Toward a Framework for Macroprudential Regulation and Supervision of Systemically Important Financial Institutions (SIFI)

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24-12-10

Abstract – One of the key features of regulatory-supervisory reform thinking post 2006-2007 Global Financial (nee US Subprime Mortgage) Crisis is emergence and popularisation of the ‘systemic’ theme. In a similar vein, talks of ‘too interconnected to fail’ superseding ‘too big to fail’ widely circulate. Yet a coherent framework for defining, identifying, and quantifying what constitutes so-called Systemically Important Financial Institutions (SIFI) is sorely lacking. Presented in a Q&A format, this article attempts to pave the way toward formulating and formalising a framework for macroprudential regulation and supervision of such entities.

Why are we talking ‘systemic’ all of a sudden?

Prior to the global financial (nee subprime) crisis of 2007, bank regulators/supervisory agencies worldwide were already well committed to the so-called risk–based supervision model—which may be traced back to the US Office of the Comptroller of the Currency (OCC) [1] and latterly championed by the likes of (UK) Financial Services Authority (FSA) [2] and Basel Committee on Banking Supervision (BCBS)—and central bankers in general welcomed of the instruments of macroprudential surveillance. In particular, some central banks, especially those concurrently mandated payment system oversight, notably Oesterreichische Nationalbank (OeNB), the Austrian central bank, perhaps having correctly identified payment/settlement/clearing circle as a network of liquidity transfer entities, began to formulate systemic contagion in the language of network models (and implicitly graph theory) [3]. Meanwhile, yet other central banks, especially with recent experience of asset bubbles, notably Banco de España (BdE), the Spanish central bank, perhaps having wisely acknowledged the impact of asset inflation on the conduct of monetary policy, began to devise microprudential measures to specifically address systemic procyclicality [4].

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With the coming (and hopefully passing) of this crisis, the very word ‘systemic’ and all things network-centric gained the much needed publicity as policy reformers came to a general consensus that one needs a proper macroprudential framework—albeit the very concept preceded this crisis—involving some kind of ‘systemic regulator’, i.e. an official body in charge of financial stability (work) in the purely systemic sense. International policy discussions grew around the cross-sectional vs. time dimensions of systemic risk, i.e. contagion vs. procyclicality, as disparate national regulators scrambled to determine who exactly is in charge of systemic–stability regulation. In so doing, methodological perspectives pioneered by the likes of OeNB and BdE came to the fore, gaining currency and credibility within policy and academic circles alike.

What is it, ‘systemic’ or ‘systematic’, or are the two interchangeable?

The short answer is that ‘systemic’ is the correct word to use here. Actually, systemic and systematic could mean exactly the same, just as ‘cyberneticist’ and ‘cybernetician’ both refer to a person of the same intellectual discipline. The semantic separation between ‘systemic’ and ‘systematic’ is useful, however, especially as (we shall see) occasions may arise where both are needed in the same sentence.

In financial economics, ‘systematic’ is a relatively well-grounded notion, deeply rooted within the ‘CAPM’ tradition, and arose within the context of distinguishing between randomness that is attributable to the larger financial market from randomness that arises idiosyncratically from individual asset. Thus systematic volatility has a ‘rhyme and reason’ to it in the sense that because some system-wide factor moves, so does an individual asset, i.e. to an extent governed by the ‘beta’ coefficient, on which is then superimposed idiosyncratic volatility, the latter which cannot be explained away by way of said factor movement. Critically here, systematic factor(s) is (are) assumed to exist, the analytical tasks being to identify (e.g. this market is largely moved by oil), proxy (e.g. this market is best represented by a market capitalisation weighted index), and/or account for (e.g. one needs no more than 2 factors to account for 95% of volatility in this market).

On the other hand, ‘systemic’ is a relatively recent addition to financial vocabulary, owing perhaps to cross-fertilisation of ideas from ‘system science’ and ‘system engineering’. The idea is that certain emergent property arises by virtue of there being a systemic whole, and cannot be accounted for by looking disaggregate at individual component parts. This systemic phenomenon comes over and above what can be accounted for by individual performance statistics. Critically here, there is no systemic factor as such, and in any event systemic ‘emergent property’ is not even guaranteed (may not exist).
What make financial institutions ‘systemically important’?

To quote the Cleveland Fed, the term “refers to financial institutions that are so big, or interconnected, or unique that they pose a risk of taking down the entire financial system should they fail”\(^2\), with the three adjectives corresponding, respectively, to the *size*, *interconnectedness* and *substitutability* criteria put forward by the (IMF/BIS/FSB) Joint Forum’s 2009 Report to G20 Finance Ministers and Governors [11].

Of these, *size* hardly needs further explaining, for it goes as far back as the FDIC’s 1984 bailout of Continental Illinois, if no earlier. The notion of *substitutability* is similarly easy to fathom, although it might be worth mentioning here that the modern usage in this context stems from recognition that as the universe of financially engineered products and services continues to expand, and counterparty relationships became correspondingly complex and multi-dimensional, it is possible that structural niches are created and fulfilled by specialising agents, whose continued existence then became a matter of public policy. But it is w.r.t. *interconnectedness*, a concept lifted from graph-theoretic/network modelling discipline (but with nary a proper reference) that our attention is presently directed.

So do we have a watertight working definition?

Not quite. The threefold, conjoined characterisation (*size* + *substitutability* + *interconnectedness*) is rather nice in that it focuses international standard setters’ and national supervisors’ minds toward financial institutions that are just that: very big, highly interconnected and/or particularly unique in the role it plays vis-à-vis other system entities.

Yet the author cautions that it would be a great disservice, i.e. vis-à-vis the ongoing regulatory-supervisory reform efforts, to then conclude that it then suffices to enhance, but not alter, the basic design of, as well as the thinking behind, the status quo, microprudentially-based *financial stability framework*.

In other words, let’s not say to ourselves: “whatever measures we already had for dealing with big banks, just expand the coverage to encompass big, unique and/or interconnected banks, and we’re done”. Albeit highly attractive as a quick-win proposition, this *microprudential-writ-large* logic undermines genuine reform initiatives, both in scale and in scope, and may already be lurking behind a number of proposals currently circulating amongst policy debate circles. *To wit*, where we once had capital adequacy

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measures commensurate with size, and then with risk-adjusted assets, now the obvious next step is to consider slapping capital charges additionally on basis of uniqueness/interconnectedness.

Not that introducing capital surcharges on basis of systemic import is in and of itself a bad idea. Indeed the author tends to view it favourably; even if others may have come to consider it a tax on natural monopoly, then so be it. The point is that we can do much better than to just take the current capital adequacy framework and simply modify the degree of proportionality to take uniqueness and/or interconnectedness into account.

All the discussion seems moot as soon as one realises one cannot judge any financial institutions to be systemically important or otherwise, until the notion of systemic risk itself is conceptually handled and quantitatively measurable. And at the very least, systemic risk requires systemic thinking on our part.

Backtracking a bit, what is ‘systemic risk’, or for that matter, what is ‘risk’?

In essence, all risks are probabilistic in nature. Formally, risk may be defined by a triplet: possibility, probability and utility. That is, there has to be more than one possible outcome with which we are faced, there has to be a notion of probability ‘measure’ associated with the outcome, not that our knowledge of the exact probability distribution is complete by any means, and we have to have some kind of stake, with preference of some outcomes over some other.

Risk analysis is also necessarily probabilistic, although here it can be said that the path pursued now forks 2 ways. First, we remain probabilistic through and through, which is to say that we continue to associate risk measurement with probability ‘measure’, culminating in a proper statistical analysis, producing some kind of probability distribution/expectation, e.g. profit/loss distribution, expected shortfall, etc.

Second, we partially take away the probabilistic interpretation by conditioning the resultant gain/loss, etc. on probable events, but without qualifying our conclusion with any kind of probabilistic estimate. From a non-probabilistic perspective, this is essentially what many utilise when they perform scenario analysis, i.e. of which stress testing is just a special case thereof.

By way of a diagram:

![Figure 1 — risk analysis: statistical vs. scenario](image-url)
Generally speaking, in finance risks exist at 2 levels, *individual* and *portfolio*, albeit this distinction can be arbitrarily *nested* (e.g. a financial sector is a portfolio comprising individual financial institutions, each of which can in turn be thought of and handled as a portfolio comprising individual financial assets, and so on). By way of a diagram:

**Figure 2 — risk level: individual vs. portfolio**

Particularly from the perspective of a financial regulatory-supervisory agent, charged with *prudential mandates*, the risk that a particular ‘individual’ financial institution may falter, cease to operate intermediary functions and/or default on its financial obligations is said to be the *object of* (micro) *prudential policy* conduct, while the risk of failures, disruptions and/or losses impacting the collective ‘portfolio’ of financial institutions, as well as bilaterally effecting the real sector, is said to be the *subject of* macroprudential (stability) policy conduct. By way of a diagram:

**Figure 3 — view of (system of) financial institution(s): individual vs. portfolio**

Vis-à-vis financial institutions, systemic risk clearly belongs to the realm of macroprudential financial stability concerns. But here the author wishes to pursue a further fine tuning, distinguishing 2 types of macroprudential problems: those manifesting ‘genuine’ systemic phenomena from those embodying ‘classical’ portfolio effects.
With portfolio effects, individual contributions to risk overall can be assessed locally (i.e. based on an individual financial institution’s balance sheet items, off-balance-sheet exposures, market shares, etc.) and tallied together algebraically (i.e. via a quadratic form calculation involving some variance-covariance type matrix, etc.); whereas, with systemic phenomena, the very ‘emergent property’ nature demands from our part a holistic evaluation of the system, its behaviour and evolution as a total system.

With portfolio effects, the main issues are concentration and contagion. The more concentrated a portfolio is, obviously the more sensitive overall portfolio performance to particularly to the area of concentration. Similarly, contagion is a function of how much alike, or not, constituent parts are driven by common factor(s), as per CAPM tradition (whether this phenomenological, or based purely on market perception, is beside the point).

With systemic phenomena, challenges lie with the nonlinear (chaotic) dynamics, characterised by chaotic system behaviours, whereby slight departure in initial conditions could impart highly divergent paths, and network (interconnectivity) dynamics, characterised by graph-theoretic system properties, where it is noted that while interconnectivities amongst system entities do enhance overall systemic stability, this stable regime is precariously ‘knifed-edged’, hence the ‘robust yet fragile’ paradox: highly interconnected (banking, telecommunication, political, etc.) systems hardly fail, but when they fail, they fail big.

In short, nonlinear and network dynamics give rise to ‘systemic phenomena’, as distinct from ‘portfolio effects’ due to concentration and contagion issues.

By way of a diagram:

**Figure 4** — macroprudential (stability) concerns: portfolio effects vs. systemic phenomena

Systemic risk is thus the risk of failures, disruptions and/or losses impacting the system of financial institutions over and above the sum of individual risks facing all the constituent financial institutions taken together; it is an emergent property inherent to the systemic nature of how a set/subset of financial institutions collectively operate; it requires analytical appreciation of the nonlinear/network dynamics at work.
Is ‘highly interconnected’ the same thing as ‘systemically important’?

No, and for three reasons. First, had we taken to determining systemic import in terms of size + interconnectedness + substitutability, then clearly the two do not equate, one being one-third of the definition of the other.

Second, when used together within the same context, ‘highly interconnected’ describes a system; whereas, ‘systemically important’ describes its component (regardless of whether such a component is indeed recognised singly as a system of sub-components).

Third, if we took, as the author does, systemic risk to be an emergent property of the systemic whole, then ‘highly interconnected’ applies insofar as that part of the financial sector we are dealing with possesses/exhibits network (interconnectivity) dynamics, just as ‘highly nonlinear’ might apply insofar as that part of the financial sector we are concerned with possesses/exhibits nonlinear (chaotic) dynamics. So it does depend on our ‘analytical handle’. Put in another way, characterising any collection of entities as ‘highly interconnected’ implies that one must be looking at these objects through a graph-theoretic/network modelling perspective.

On the other hand, the phrase ‘too interconnected to fail’ [12], meant as a token of recognition that something above and beyond ‘too big to fail’ is called for, can be used rather loosely.

Then exactly how should we go about recognising any given entity as ‘systemically important’?

Having established systemic risk as an emergent property, the natural way to proceed would be to find the way to quantify and measure the extent of ‘total’ systemic risk (once again, over and above non-systemic aggregation of risks facing individual financial institutions), the means and methods by which this quantity can then be disaggregated and apportioned to individual system entities, and finally some kind of scale (minimally an ordinal scale), benchmark, threshold, etc. by which disaggregated/apportioned systemic risk contributions can be judged in relative terms. In spirit, this approach is akin to breaking portfolio VaR into individual incremental VaR contributions that, in turns, do not add up to the total VaR figure, or allocating economic capital to various interrelated functions within a given enterprise.

Practically however, we must contend with the reality that ‘total’ systemic risk cannot be (and may never be) quantifiable and summarised in the same way that, say, an equity portfolio risk may be quantifiable and summarised by way of a quadratic form.
So we have to decide on a compromise. Will it suffice to operationally define ‘systemic important’ in relative, i.e. *ordinal scale* (as in, for example, this bank is the most systemically important, or more systemically important than this other bank, etc.)? Or do we need a sense of proportionality, i.e. *interval scale* (as in, for example, this bank is 1.5 times more systemically important than this other bank, or these two banks combined are still not as systemically important as that other bank, etc.)? Or do we simply want to cast a *binary/Boolean* ‘yes SIFI’ / ‘no SIFI’ judgement? Obviously it much depends on the objective of the exercise. Do we just want to rank SIFI so that, for instance, supervisors can plan their on-site visits and manpower accordingly? Or do we wish to quantitatively assess SIFI in order, say, to tighten liquidity ratio requirements commensurately? Perhaps it is enough just to identify SIFI from non-SIFI?

In particular, w.r.t. risk-based supervision, the focus would be to construct an *a priori* metric of systemic import with which to direct supervisory resources, hence much less model precision is required than would be the case, say, if one wishes to stress test the financial system using failure(s) of one or more member bank(s) as the stress scenarios [14], to factor in systemic risk exposure in the pricing of firm capitals [15], to obtain such network statistics as ‘average path length’, clustering coefficient, and so on [16], to calibrate system parameters from market data [17], or to evaluate the extent to which homogeneity/heterogeneity amongst constituent entities effect fragility/robustness of the overall system [18].

In short, one should be fully cognizant of the nature of the *SIFI scale* appropriate to the regulatory-supervisory tasks at hand, be it binary, ordinal, or interval. In any event, it is not *a priori* clear that more detail, i.e. interval-scaled, evaluation is necessarily better than cruder, i.e. binary, assessment. For example, in a jurisdiction where for some historical reasons microprudential and macroprudential tasks are completely segregated, simplistic ‘SIFI’ / ‘non-SIFI’ labelling very much matters; on it weights such issues as boundary of regulation, regulatory arbitrage, appropriateness of state-financed bailouts, etc.

By way of a diagram:

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Figure 5 — SIFI scales: binary vs. ordinal vs. interval
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So is it fair to say that the definition of ‘systemically important’ is metric-dependent?

Quite true, but this is by no means unique. Why is investment portfolio risk defined in terms of standard deviation, for instance? Why not, say, mean absolute deviation, or any other dispersion metrics for that matter? It is perhaps that the arbitration process, as it were, is still open, subject to academic opinions, and perhaps more transparent than an earlier era, when it was indeed possible to simply decree forthwith: “volatility shall mean sigma.”

In short, if we all agree to pursue anything above and beyond the rather vacuous “a SIFI is a FI (Financial Institution) that is I (important) to the S (system)”, then the first issue to resolve is whether we have a working analytical methodology that will assign a score on the aforementioned SIFI scale relevant to the regulatory-supervisory tasks at hand.

What analytical methodologies are available for identifying, quantifying, prioritising SIFI?

This is obviously an open issue. Nonetheless, let’s focus on analytical methodologies aimed at capturing and exploiting the network dynamics aspect of systemic phenomena (rightmost element as per Figure 4).

Given the rapidly growing body of literatures on network models of systemic phenomena, it is useful to distinguish three levels of network methodologies and the types of analysis they support.

Static Network Analysis – at this level all we know of the network is essentially captured by some form of matrix of connectivities. System entities correspond to the ‘graph-theoretic’ notion of nodes, while connections correspond to edges—which may be directed (with arrows) or undirected (without an arrow)—whence the modelled system in total can be drawn as a graph. 3 Here we will be working with directed graphs, also called digraphs. The resultant ‘structural’ diagram (the collective specification as to which nodes have edges connecting to/from which nodes), or (network) topology, may resemble any of a number of stylised configurations. Well-known topologies include ‘ring’, ‘star’, ‘mesh’, ‘cascade’, and ‘fully interconnected’ networks.

At this point it is then possible to apply mathematical techniques to a priori extract a number of salient features inherent to the system without actually allowing for any kind of ‘behavioural’ modelling.

3 Mathematically speaking, a graph is the same as a network, although some authors may choose to reserve the term ‘network’ for a graph whose edges are associated with quantities, such as to signify varying connectivity ‘weights’ or ‘strengths’. 
For regulatory-supervisory applications, each node may correspond to an individual bank, hence each edge an interbank exposure (generally on a gross basis). Alternatively, a node may represent the banking sector as a whole, with another to represent the real sector, and so on, so that procyclicality mechanism, for instance, can be modelled as a flow of causation via the edge(s) connecting the two. This paper is essentially confined to just this level of analysis.

As an example of this genre, the author revisited the concept of (Bonacich’s) Eigenvector Centrality (BEC) [19], an analytical framework purportedly utilised by the Google (Inc.) search engine in ranking search results [20][21], and extended it methodologically/conceptually to macro-prudential application, where network connectivities are essentially graded, hence a weighted network [22], as opposed to the simple ‘yes connected/no not connected’ type of linkage. In particular, the proposed Systemic Import Analysis (SIA) methodology (for a priori ranking of financial institutions in terms of regulatory-supervisory concern) is based on the Entropic Eigenvector Centrality (EEC) criterion introduced by the author [23].

Dynamic Network Analysis – at this intermediate level each node is endowed with some kind of state variable(s), each edge is endowed with propagation or update rule, and therefore the entire graph can be said in a simulation environment to behave dynamically, with the collective state of the system (comprising individual entity states) changing over time as external shocks are applied and propagated through the network, i.e. via such linkages as credit lines or indeed any form of interbank exposures [24][25], causing individual nodes to update along the way. Robustness analysis can also be performed by simulating failure(s) of individual node(s), i.e. to see which/whether other node(s) will also succumb.

Agent-Driven Network Analysis – at this advanced level, each entity, while still represented as a node in a graph, is best thought of as a semi-autonomous decision making agent [26][27] capable to choosing the best responses to various input stimuli, even able to modify its connectivities vis-à-vis other system entities. Here, not only are state variables changeable, but so is the very network topology itself. It is fair to say that regulatory-supervisory research, comprising theoretical/methodological works, as well as empirical findings in case countries [28][29][30][31][32][33][34][35][36], has barely (if at all) penetrated/progressed up to this level of analysis.

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4 One key advantage of EEC is the ability to assess the ‘degree of centrality’ for a weighted network while at the same time lessening the possibility of obtaining ‘degenerate solution’ from the analysis.
How can we operationalise/framework our mandated systemic-macroprudential policy conduct?

Let’s assume that we have just the basic static network analysis at our disposal. Mimicking the 4-step ‘identify ===> measure ===> mitigate ===> report’ risk management process loop, we might as well proceed as follows:

1. Identification:

   1.1 Appropriate system boundaries—domestic vs. international, supervised as (from the point of view of) home regulator vs. supervised as (from the point of view of) host regulator, banking in particular vs. financial in general, singly vs. jointly regulated (i.e. with the securities commission, insurance regulator, etc.), statutorily mandated vs. publicly expected, and so on—need to be clearly established.

   1.2 Relevant propagation channels for systemic phenomena—liquidity, credit, via derivatives, reputational, etc.—all need to be cataloged and every so often updated to take into account of what we theoretically/academically/experientially know about (or think we know) about how a modern, digitally integrated financial system operates.

2. Measurement:

   2.1 Guesstimated dollar loss to the system per event scenario impacting a SIFI – no matter what analytical methodology used, it should be possible to specify a multitude of event scenarios; in other words, not just generic ‘failure of bank so and so’.

   2.2 Relative SIFI assessment score – no matter what analytical methodology used, it should be clearly explained to the public; only then will it be able for the regulator/supervisor use the result as a basis for calibrating any kind of macro-prudential instruments.

3. Mitigation:

   3.1 Structural policy – essentially the strategic financial landscaping policy, but explicitly with the view to enhance financial system robustness, i.e. as opposed to competitiveness, which used to be the principal cornerstone of policymaking in this regard.

   3.2 Parametric measure – essentially the quantitative prudent safeguarding measure, encompassing anything from liquidity to capital to leverage to asset quality, etc.
3.3 \textit{Scenario planning} – essentially the \textit{contingent crisis recovery} planning, ideally to the point where it is possible to optimally pinpoint where, when, and how much intervention is necessary, effective, and justified.

4. Reporting:

4.1 Scope for \textit{internal reporting} as a decision support function to regulatory-supervisory executives: a fine balancing act between vigilance and ‘crying wolf’.

4.2 Protocol for \textit{external reporting} to outside stakeholders and the general public: a fine balancing act between early warning and ‘self fulfilling’.

\textbf{In conclusion}

\textit{Why are we talking ‘systemic’ all of a sudden?} No doubt, the subprime-mortgage-turns-global-financial crisis was a major factor; this still does not take away from the fact that the intellectual root of ‘systemic phenomena’ thinking, as well as the practical foresight of applying such to modern financial system context, certainly preceded it by great many years.

\textit{What is it, ‘systemic’ or ‘systematic’, or are the two interchangeable?} Semantic equivalence is certainly there, but from a pedagogical standpoint the author believes it useful to consign all things ‘systematic’ to CAPM-type, factor-analysis thinking, and reserve ‘systemic’ for the more modern sense involving nonlinear and network dynamics.

\textit{What make financial institutions ‘systemically important’?} The current consensus seems to be that a financial institution is ‘systemically important’ if it is big, highly interconnected with other entities, and unique in the function it performs.

\textit{So do we have a watertight working definition?} The author does not think so, hence, to an extent, the motivation for this article.

\textit{Backtracking a bit, what is ‘systemic risk’, or for that matter, what is ‘risk’?} One encounters risk when there are more than a singular outcomes to consider (possibility), associated to which is the notion of likelihood of one set of outcomes over another (possibility), and one’s fortune has to be differentially tied to different outcomes (utility). Systemic risk is then defined as the risk of failures, disruptions and/or losses impacting the system of financial institutions over and above the sum of individual risks facing all the constituent financial institutions taken together, hence an emergent property of the systemic whole.
Is ‘highly interconnected’ the same thing as ‘systemically important’? No. The former is too narrow, describes a system, and embodies graph-theoretic/network modelling perspectives; whereas, the latter may be taken as a broad concept, describes a particular component vis-à-vis the system to which it belongs, and encompasses systemic phenomena in general.

Then exactly how should we go about recognising any given entity as ‘systemically important’? First decide on the scale by which SIFI assessment score is graded, then whether any given financial institution is ‘systemically important’, or how much so, is a matter of how it is graded on the SIFI scale.

So is it fair to say that the definition of ‘systemically important’ is metric-dependent? Yes, although this is by no means the first time financial concept is definitionally tied to a statistical measure. Hence to go beyond “a SIFI is a FI (Financial Institution) that is I (important) to the S (system)”, one needs an analytical methodology that will quantitatively grade whether/how much a FI is SI.

What analytical methodologies are available for identifying, quantifying, prioritising SIFI? For such a purpose, the author groups graph-theoretic/network modelling technologies into three tiers (of increasing opportunity for realism as well as model risk): static, dynamic, and agent-driven network analysis methodologies.

How can we operationalise/framework our mandated systemic-macroprudential policy conduct? In terms of identification, one needs to know where appropriate system boundaries lie and what relevant propagation channels are. In terms of measurement, one needs to be able to measure, i.e. guesstimate, dollar loss from systemic event as well as measure, i.e. assign, relative assessment score to each individual entity. In terms of mitigation, a regulatory-supervisory authority may have at disposal/be charged with anything from strategic financial landscaping mandate, to quantitative prudential safeguarding legislature, down to contingent crisis recovery responsibility.

Certainly the road here is long and winding. W.r.t. definition, one requires a working analytical methodology that will grade individual FI on some kind of acceptable SI scale, which makes it a metric-dependent definition. In turn, this puts great emphasis on advancing the state of art and science in modelling ‘systemic phenomena’. Nonetheless, the author hopes such efforts will yield the much-needed substance, precision and concreteness to the pursuit of framework for macroprudential regulation and supervision of SIFI.
Bibliography


