Network models, stress testing, and other tools for financial stability monitoring and macroprudential policy design and implementation

November 11 and 12, 2015.
Mexico City

Manuel Ramos-Francia[1]

Opening Remarks

- Good morning. It is my pleasure to give everyone a warm welcome to our conference: "Network models, stress testing, and other tools for financial stability monitoring and macroprudential policy design and implementation." I would like to thank all, and in particular those researchers and policy makers that have come from abroad, for sharing your knowledge and insights with us. I would also like to express my gratitude to the organizers: CEMLA, the University of Zürich, the Journal of Financial Stability and, the host, the Banco de México, more specifically, its Financial Stability Division.

- At least since the times of Walter Bagehot, the importance of financial systems was well understood.[2] Mr. Bagehot knew the advantage the English economy had over other ones due to its financial system. England´s unprecedented economic growth at the time was possible due to its advanced financial system, which gathered capital and allocated it where it had the best investment opportunities.

- In effect, financial systems bring about enormous benefits. For instance, their participants have significant gains as they are able to smooth their incomes through time and states of nature in ways they would have been but only a remote possibility under the absence of such systems. ***Notwithstanding their benefits, financial systems link us in ways that can lead to significant costs under certain contingencies***.

[1] I would like to thank Santiago García-Verdú for his insightful comments and suggestions.

[2] Walter Bagehot lived from 1826 to 1877 in England. In 1860, he became editor-in-chief of The Economist. He is the author of "Lombard Street: A Description of the Money Market," among other books.

- Such contingencies can come about for a plethora of reasons. Perhaps, at a basic level, while we are wired for languages, as has been underscored, for example, by Chomsky, we are not so for numbers, let alone for probability, as we have been reminded, for instance, by Taleb.[3] At a more general level, and being part of our concern today, we seek to understand **how, when, and why** financial systems can go wrong, in short, about their stability, and what can be done to avoid, and to deal with such contingencies, possibly through the implementation of macro-prudential policies.

- The conference features as two of its main tools **1) Networks Models** and **Stress Testing**, and **2) Macro-prudential Policy,** as its main subject matter. These tools have become the workhorses for researchers and policy makers to gain a deeper understanding of the referred contingencies. Of course, macro-prudential policy has gained unprecedented impetus in the aftermath of the global financial crisis.

- One could argue that the study of networks started with the Königsberg bridge problem solved by Euler in 1736, all the way to the more recent and, until a few years ago, elusive four-color map theorem.[4,5,6] Naturally, today there are many notable researchers studying networks.

- **Networks** allow us to better understand how different entities, be them, for example, financial institutions or economies, **interact** in a financial system with each other. Also, they shed light upon what has been called the **cross-sectional dimension** of systemic risk.

---

[3] See, respectively, Chomsky, N. (1965). "Aspects of the Theory of Syntax." MIT Press, and Taleb, N.N. (2005). "Fooled by randomness: the hidden role of chance in life and in the markets." New York. Random House.

[4] The city of Königsberg in Prussia (presently Kaliningrad, Russia) was crossed by the Pregel River. The river had two islands that were connected to each other and to the rest of the city by seven bridges. The problem at hand was to find a path walking through the city such that: it would cross each bridge only once; the islands could only be reached by the bridges; once a bridge was entered it had to be crossed; and, the starting and finishing points could be different. Euler proved that the problem had no solution.

Euler, L. (1736) "*Solutio problematis ad geometriam situs pertinentis*." Comment. Acad. Sci. U. Petrop. 8, 128-140. Reprinted in Opera Omnia Series Prima, Vol. 7. pp. 1-10, 1766.

[5] The four color map problem can be stated as follows. Given any separation of a plane into contiguous regions (i.e., what one could call a map), it takes no more than four colors to color the regions of the map so that no two neighboring regions have the same color.

[6] See for example, Appel, K and W. Haken (1977). "Solution of the Four Color Map Problem." *Scientific American* 237 (4): pp. 108–121

- **Stress Testing** has proved to be a very powerful tool as well. One could argue that it started with simulation.[7] Three years before Euler´s paper was published, the Count of Buffon posited his needle problem, which conceivably was the predecessor to simulation as a subject.[8] Yet, it was not until Ulam and Metropolis published their 1949 paper that simulation was formally introduced.[9]

- Certainly, it has come a long way since then. **Simulation,** and more generally **Stress Testing**, one could argue, have given us the closest to an experiment in finance as one could have.[10] Moreover, the use of **Stress Testing** has increased and, in tandem, has been adopted or endorsed by institutions like the Prudential Regulatory Authority (PRA), the European Banking Authority (EBA), central banks, including the Bank of Mexico, and various Councils of Financial Stability, where many financial authorities intersect.[11,12]

- **Macro-prudential policy** is, in a sense, a young subject. Let me quote Xavier Freixas and co-authors (2015) on the subject. *"…there is much confusion about what constitutes **macro-prudential policy** and little agreement about how to operationalize it, in part because its objective is not clearly defined, and in part because there is scarce historical experience about the use of macro-prudential tools to gauge their effectiveness and calibration.*"[13]

---

[7] Models such as Ramsi from the Bank of England´s, and the Systemic Risk Monitor from the Central Bank of Austria are based on simulation. Of course, stress testing has relied on other methodologies as well.

[8] Buffon´s needle problem was originally conceived as a geometric probability problem. Yet, it allows one to estimate π by simulation. Buffon, G. (1733). "Editor´s note concerning a lecture given 1733 by Mr. Le Clerc de Buffon to the Royal Academy of Sciences in Paris." Histoire de l´Acad. Roy. des Sci., pp. 43-45.

[9] Metropolis, N. and S. Ulam (1949). "The Monte Carlo Method." *Journal of the American Statistical Association*, Vol. 33, No. 247, pp. 335-341.

[10] Of course, this might be up to a debate. On the one hand, e.g., Campbell, Lo and MacKinlay (1996) characterize finance as a non-experimental subject (Campbell, Lo and MacKinlay (1996). "The Econometrics of Financial Markets." Princeton University Press.) On the other, one could argue that this has changed with the development of experimental economics and finance as subjects. See, e.g., Chamberlin, E. H. (1948). "An Experimental Imperfect Market." *Journal of Political Economy*, 56(2), 95-108.

[11] The Prudential Regulation Authority (PRA) was created as a part of the Bank of England. It is responsible for the prudential regulation and supervision of banks, credit unions, insurers and major investment firms.

[12] For example, the Financial Stability Board endorses the use of Stress Testing. See, e.g., FSB (2015) "Press release of the Meeting of the Financial Stability Board in London." September 25.

[13] Freixas, X., L. Laeven and J.L. Peydró (2015). "Systemic Risk, Crises and Macroprudential Policy." MIT Press.

- This quote, I think, highlights one of the reasons why we are gathered here today: that is, is to learn from each other so as to substitute for the scarce historical experience. By the same token, we as policy makers need the best possible theoretical support for the decisions we take. Of course, this also underscores the need for financial institutions, including central banks, to maintain close links with researchers as yourselves.

- It is worthwhile to consider a more general context. Previous to the global financial crisis, the perception existed that the micro-prudential approach was sufficient to deal with the market failures prevalent in the financial sector which were then recognized. **Three of the most prominent ones are:**

  ✓ **Adverse selection;**
  ✓ **Moral hazard; and,**
  ✓ **Limited liability.**

  Most importantly, though, was **the perception that supervising and regulating financial institutions at an individual level was sufficient to achieve financial stability.**

- Next, let me point out the following episodes from the **economic profession** which I think reflect the **general feeling prior to the global financial crisis.**

  ✓ **First**, **Lucas** in his 2003 presidential address to the American Economic Association, declared that the "…***central problem of depression-prevention has been solved****, for all practical purposes,* […]"
  ✓ **Second**, **Bernanke**, in a speech in 2004 explaining the possible factors behind the "Great Moderation", stated: "…*The increased depth and* ***sophistication of financial markets***, ***deregulation*** *in many industries, […], and increased openness to trade and* ***international capital flows*** *are […] examples of structural changes that may have increased* ***macroeconomic flexibility and stability***."[14]
  ✓ **Third**, the response to **Rajan´s** speech at the Federal Reserve Bank of Kansas City in August 2005. His answer to the question "Has Financial

[14] The term was coined in Stock, J. and M. Watson (2002). "Has the business cycle changed and why?" NBER Macroeconomics Annual. The cited speech is: Bernanke, B. (2004). "The Great Moderation". February 20: Source: federalreserve.gov.

Development Made the World Riskier?" was essentially yes. Back then, **he was severely criticized**.[15]

- ✓ **Fourth**, **Blanchard stated in an interview** "…*Before I came to the Fund, I thought of* ***the financial system as a set of arbitrage equations.*** *Basically the Federal Reserve would choose one interest rate, and then the expectations hypothesis would give all the rates everywhere else, with premia which might vary, but not very much.* ***It was really easy***."[16]

- **Moreover, let me draw the following analogy**. As known, individual monetary policies interact on what is known as the International Monetary System, in which countries are expected to follow a set of rules.[17] Prior to the crisis, many had the perception "…*that if each country maintained an adequate and orderly set of economic policies, then the rest of the world economy would take care of itself. […] At most, only a continuous exchange of information was really needed in order* ***to maintain economic and financial stability*** […]."[18]

- Thinking that the micro-prudential approach will be sufficient to procure **financial stability is somewhat analogous** to think that "…if each country [in this case a bank] maintained an adequate and orderly set of economic policies, then the rest of the world economy [the banking system in this case] would take care of itself."

- Needless to say, the global financial crisis shattered these perceptions. Indeed, the importance of **other market failures** has been recognized, as well as the market failures mentioned above. Let me underscore some of the most prominent issues:

[15] Rajan, R. (2005) "Has Financial Development Made the World Riskier?" Paper presented at the Federal Reserve Bank of Kansas City Economic Symposium on The Greenspan Era: Lessons for the Future.
[16] Blanchard joined the Fund in September 2008, just before the Lehman collapse. Reference: Wesel (2015). "Olivier Blanchard's Five Lessons for Economists from the Financial Crisis," WSJ, April 1.
[17] Needless to say, there is no authority which could strictly enforce these rules.
[18] This concept was called the house-in-order doctrine by Padoa-Schioppa. For example, see Ramos-Francia and García-Verdú (2012). "Cooperation among Central Banks during Crises: Lessons from the Recent Experience." Conference Volume: "Conferencia Conmemorativa del 60 Aniversario del CEMLA: La Cooperación entre Bancos Centrales a Principios del Siglo XXI."

a. The **originate to distribute credit** scheme;
b. The **too big to fail**, **Systemically Important Financial Institutions (SIFIs), and Global Systemically Important Banks (G-SIBs)** concepts.
c. The incentives to **increase leverage** in some institutions, e.g. investment banks, certainly beyond what is socially optimal.
d. The structure of **executive compensation,** which in some cases leads them to take on too much risk.[19]
e. The **huge atomization and inefficient reporting and information disclosing** in some financial markets, which in case of a shock leads to insufficient knowledge about where risks lie and of their magnitude.
f. The pro-cyclicality of capital.
g. An overreliance on credit agencies which, as has been argued, do not have the proper incentives to act efficiently.

- **Given enough time and some triggering shock to one or various of the factors above in the case of one or more financial institutions, what can make this a systemic issue are the *interconnections* in the financial system**. It could come through different channels, e.g., depending on the institution´s size, and specialization, among others.[20]

- Moreover, there are also some **macroeconomic** issues. For instance, the search-for-yield phenomenon, in which global asset management companies face significant pressure to obtain returns under an environment of very low interest rates in AEs. This has contributed to significant capital flows in and out of EMEs, which may very well turn to be a systemic risk factor.

- Accordingly, some **macro-prudential policy tools and regulations** have emerged, while others have regained their luster. Allow me to mention some of the most noteworthy ones, which can be classified in the following groups (Claessens, 2014).[21]

[19] In effect, in Rajan (2005, p. 315) argues that "changes in the financial sector altered managerial incentives, which in turn have altered the nature of risks undertaken by the system, […]."
[20] At a firm level, it makes a potential liquidation process too slowly to be efficient. At a more general level, it makes risk harder to understand and thus to supervise and regulate.
[21] Claessens, S. (2014). "An overview of macroprudential Policy Tools." IMF Working paper.

1. **Restrictions on borrowers**; e.g., loan to income, debt to income, and loan to value ratios, lending to sectors, and credit growth.
2. **Restrictions on financial sector balance sheets**; e.g., reserve requirements, liquidity coverage ratio, and total loss absorbing capacity.[22]
3. **Capital provisions and surcharges;** e.g., countercyclical capital requirements, leverage restrictions, and capital surcharges associated with systemic risk.
4. **Taxation/Levies**; e.g., taxation on specific assets and or/liabilities, and as a function of externalities.
5. **Others**; e.g., accounting practices, executive compensation, corporate governance, information depositories, central counterparties clearing houses, and resolutions.[23]

- As a result, **the macro-prudential approach to risk management** has gained a central role. Yet, it is crucial to acknowledge that we are in its initial stages. Naturally, some essential questions arise:

  a. How **effective are macro-prudential regulations**?
  b. How do **macro-prudential regulations interact with each other and with other policies**?
  c. Have we moved the **regulation pendulum too far**?
  d. What are the **unintended consequences** of the new regulations, for both AEs and EMEs?

  among other pertinent questions.

- In this context, this conference will touch upon some of the **specific tools** that have been developed to try measuring systemic risk such as **Networks** and **Stress Testing**, and other tools to monitor **financial stability**, as well as **particular aspects** of **Macro-prudential policy and design**.

- **Against this backdrop, let me then *briefly* comment on some of the papers that will be presented at the conference.** I apologize in advance to those authors which I will not mention for the benefit of time. The conference includes two keynote sessions, and eight ordinary ones.

- I am sure Professor Sanjeev Goyal and Professor Xavier Freixas will have much to say about the key issues at the frontier of knowledge on these

[22] These increase their risk absorption capacity.
[23] These improve risk distribution and its monitoring.

subjects, and I believe everyone is very much looking forward to their respective keynote sessions.

- As a general overview, it is useful to group the ordinary sessions as follows:

  ✓ **In terms of policy: the first and sixth sessions** assess **Macro-prudential Policy** design and evaluation, respectively**,**
  ✓ **In terms of methodological tools**: **the third, fourth and fifth sessions** cover **Financial Networks** and **Stress Testing**;
  ✓ **In terms of subjects**: the **second and seventh sessions** examine **Systemic Risks**, while the **eighth session** takes a look at **Financial Stability**.

  In my comments next, I will follow this order.

- **In terms of policy**:

  ✓ **The first session is titled:** "Macro-prudential Policy Design". **In one of its papers, Christoph Aymans and co-authors** propose "Macro-prudential policies for controlling the Basel cycle." While we commonly think about the trade-off between economic growth and systemic risk, or between excess returns and volatility, **they explore the trade-off between micro-prudential and macro-prudential risks**, **giving some clues about their interaction.**

  ✓ The **sixth session** covers "Macro-prudential policy evaluation" with two papers. My friend and grad schoolmate **Dimitrios Tsomocos and co-authors** ask "How does macro-prudential regulation change bank credit supply?" They examine an extension of the celebrated Diamond-Dybvig (1983) model, in which savers can use a bank to invest in a risky project operated by an entrepreneur.[24] As they explain, in their model, the bank and the entrepreneur face limited liability and there is a possibility of a run which depends on the bank´s leverage, and the mix of safe and risky assets. The possibility of the run reduces the incentive to lend and take risk, while limited liability pushes for excessive lending and risk-taking. The authors explore how several regulations interact to affect the frictions in their

[24] Diamond and Dybvig (1983). "Bank runs, deposit insurance, and liquidity." *Journal of Political Economy* 91 (3): 401–419.

model, **providing some answers to the question on how macro-prudential regulations interact**.[25]

Srobona Mitra and co-authors contribute by: "Evaluating the net benefits of macro-prudential policy: A cookbook." In their paper, they propose a framework for assessing the net benefits of macro-prudential policies in terms of the following: the probability of a crisis, the loss in output given a crisis, policy effectiveness in bringing down both the probability and damage during a crisis, and the output-cost of a policy decision. **These elements are relevant to be able to rank different policies.**

- **In terms of methodological tools**:

  - ✓ **The third session** explores "Contagion Risk in Financial Networks." The paper by **Marco d'Errico and co-authors** titled "passing the hot potato: how does credit risk flow in the CDS market?" describes how credit risk flows by exploring the network structure of the CDS market. They analyze the flow of risk in the network in terms of fundamental credit risk and counterparty credit risk.[26] **This facilitates to monitor risk and its distribution more reliably, in a network in which risks do not flow in a simple way.**

  - ✓ **The fourth session** is called "Structural Properties of Financial Networks." In one of its papers, titled "Measures of financial network complexity, a topological approach" **Mark Flood and co-authors** present a definition of complexity in financial networks, and argue about its relevance. **Measuring complexity consistently through time and across financial networks is no small feat, yet it is relevant for both monitoring and regulation purposes.**

  - ✓ **The fifth session** covers "Stress Testing" with two papers. First, **Kartik Anand and co-authors** propose "Quantifying contagion risk in funding

[25] The regulations they consider are: capital regulation, liquidity regulation, deposit insurance, loan to value limits, and dividend taxes.

[26] As one of their main results, the authors explain that they find that the CDS network structure displays a bow-tie topology. As they describe: in it a set of *ultimate risk sellers* sell credit risk only to a set of strongly connected dealers. The dealers then pass on the risk to one another in a dense sub-network. Eventually, dealers sell risk to a set of *ultimate risk buyers* consisting mainly of asset managers and banks. Graphically, they explain, this network resembles a bow-tie.

markets: A model-based stress testing approach." They put forward a model-based stress-testing framework in which banks´ solvency risk, funding liquidity risks, and market risks are interweaved. **Such an approach is central to understanding the cross-effects of risk factors in banks.**

Mark Paddrik and co-authors present "A system-wide stress testing of the CDS market." They argue that supervisory stress testing typically focuses on the resilience of large banks to tolerate the direct effects of a credit shock. Nonetheless, for example, they find that the indirect effect of the largest counterparty´s failure on the bank´s other counterparties could be significant in many cases, **highlighting the importance of second round effects when performing stress testing.**

- **In terms of subjects**:

  ✓ **The second session** is named "Financial Interconnectedness and Systemic Risk." It includes the following two papers: **Rodney Garratt and co-authors** seek "The missing links: A global study on uncovering financial network structure from partial data" by performing a horse race between different methods that reconstruct networks based on partial data. They use a rich cross-sectional database. **Their study sheds light on the performance of different methodologies to estimate a financial network structure, and thus measure systemic risk more efficiently**.

  Stefano Battiston and co-authors explore the "Interconnectedness as a source of uncertainty in systemic risk." They study how the structure of networks can impair the capacity of regulators to assess the level of systemic risk. **Thus, interconnectedness, while having well-known benefits, in this context, it is seen as a drawback when monitoring systemic risk.**

  ✓ **The seventh** session reviews "Systemic risk and SIFIs." In one of the papers: **Doyne Farmer and co-authors** study "The intra-firm complexity of systemically important financial institutions." While the SIFIs designation is based on "size, complexity, and systemic interconnectedness," less attention has been paid to a firm´s "complexity." They measure the complexity of a financial institution by using the

structure of an individual firm´s control hierarchy as a proxy.[27] **They explore an aspect of financial institutions that was overlooked in the past, and is now deemed relevant, for example, in terms of a possible resolution.**

- ✓ **The <u>eighth</u>** session closes with "Financial Stability" and includes the paper: "Is trouble brewing for EMEs?" written by **Santiago García-Verdú and myself**, in which we study the possible presence of **run-like dynamics in bond flows to and from EMEs.** These dynamics are motivated by the existence of an agency problem in global asset management companies, their consequent aversion to being ranked last, and the size of the assets under their management relative to EMEs financial markets. **This type of incentives for capital managers could have financial stability implications. All in all, this is one of the main policy dilemmas presently being faced by EMEs.**

  Finally, **Juan Solé and co-authors** use the Financial Accounts of the US to obtain time series of bank and nonbank credit to different sectors, and to examine the cyclical behavior of these series in relation to (i) the long-term business cycle, (ii) recessions and recoveries, and (iii) systemic financial crises. Among other things, they describe that bank and nonbank credit display different dynamics throughout the business cycle. **Such characterization could ease the implementation of credit growth restrictions at a more granular level.**

- To **conclude**, let me add one final comment. Let us not forget that these are all means to an end. Research is important to society not only for the sake of knowledge *per se*, but also to the extent to which such research allows us to have more stable financial systems which will promote economic growth, and let our societies flourish.

- Without further ado, let me congratulate all for your laudable efforts, and cede the floor to Professor Sanjeev Goyal.

[27] The control hierarchy the authors used is a network representation of the institution and its subsidiaries.