data", Delegated Regulation 151/2013.

European Union Parliament, (2012), "European Market Infrastructure Regulation", Regulation 648/2012.

FSB (Financial Stability Board), (2010), "Reducing the moral hazard posed by systemically important financial institutions". Working paper available at http://www.financialstabilityboard.org/wp-content/uploads/r_101111a.pdf?page_moved=1.

IMF (International Monetary Fund), BIS (Bank for International Settlement), and FSB (Financial Stability Board), (2009), "Report to G-20 Finance Ministers and Governors. Guidance to Assess the Systemic Importance of Financial Institutions, Markets and Instruments: Initial Considerations", available at http://www.bis.org/publ/othp07.pdf.

Nier, E., Yang, J., Yorulmazer, T., and Alentorn, A., "Network models and financial stability", *Journal of Economic Dynamics and Control*, 31, 2033-2060 (2007), and *Bank of England Working Paper* 346, (2008).

Strahan, P.E., (2013), "Too Big to Fail: Causes, Consequences, and Policy Responses", *Annual Review of Financial Economics*, 5, 43-61.

US 111th Congress, (2010), "Dodd-Frank Wall Street Reform and Consumer Protection Act", Public Law 111-203.

Sitography

BIS (Bank of International Settlements). OTC derivatives statistics. Available at http://www.bis.org/statistics/derstats.htm.

BIS (Bank of International Settlements). Exchanged traded statistics. Available at http://www.bis.org/statistics/extderiv.htm.

BIS (Bank of International Settlements). *Triennial Central Bank Survey*. Available at http://www.bis.org/publ/rpfx13.htm.

DTCC (Depository Trust & Clearing Corporation). Trade reporting repository. Available at https://rtdata.dtcc.com/gtr/dashboard.do.

ESRB (European Systemic Risk Board). ESRB risk dashboard. Available at https://www.esrb.europa.eu/pub/rd/html/index.en.html.

GTRAnalytics. Trade repository tool. Available at http://www.financial-machineries.com/gtr-analytics.htm

ISDA (International Swaps and Derivatives Association). Derivatives statistics. Available at http://www.swapsinfo.org/charts/derivatives/price-transaction.

OCC (Office of the Comptroller of the Currency). US derivative statistics. Available at http://www.occ.gov/topics/capital-markets/financial-markets/trading/derivatives/derivatives-quarterly-report.html.

Institutions
Markets
Technologies
IMT
INSTITUTE FOR ADVANCED STUDIES LUCCA

Piazza San ponziano 6, 5100 Lucca, Italy. www.imtlucca.it