working paper

13 09

Policy in Adaptive Financial Markets—The Use of Systemic Risk Early Warning Tools

Mikhail V. Oet, Stephen J. Ong, and Dieter Gramlich

FEDERAL RESERVE BANK OF CLEVELAND

Working Paper 13-09 May 2013

Policy in Adaptive Financial Markets—
The Use of Systemic Risk Early Warning Tools

Mikhail V. Oet, Stephen J. Ong, and Dieter Gramlich

How can a systemic risk early warning system (EWS) facilitate the financial stability work of policymakers? In the context of evolving financial market dynamics and limitations of microprudential policy, this study examines new directions for financial macroprudential policy. A flexible macroprudential approach is anchored in strategic capacities of systemic risk EWSs. Tactically, macroprudential applications are founded on information about the level, structure, and institutional drivers of systemic financial stress and aim to manage the financial system risk and imbalances in two dimensions: across time and institutions. Time-related EWS policy applications are analyzed in pursuit of prevention and mitigation. EWS applications across institutions are considered via common exposures and interconnectedness. Care must be taken in the calibration of macroprudential applications, given their reliance on quality of the underlying systemic risk-modeling framework.

Keywords: financial stability, regulation, macroprudential, policy instrument, early warning system, systemic risk, financial stress, imbalance.

JEL classification: G01; G18; G28; E32; E37.

Mikhail V. Oet is at the Federal Reserve Bank of Cleveland and Case Western Reserve University; he can be reached at mikhail.v.oet@clev.frb.org. Stephen J. Ong is at the Federal Reserve Bank of Cleveland; he can be reached at stephen.ong@clev.frb.org. Dieter Gramlich is at Baden-Wuerttemberg Cooperative State University; he can be reached at gramlich@dhbw-heidenheim.de.

Contents

1. INTRODUCTION

The shared limitations of risk managers and regulators to abate the persistent spillovers in the financial systems also challenge the development of early warning tools that help us spot possible instabilities. This study aims to consider potential policy applications of such systemic risk early warning systems in the context of these limitations.

The recent financial storms seem to have caught most of us by surprise. Large diversified financial institutions with massive investments in risk management learned they knew virtually nothing about systemic risk and correlated failure. At the same time, central banks learned that despite their focus on early warning models of individual institutions' safety, these models were not able to anticipate the coming crisis. The international differences in the intensity of supervisory spectrum—from Fed's regulation-intensive to BOE's regulation-light[1]—made little difference: in this joint crisis of the financial systems, financial institutions and central banks were similarly caught unawares.[2]

In the post-mortem of the 2007-2009 global financial crisis, the harsh judgments on institutional failures have been universal. Risk management failures were highlighted through a litany of crisis-related problems including: creation of incentives and lack of controls for rogue trading, "price fixing" (e.g. LIBOR), foreclosure abuses, international "money laundering", "tax evasion," and "misleading clients with worthless securities" while profiting by them with offsetting bets (Denning, 2013). Hellwig (2009, p. 51) criticized "risk managers, risk controllers, and, most importantly, top management at institutions… for not having taken account of the possibility of … [systemic risks]. They relied on the quantitative risk models that they had

1 Goodhart (2004), Mayes and Wood (2007), Ellyatt (2012, December 14).
2 Gordon Brown (2010) called it a failure of collective action, as global institutions jointly failed to keep pace with the instabilities inherent in interconnected unregulated global economies.

developed and believed in their ability to control risks on the basis of these models. Their exposure to systemic risks … had not been incorporated into the models – and could not have been incorporated because they did not have the requisite information." Similarly, Haldane and May (2011, p. 351) attributed risk management flaws to the poor understanding of the financial system's complexity including the systemic spillover potential that came with the extraordinary innovation in financial instruments: "In the run-up to the recent financial crisis, an increasingly elaborate set of financial instruments emerged, intended to optimize returns to individual institutions with seemingly minimal risk. Essentially no attention was given to their possible effects on the stability of the system as a whole." Stulz (2008) argued that the critical failures warrant improvement in risk management, particularly improvement focused on scenarios involving the spillover and feedback mechanisms involved in crises.

Regulatory shortcomings were equally exposed. For example, the recently released transcripts of the deliberations of the Federal Reserve Federal Open Market Committee (FOMC)[3] during 2007 revealed that "Federal Reserve officials were largely unaware of the financial crisis brewing in 2007, until they found themselves in the middle of it."[4] The European Central Bank had been similarly criticized for turning "a blind eye to "irresponsible lending" by German, French, British, and Belgian banks, and for "failing to use its powers to rein in speculative bubbles in countries such as Ireland and Spain" (Phillips, 2011, August 31). Richter and Wahl (2001, p. 4) conclude that "the ECB did not see the crisis coming." This case of blindness had to have been very contagious, as few central bankers were immune. Bank of England failed to see the crisis coming as well, according to its deputy Governor Sir John Gieve who urged the

[3] Full transcripts of FOMC deliberations are released to the public with a five year lag.

[4] Kurtz, A. (2013, January 18). Federal Reserve was blind to crisis brewing in early 2007 - Jan. 18, 2013. CNNMoney - Business, financial and personal finance news. Retrieved January 24, 2013, from http://money.cnn.com/2013/01/18/news/economy/federal-reserve-transcripts/index.html

development of tools bridging the interaction "of individual banks and … financial cycle and prevent[ing] the financial cycle… getting out of hand."[5]

Some consider too much regulation to be the problem, others blame too little regulation.[6] Some say that our hubris to rely on models has been exposed and any efforts to manage the future state of risk exposures, the economy, financial systems, etc. that are based on patterns from the past are necessarily doomed.[7] These considerations emphasize the persistent limitations of traditional, micro-focused, early warning models[8] to allow risk managers and regulators to cope with risk. In fact, "many observers[9] have argued the regulatory framework in place prior to the global financial crisis was deficient because it was largely "microprudential" in nature."[10] Others emphasize that this failure of microprudential models is endemic: "microprudential EWS models cannot, because of their design, provide a systemic perspective on distress."[11] They argue that a disruption in the financial system by its very nature manifests our collective failure to

---

5 Winnett and Swaine (2008, December 22). This extraordinarily impaired sight appears in no-way a unique attribute of the recent turmoil. Recall, for example, the staggering optimism of the Japanese asset prices in the 80's. "At the peak of the speculative bubble in 1989, the gardens of the emperor's palace were worth more than all of Canada. A 1200 square meter premise in central Tokyo was worth almost 850 million US-dollars (Hanusch and Wackermann, 2009, p. 6)." Despite the unprecedented bubble, the Bank of Japan and the Japanese financial institutions, failed to foresee the burst of the speculative bubble in 1991 that initiated the infamous "lost decade" crisis (Hayashi and Prescott, 2002; Hanusch and Wackermann, 2009).

6 See Eichengreen (2009) and Friedman and Kraus (2011) on failures to regulate. These failures would include examples of both potential overregulation (e.g. Community Reinvestment Act) and potential underregulation (e.g. financial liberalization and deregulation). See Paul (2008, September 23), Roberts (2008), Demyanyk and Van Hemert (2011), Ergungor (2007) for the arguments, evidence, and analysis of the relationship of Community Reinvestment Act with the 2007-2009 financial crisis. See Saunders et al. (2012) for analysis of deregulation and risk taking and Crotty (2009) for their structural significance to the global financial crisis.

7 Stulz (2008).

8 Borio (2003) classifies regulatory early warning system (EWS) models as micro- or macroprudential. Traditional EWS models "extrapolate the risk of a single financial institution (micro risk)" (Gramlich et al., 2010) and aim "at preventing the costly failure of individual financial institutions (Hanson et al., 2011).

9 For example, see Cihák and Poghosyan (2009) who analyze limitations of traditional CAMEL grades and suggest that market-based provide significant explanatory power not contained in the indicators of individual institutions. Hanson et al. (2011) provide an extensive review, citing Crockett (2000), Borio et al. (2001), Borio (2003), Kashyap and Stein (2004), Kashyap et al. (2008), Brunnermeier et al. (2009), BOE (2009), French et al. (2010) to support this point.

10 Hanson et al. (2011), p. 1.

11 Gramlich et al. (2010), p. 208.

control it.[12] Where most people agree is that disruptions of financial stability are disturbing and creating spillovers that must be handled—a problem of systemic risk.[13] Thus, risk managers, regulators, and academics increasingly study factors that explain systemic risk, consider vulnerabilities and patterns of contagion within the networks making up the financial system, study the feedbacks mechanisms that give rise to destabilizing spillover patterns, in short, work on the problem to advance our understanding of risk in the financial system as a whole—the macroprudential problem. [14] This work which commenced significantly after the wave of the global financial crises in the 1990-s is beginning to bear fruit on every front: in the study of financial networks, study of systemic feedback mechanisms, as well as the study of macroprudential early warning systems. A new wave of understanding leaves researchers cautiously optimistic in yielding encouraging "evidence that early warning indicators exist which signal costly asset price developments in 'real time' and with sufficient lead to react." [15]

In affirming the regulatory responsibility for financial stability[16], Chairman Bernanke highlighted the critical question of the appropriate "field of vision":

> *"Under our current system of safety-and-soundness regulation, supervisors often focus on the financial conditions of individual institutions in isolation. An alternative approach, which has been called systemwide or macroprudential oversight, would*

---

12 Brown (2010) writes: "The crisis exposed the contradiction of globalization itself: as economies have become more interconnected, regulators and governments have failed to keep pace and increase coordination (p.7). … It is a failure intrinsic to unregulated global markets, an instability that results from the manner in which increasing flows of capital around the world happened and impacted the economy. And it is a failure of collective action at an international level to respond quickly enough to structural imbalance and inequities that arose. At its simplest, then, this is the first true crisis of globalization (jacket notes)."

13 "The prevalent view (Group of Ten, 2001) is that systemic financial risk is the possibility that a shock event triggers an adverse feedback loop in financial institutions and markets, significantly affecting their ability to allocate capital and serve intermediary functions, thereby generating spillover effects into the real economy with no clear self-healing mechanism (Oet et al., 2013a, p. 792)."

14 Particularly, the research at the Bank of International Settlements (Borio, 2003, 2006, 2009, 2010; Borio et al., 2001; Borio and Lowe, 2002a, 2002b, 2004), at the International Monetary Fund (Nier, 2011; Lim et al., 2011a, 2011b), at the Bank of England (Haldane and May, 2011), at the European Central Bank (Alessi and Detken, 2009; Detken, 2012), and the Federal Reserve (Oet et al., 2013a, 2013b).

15 Alessi and Detken (2009), p. 8.

16 Bernanke (2011).

> *broaden the mandate of regulators and supervisors to encompass consideration of potential systemic risks and weaknesses as well."*[17]

At the same time, no *systemwide* oversight and no early warning tool of *systemic risk* can get very far without a good understanding of the *system*. Here critically, a gigantic body of interdisciplinary research reveals that the financial system is *complex*: inherently unpredictable in the long-run, sensitive to initial conditions, adaptive to change in its organizational patterns, and revealing non-linear dynamic behavior.[18] Thus, our puzzle becomes to understand the potential policy options that emerge with the new macroprudential tools of early warning in the context of the evolution of financial markets' complexity.

The rest of this paper is structured as follows: Section 2 discusses the research question and the conceptual model of financial stability tools in adaptive settings. Section 3 discusses potential uses of the emerging early warning tools. Section 4 concludes with a discussion of critical policy implications.

2. RESEARCH QUESTION AND CONCEPTUAL MODEL

What are the policy applications of the emerging early warning tools for systemic risk oversight in the context of complex and adaptive financial systems?

Figure 1 shows the conceptual model guiding the research, mapped in literature. The model suggests that macroprudential policy in adaptive financial systems is a continuous process and must be to keep up with the financial system transformation. In this process, macroprudential policy is continuously adjusted from its ***objectives***, through reconsideration of its ***functions***,

---

17 Bernanke (2008).

18 For overview of this research see Arthur (1995) and Farmer and Lo (1999), Boyer (1999) for the analysis of heterogeneity of financial markets, and Hollingsworth et al. (2005) for socio-economic implications of financial system's complexity from an institutitonalist perspective.

through redesign of its ***forms***, through its methodological ***revaluation.*** This is a continuous process of policy adjustment that reflects the adaptive transformations in the financial system.

Insert Fig. 1 about here

The context of the economy as an *adaptive*[19] *complex system* was pioneered by Holland (1975, 1988) in his work on adaptive nonlinear networks and was significantly extended in the past four decades.[20] Following Holland (1988, pp. 117-118), the global economy forms an adaptive system through the following seven features: 1) interaction of many interdependent agents, 2) scarcity of global controls that allow competitive, as well as coordinating and shifting agent associations, 3) multilevel hierarchical agent associations with asymmetric interactions across levels, 4) system adaptation through a continual recombination of agent interactions as the system accumulates experience, 5) the presence of niches exploitable by particular agent adaptations, 6) continuous creation of niches through technological innovation, and 7) suboptimal performance due to the continual thriving of niche interactions.

Nicolis and Prigogine (1977, p. 464) show that in adaptive systems relative *instability* is a continuous state feature of the system, and that the onset of an adaptive "process is dictated by the behavior of the fluctuations." In fact, the main reason for the onset of an adaptive process is that an adaptive "system is necessarily undergoing instabilities, and hence is capable of amplifying certain disturbances including some of its own fluctuations."[21] Put differently, a

[19] Some researchers use the term *self-organizing* interchangeably with the term *adaptive* to emphasize the emergence of coordination among agents in the process of adaptation. In this paper *adaptive* is preferred, as it refers to a more general set of interactions, including coordinating interactions.

[20] See Arthur (1995) and Arthur et al. (1997) for applications of adaptive network modeling to financial markets. Brock and Hommes (1997, 1998) study financial markets as adaptive belief systems and Hommes (2001) extends this approach to markets as nonlinear adaptive evolutionary systems. See Aghion and Howitt (1992) and Howitt et al. (2008) for complexity-based macroeconomic models. See Farmer (2002) and Farmer et al. (2005) for complexity-based modeling of financial markets. See Beyeler et al. (2007), Bech and Atalay (2010), and Soramäki et al. (2007) for studies on topology and contagion in specific financial markets. See Farmer (1990) and Brock and Durlauf (2001) for critical methodologies.

[21] Nicolis and Prigogine (1977), pp. 465.

continuous state of relative financial instability is an integral aspect and an integral problem of an adaptive financial system.

The conceptual model reflects the evolving relationship between the financial system context and its risk policy objectives, functions, forms, and evaluation. The formation of systemic risk policy objectives is discussed through seminal contributions of Acharya (2001), Elsinger et al. (2002), Borio (2003), Rochet (2004, 2005), and Nier (2011). Principally these objectives include time- and cross-sectional aspects. Systemic policy functions are considered starting with the influential contributions of Gonzalez-Hermosillo (1996), De Bandt and Hartmann (2000), Borio (2006), and including current research. The intrinsic functions involve identification of systemic conditions, forward-looking and forecasting capacities, identification of systemic imbalances, differentiation of excessive exposures, and sensitivity to systemic risk posed. Policy forms are based following the findings of Lim et al. (2011a, 2011b) and Galati and Moessner (2012). Current typology of these forms comprises early warning systems, asset price models, stress-testing, and microprudential feeds. The focus of this study is on the potential policy applications of early warning tools. Policy evaluation in adaptive financial system is considered in light of formative contributions of Lucas (1976), Sabatier (1991), and Brock et al. (2003). Following Brock et al. (2003), the evaluation approaches include expected loss calculations, model uncertainty aversion, local robustness analysis, and robustness with multiple models.

3. THEORETICAL FRAMEWORK FOR MACROPRUDENTIAL TOOLS

3.1. Objectives of Macroprudential Policy

The inherent instability of an adaptive system also grounds the system's meaning to its agents and frames their objectives. *Financial stability* can thus be viewed as an ability to control one's choices in an adaptive system in order to regulate preferential outcomes which would also include the relative state of system instability. [22] This is a problem of control, of ability to regulate one's environment—a prudential problem[23]—shared with all risk managing agents. As a result of these inherent objectives, recent prudential policy research focuses on two topics: first, a greater understanding of the role of prudential policies as a core component of the overall financial stability[24] and, second, the particular crisis-related challenges. As an example of the latter, Cukierman (2011) explores the issues of insufficiency of microprudential approaches to handle macrofinancial (systemic) risk, the need to reflect new dynamics of markets in stability policy, and the need for institutions and instruments to monitor and manage systemic risk.[25] As an example of the first, Borio (2003) and Nier (2011) consider the co-existence of dual perspectives in prudential policies: microprudential and macroprudential. Microprudential policy seeks to limit risk of failure of individual institutions, while macroprudential policy seeks to limit costs of financial distress in terms of the macroeconomy. Among the critical differences between the two prudential policies is the treatment of aggregate risk in the financial system. In the microprudential perspective, aggregate risk is exogenous – independent of behavior of individual

[22] Schinasi (2004, p. 8) proposes a related definition of financial stability as a continuous range where "A financial system … is capable of facilitating (rather than impeding) the performance of an economy, and of dissipating financial imbalances that arise endogenously or as a result of significant adverse and unanticipated events."

[23] In the context of this paper, the term *prudential* is synonymous to the term *supervisory,* defined plainly as an attribute of critical watching (Oet et al., 2012).

[24] See for example, IMF (2011), p. 9. Also, Cukierman (2011), p. 27.

[25] Cukierman (2011), p. 31.

institutions. In the macroprudential view, aggregate risk is endogenous – dependent on collective behavior of institutions. This endogeneity leads to the fundamental challenge in the macroprudential approach: understanding of the process by which the risk aggregates in the system over time and across the system participants. Thus, the principal problems of macroprudential policies deal with aggregate risk in two dimensions: first, time and second, cross-sectionally.[26]

Policy in the time dimension is concerned with aggregate risk evolution over time relative to the financial cycle and the adverse amplification between the financial system and the real economy (procyclicality).[27] Furthermore, the time dimension objectives form a dual set of long-term and short-term goals. In the long run the objective is "to avoid macroeconomic costs linked to financial instability," while in the short run, the objective is to "limit financial system-wide distress."[28] Similarly, policy in the cross-sectional dimension is concerned with a complementary dual set of issues: common exposures and interconnections among institutions. Accordingly, the cross-sectional macroprudential objectives include the common exposure imbalance-based goal to limit severity of failure, common exposure imbalance-based goal to limit probability of failure, and interconnectedness-based goal to strengthen infrastructure resilience. Any macroprudential tool designed to support these objectives must enable corresponding strategic capacities.

Post-crisis normative research further details these objectives and recognizes that some macroprudential problems also integrate other financial stability policies: monetary and fiscal. For example, within individually common exposures, Nier (2011) adds further specificity by

---

26 IMF (2011), p. 8.
27 Borio (2003), p. 11.
28 Borio (2003), p. 2.

distinguishing the dual—severity and probability—dimensions of failure with the idea that different macroprudential policy instruments are needed to address them. Hannoun (2010) further includes the goals of liquidity management, leaning against financial imbalances, and price stability as elements of monetary stability policy. [29]

In summary, current research on prudential policy shows an effective consensus that emphasizes the necessity of the macroprudential policy in addition to the traditional microprudential approach. The consequent questions that need to be answered concern the functions of macroprudential tools and their resulting design and policy applications.

3.2. Functions of Macroprudential Policy Tools

Functions of macroprudential policy tools follow the consensus view expressed by Borio (2006, p. 3413) that macroprudential policy contains two strategic dimensions: “first, improving measurement of systemic conditions, and second focusing on limiting build-up of imbalances.”

Identification of systemic conditions—stress identification is the basis of an effective macroprudential policy tool. A major finding from analyses of the recent financial crisis from a systemic perspective (Allen and Carletti, 2010; Cukierman, 2011; IMF, 2009; UNCTAD, 2009) is that principal problems originated due to inherent information asymmetry among interconnected financial agent institutions and propagated significantly via information uncertainty in the financial markets. The financial agents had not recognized this susceptibility to informational uncertainty—as a systemic dimension—sufficiently in advance. The lack of transparency about the system´s level of stress and its causes, however, makes it difficult to

[29] Hannoun also includes goals of aggregate demand management and building fiscal buffers as well as several goals extending the cross-sectional objectives. The first of these—limiting system-wide currency mismatches—can be considered a component of cross-sectional common exposures objectives. The second—strengthening infrastructure resilience—can be considered a component of the cross-sectional interconnections objectives.

assess the nature of a developing stress episode adequately, design efficient crisis management strategies, and, from a broader point of view, prevent future systemic crises. The first function of a macroprudential policy tool is therefore to measure systemic conditions in a way that provides a continuous signal of stress and broad coverage of the system's areas.

Identification of systemic imbalances—the notion of financial imbalances has long been intertwined with financial stability (Schinasi, 2004; ECB, 2005). In the context of a financial system's stability, accumulation of imbalances as vulnerabilities characterizes the system's transition to unstable state, whether through an endogenous process or due to exogenous shocks.[30] The European Central Bank (ECB, 2005) defined financial stability as the ability of "financial intermediaries, markets, and market infrastructures… [to withstand] shocks and the unraveling of financial imbalances." As early as 2001, Borio et al. (2001, p. 42) urged that "[p]olicymakers need to be able to respond to the development of financial imbalances that have adverse implications for the business cycle and financial stability. The costs of not doing so can be very high." Lowe (2001, p. 30) noted that policy seeking to contain financial imbalances can reduce "the probability of bad outcomes that are associated with financial instability." Accordingly, the pursuit of financial stability objectives necessitates that policy regimes explicitly address the "the build-up of financial imbalances… [lest they] may unwittingly accommodate their expansion (Borio 2009, p. 37).[31]

Forward-looking and forecasting capacities— there is a well-established consensus that forward-looking capacity is integral to macroprudential policy. In the 1996 theoretical assessment of banking system fragility, Gonzalez-Hermosillo argues that a macroprudential

30 Schinasi (2004), pp. 8-10.

31 Borio and Lowe (2002a, 2002b, 2004) provide empirical evidence that financial imbalances help predict systemic distress, while Bailliu et al. (2012) examine theoretical optimality of policy response to financial imbalances and review theoretical precedents (e.g. Angelini et al., 2011; Boivin et al., 2010; Christensen et al., 2011; and Kannan et al., 2009).

measure of financial system's stability must be forward-looking based on the probability that the banks will remain solvent following a destabilizing shock.[32] In the late 1990-s and early 2000-s, several International Monetary Fund studies emphasize conceptual development and implementation of the forward-looking capacity in macroprudential mandates. The forward-looking capacity is consistently included in the macroprudential strategic sets developed by the central banks in Asia and Australia following the 1997 Asian crisis.[33] E.g., in Hong Kong, the Monetary Authority adopts "a forward-looking stance in supervision, [so that the] risks inherent in the business activities of banks can be identified early and mechanisms to manage such risks will be set up to deal with them effectively as they arise."[34] Yam (2007, p. 34) stresses that the forward-looking perspective constitutes "[t]he essence of macroprudential surveillance… It aims to assess risks which might potentially occur. Risk-based supervision also aspires to have a forward-looking perspective to risk, and aims to prioritize supervisory resources based on the risks presented by an individual institution to the financial system as a whole."

Summarizing the conceptual, theoretical, and empirical advances in the past twenty years, the International Monetary Fund (2011) has issued a series of comprehensive studies of macroprudential policy tools that specifically address their objectives and strategic capacities. The studies prominently underscore the importance of the forward-looking capacity of macroprudential tools. IMF (2011, p. 15) asserts that "[f]or macroprudential policy purposes, aggregate risk monitoring should be robust, forward looking, and contrarian."

Differentiation of excessive exposures and sensitivity to systemic risk posed—the objectives of limiting probability and severity of systemic failure and strengthening

32 Gonzalez-Hermosillo (1996), pp. iii-2.
33 Kardar (2011), CGFS (2010), Lim et al. (2011a, 2011b).
34 Yue (2001), p. 237.

infrastructure predicate on the sensitivity to systemic risk and on the capacity to distinguish excessive exposures (see Fig. 1). De Bandt and Hartmann (2000, p. 5) trace the emergence of this idea in early systemic risk literature. The authors focus on the distinction between systemic risk origination due to contagion versus common shocks and find that literature experiences "general difficulty to develop empirical tests that can make a clear distinction between" them. The early studies of systemic risk origination explore origination induced by common shocks (e.g. King and Wadhwani, 1990; Masson 1999a, 1999b) and common macroeconomic factors[35] (e.g. Calvo and Reinhart, 1996; Kodres and Pritsker, 1999).

The research on common exposures as a critical macroprudential idea has made important advances in the early 2000s. Acharya (2001)[36] proposes a theoretical study of a proposed prudential approach that separately considers exposures to systematic and idiosyncratic risk factors. "For any given level of individual bank risk, correlation-based regulation would encourage banks to take idiosyncratic risks by charging a higher capital requirement against exposure to general risk factors."[37] Elsinger et al. (2002) consider correlated exposures (as a source of systematic risk) and interbank exposures (as a source of contagion) in assessing the financial stability of the Austrian banking system and "find that correlation in banks' asset portfolios dominates contagion as the main source of systemic risk."[38] Theoretical studies of Rochet (2004, 2005) focus on "systematic risk, generated by a common exposure of banks to macroeconomic shocks."[39] Recent theoretical studies specifically focus on common exposures as a source of systemic risk (see Allen et al., 2012; Allen and Carletti, 2011). Wagner (2010),

---

35 In this approach, the notion of common exposures is studied through distinct asset classes, for example common investments in Lagunoff and Schreft (1998) and interbank exposures in Furfine (1999).

36 Acharya (2001) mimeo has been subsequently published as Acharya (2009).

37 Acharya (2009), p. 227.

38 Elsinger et al. (2002), p. 2.

39 Rochet (2005), p. 108.

Ibragimov et al. (2011), and Allen et al. (2012) explore the paradox between private optimality of diversification across asset classes and its social sub-optimality. In these studies, systemic risk arises as private diversification results in common exposures that amplify bank similarities and contribute to the negative externality.

Needless to say, the 2007-2009 financial crisis provided substantial emphasis for the critical role of common exposures in the systemic risk origination across institutions. This emphasis has also sharpened the policy focus on operationalizing the macroprudential mandates across the globe, the search for an international macroprudential policy consensus, as well on the design of macroprudential instruments. Substantial contributions in continued development of these questions are made by Borio (2009, 2010), Lim et al. (2011b), Nier (2011), and De Nicolò et al. (2012). Borio (2009, p. 31) clearly lays out the operational elements of the cross-sectional agenda, "concerned with how aggregate risk is distributed in the financial system at a given point in time. The policy issue here is how to calibrate prudential instruments so as to address common exposures across financial institutions and the contribution of each institution to system-wide tail risk." "This calibration can help ensure that each institution pays for the externality it imposes on the system."[40] De Nicolò et al. (2012, p. 12) expand the analysis of the relationship between the common exposures and time-varying requirements, pointing out that "Basel III also allows for adjusting risk weights in order to control exposures to specific assets." The authors suggest additional sources of possible time-varying responses to common-exposure-induced externalities. These include a) capital requirements, b) liquidity requirements, c) restrictions on activities, assets, or liabilities, and d) taxation.

[40] Borio (2010), p. 3.

In the United States, traditional microprudential supervisory guidance includes aspects of critical cross-sectional macroprudential elements. Bernanke (2008) states that "the [US] regulators were concerned not only about individual banks but also about the systemic risks associated with excessive *industry-wide* concentrations (of commercial real estate or nontraditional mortgages) or an *industry-wide* pattern of certain practices (for example, in underwriting exotic mortgages). ... [T]heir task is to determine the risks imposed on the system as a whole if common exposures significantly increase the correlation of returns across institutions." Bair (2009) and Bernanke (2009) discuss that the design of the US macroprudential mission includes cross-sectional "monitoring large or rapidly increasing exposures—such as to subprime mortgages—across firms and markets, rather than only at the level of individual firms or sectors", as well as "analyzing mutual exposures…for possible spillovers."

In the European Union, the importance of macroprudential focus on common exposures is keenly recognized. In particular, EU regulators are concerned with "significant risks to financial stability [that] can emerge when systemic risks identified at the national level may impact other jurisdictions through spillover effects and common exposures of financial institutions."[41] Accordingly, the European Systemic Risk Board (ESRB 2012, p. 2) recommendations emphasize "closer measuring and monitoring … [to] help authorities …in encouraging credit institutions to take necessary ex ante measures to correct distortions in risk management and in limiting excessive exposures. From the macro-prudential viewpoint, it is important that this is done at the level of the banking sector as well as at the level of individual firms."

---

[41] Constâncio (2012).

3.3. Forms of Macroprudential Policy Tools

In a series of IMF papers, Lim et al. (2011a, 2011b) survey the forms and global usage of macroprudential tools (See Fig. 2 and Table 1). Within the current variety of forms of macroprudential tools,[42] Lim et al. (2011b) find evidence that most tools are capable of reducing pro-cyclicality, although their usefulness "is sensitive to the type of shock facing the financial sector." This empirical finding sustains the intuition that the effectiveness of the macroprudential tools should be limited by their functional ability to identify conditions of systemic risk and imbalances. The authors also find evidence of inherent limitations in some tools and analyze the "conditions under which macroprudential policy is most likely to be effective." Their results support the idea that success of macroprudential tools is increased when the adaptive context of the financial system is addressed. Specifically, they propose that macroprudential efficacy is increased when usage includes 1) multiple tools, 2) targeted tools with higher ability to differentiate among exposures, 3) time-varying tools that can be adjusted through the range of financial conditions, 4) dynamic tools accompanied by clear rule-based communication, 5) tools that coordinate well and reinforce associated policy initiatives.[43]

Insert Fig. 2 about here

Insert Table 1 about here

3.4. Policy Evaluation in Adaptive Financial System

In his seminal critique of econometric policy evaluation, Lucas (1976, p. 20) argued that "that the features which lead to success in short-term forecasting are unrelated to quantitative policy evaluation, … and that simulations using these models can, in principle, provide no useful

[42] Including early warning systems, asset price models, stress testing, and microprudential feeds.
[43] Lim et al. (2011b), pp. 4-5.

information as to the actual consequences of alternative economic policies." In the context of the adaptive financial system, Lucas emphasized the point that the short-term success of econometric forecasting in capturing past change in the system had no policy value, since the system will change in the future in response to a policy change, resulting in "deviations between the prior 'true' structure and the 'true' structure prevailing afterwards."[44] To remedy this limitation, Lucas suggests the use of *adaptive forecasting* where policy must take into account the adaptive behavior of the economic agents.

Similarly to the Lucas advocacy of policy adaptation, social science research on public policy has long emphasized the view that policy is a process. In his study of the theories of the policy process, Sabatier (1991) emphasizes a fundamental point from these theories—that public policy requires an understanding of the adaptive behavior of the economic actors.[45]

Brock et al. (2003) discuss the relation between the evaluation of economic policy and uncertainty about economic structures. The authors extend and generalize Brainard's (1967) classic work on policy effect of model uncertainty in macroeconomic setting. They develop suggestions for policy evaluation where fundamental disagreements exist as to the determinants of the problem under study, specifically incorporating model uncertainty into policy evaluation. The premise of the research is the position that policy evaluation depends on a) policymakers objectives, b) conditional distribution of outcomes given a policy and available information. Therefore, policy evaluation is linked to decision-theoretic questions arising from different types of uncertainty. The authors express uncertainty about suitability of a policy as a loss function[46] and propose a methodology of robustness analysis that considers the change in optimal policy

---

44 Lucas (1976), p. 41

45 Sabatier (1991, p. 151) concludes that "From a policy perspective, the most useful body of work within this tradition has been that of Elinor Ostrom and her colleagues because it combines an actor-based perspective with attention to institutional rules, intergovernmental relations, and policy decisions."

46 In other words, considering the benefits and costs of the policymaker's choice.

with respect to a change in one of the parameters in the density of model factors. The authors account for different types of uncertainty as construction elements of the model space,[47] theory uncertainty, specification uncertainty,[48] and heterogeneity uncertainty.[49] In the accompanying comments, Leeper suggests that a dynamic extension of Brock et al. (2003) would a) confront the Lucas critique, b) allow the modeling of learning, and c) allow ongoing policy analysis in adaptive settings, "as new policy problems arise and the economy changes." [50]

In summary, classic literature on policy evaluation suggests that in the context of the adaptive financial system, the uncertainty in macroprudential policy can be addressed *adaptively* (Lucas, 1976), incorporating the behavior of economic agents (Lucas, 1976; Sabatier, 1991), as a continuous dynamic process (Sabatier, 1991), and considering the policymakers loss function (Brock et al., 2003) with the corresponding and ongoing (Leeper and Sargent, 2003) robust analysis of model uncertainty space.

New research on the dynamics of feedbacks in financial systems poses additional challenges for macroprudential policy. The key problem is the greater understanding of the dynamic effects and the variety of the transmission mechanisms by which regulatory policies may feed back into financial system and for which there is significant theoretical and empirical evidence.[51] This evidence shows that financial systems have a number of elements with procyclical response to various shocks. Under shocks, these elements can initiate a dynamic sequence from being shock absorbers into shock amplifiers. Many types of systemic feedbacks form dynamic responses to excitations of a system influencing the system's stability over time (See Table 2). They are time-dependent, mostly non-linear, and multi-step processes determining

47 Brock et al. (2003), pp. 268-272.
48 For example, lag length for vector autoregressions.
49 As the extent to which different observations are assumed to obey a common model.
50 Leeper and Sargent (2003), pp. 302-307.
51 For overview and further references see Bijlsma et al. (2010) and Gramlich and Oet (2012).

the relative states of stability or instability of the system. Systemic financial feedbacks may originate from endogenous or exogenous incentives, and are propagated via interactions within the system (May and Arinaminpathy, 2010). The cumulative causal outcomes of feedback effects may range from amplification (procyclicality) in cumulatively positive feedbacks to dampening (countercyclicality) in cumulatively negative feedbacks, with generally complex, asymmetric, time-dependent patterns in complex multi-loop feedback mechanisms.

Insert Table 2 about here

Consistent with the above theoretical perspective, modern policymaking practice recognizes the complexity of the adaptive economic setting. Bernanke (2004) discusses two types of central bank policies that incorporate behavioral considerations: *feedback policies* and *forecast-based policies*. Under a feedback policy regime, "the central bank's policy instrument…is closely linked to the behavior of a relatively small number of macroeconomic variables, variables that either are directly observable … or can be estimated from current information."[52] By contrast, "under a forecast-based policy regime, policymakers must predict how the economy is likely to respond in the medium term—say, over the next six to eight quarters—to alternative plans for monetary policy."[53] The adaptive challenge of policymaking is addressed through three distinct features of regulatory policies, *preemptive policymaking*, *structural monitoring*, and *risk-management approach*.[54] In particular, under the risk-management approach to policymaking, "a central bank needs to consider not only the most likely future path for the economy but also the distribution of possible outcomes about that path." To reach a policy decision, the regulators must evaluate "the probabilities, costs, and benefits of

52 Bernanke (2004).
53 Bernanke (2004).
54 Greenspan (2004), Bernanke (2004).

the various possible outcomes under alternative choices for policy." Under "risk-management policy paradigm," the regulators "may at times… undertake actions intended to provide insurance against especially adverse outcomes." [55]

4. USE OF SYSTEMIC RISK EARLY WARNING TOOLS FOR POLICY

The global financial crisis has propelled a powerful wave of new research in early warning tools for systemic risk. This research brings with it a wealth of new findings and creative empirical ideas. Some of the notable recent papers include Davis and Karim (2008a, 2008b), Melvin and Taylor (2009), Barrell et al. (2010, 2012), Rose and Spiegel (2011), Alessi and Detken (2011), De Nicolò and Lucchetta (2011), Babecký et al. (2013), Slingenberg and Haan (2011), and Zhu et al. (2012). In this study, we particularly focus on five studies of systemic early warning that resulted in macroprudential policy proposals: Frait and Komárková (2011), Schoenmaker and Wierts (2011), Sinha (2011), BOE (2011), and Oet et al. (2013a, 2013b).

In the discussion that follows, it is useful to define the usage of certain terms. Policy strategies are broad methodologies pursued by the regulators to achieve their objectives (e.g. countercyclical capital, defensive buffers).[56] Policy instruments are specific actions tied to measurable economic factors. Limit strategies pursue factors that can be directly controlled by economic agents. Target strategies pursue factors that cannot be directly controlled, but can be indirectly influenced. Limits involve factors that are typically, but not necessarily, adverse. Targets involve factors that are typically, but not necessarily, defensive.

55 Greenspan (2004).
56 See BCBS (2010a, 2010b).

Tables 3-5 compare the strategies and instruments of various proposed macroprudential mandates. As shown in Table 3, in the time dimension, all mandates generally maintain a consistent set of strategies for all phases (stable, ex-ante, critical, and ex-post phases) and objectives (prevention and mitigation for both short- term and long- term).[57] In the cross-sectional dimension, consistent but distinct strategy sets characterize the pursuit of the imbalance and interconnectedness goals. The discussion of potential uses of early warning tools, to borrow Holland's (1988) term, "is recklessly egotistical" in relying on the features of the Systemic Assessment of the Financial Environment (SAFE) framework (Oet et al., 2011 SAFE, 2012, 2013a, 2013b) to illustrate the macroprudential applications.[58] As discussed below, the systemic EWS model basis results in a substantial comparative richness in the feasible tactical instruments in the time- and cross-sectional dimensions.

Insert Table 3 about here

Insert Table 4 about here

Insert Table 5 about here

4.1. A Tour of a Systemic Risk Early Warning System[59]

The systemic risk EWS contains two components: first, a measure of systemic conditions, and second, a set of factors that are able to explain this measure. For example, a financial stress index (FSI) serves as a useful measure of systemic conditions by providing a continuous signal of financial stress and broad coverage of the areas that could indicate it. Economically, financial

[57] The seeming exception of Frait and Komárková (2011) strategies of buffer release and capital injection are forms of time-varying targets strategy.

[58] BOE (2011) discusses the strategic features of a number of instruments in use across the globe, proposed for the BOE macroprudential mandate. Mandate implementation would probably involve the capacities of BOE-developed model basis, e.g. the RAMSI framework.

[59] Oet et al. (2012, 2013a, 2013b).

stress is defined to be "*observable,* continuous manifestations of forces exerted on economic agents."[60] Guided by the empirical evidence from systemic risk early warning literature, the EWS may use financial imbalance theory to explain financial stress.[61] Financial imbalances are defined as deviations of financial variables from their mean, so they represent pressures in the financial system.

A responsive EWS methodology uses daily public market data collected from different sectors of the financial markets and employs some dynamic weighting method to capture the changing relative importance of the different sectors. While stress is always present in the financial system, significant stress is identified by observations of extreme co-movements of stress components across all markets. The FSI provides stress grades to allow interpretation of significant stress. These stress grades are modeled and calibrated against independent benchmarks of distress in each of the financial sectors. The EWS explains financial stress in the markets as a build-up of aggregate imbalances of financial institutions (the agents). The imbalances represent changing microeconomic responses of individual institutions. Thus, the EWS supports the macroprudential functions of identification: first, to detect financial system stress, and second, to spot institutional financial imbalances.

The EWS constructs the agent imbalances using z-scores. An imbalance $\underline{X_t}$ is defined as a deviation of some explanatory variable X_t from its mean. That is, each X_t explanatory variable is aggregated, deflated (typically by a price-based index), demeaned, and divided by its cumulative

60 Oet et al. (2011 CFSI), p. 12. Illing and Liu (2003, 2006, p. 243) examine financial stress "as a continuous variable with a spectrum of values, where extreme values are called a crisis." This concept of financial stress extends Bordo et al. (2000) notion of "an index of financial conditions" which studies whether aggregate price shocks are useful for dating financial instability.

61 It was developed by Borio and Lowe (2002a, 2002b, 2004) and Borio (2009) for aggregate macroeconomic imbalances. Borio and colleagues study the relationship between "banking distress" and aggregate macroeconomic imbalances such as imbalances in credit-to-GDP, property prices, and equity prices. Oet et al. (2011 SAFE, 2013a, 2013b) apply imbalance theory to institutional data.

standard deviation at time *t*. The resulting z-score is designated $\underline{X_t}$. By construction, $\underline{X_t}$ describes imbalance as the distance in standard deviations from the mean of the X_t explanatory variable.

The system allows forecasting of developing vulnerabilities. To mitigate inherent uncertainty, the EWS develops a set of medium-term forecasting specifications that gives policymakers enough time to take ex-ante policy action and a set of short-term forecasting specifications for verification and adjustment of supervisory actions.

The institutional imbalances may consist of several classes of institutional exposures: e.g. risk, return, liquidity, and system structure. In each exposure class, the EWS includes imbalances with significant statistical and Granger properties in explaining financial stress in the past. The EWS explains financial stress using both public and proprietary supervisory data from systemically important institutions, regressing institutional imbalances using an optimal lag method. The institutional imbalances are selected considering their optimal lag characteristics, based on the notion that shocks to various agent exposures take varying amount of time to precipitate to the conditions that materially change the agents' market behavior—i.e. the conditions tied to the financial markets' stress. The EWS considers two sets of these imbalances: those that historically have taken relatively short time (from one to six quarters) to precipitate into the financial system stress, and those that take relatively longer. The two modeling perspectives have distinctly different functions and lead to different model forms. Short-lag models function dynamically, seeking to explain stress in terms of recent observations of it and of institutional imbalances that tend to produce stress relatively quickly and with a short lead. Long-lag models seek to explain the buildup of financial stress well in advance, in terms of institutional imbalances that tend to anticipate stress with a long lead. For each of the two forecast horizons (short-lag and long-lag), the respective EWS forecast combination highlights the most persistent features of the institutional imbalance models in explaining and forecasting financial system stress.

In the EWS, some imbalances are adverse: that is, the larger the deviation of such an imbalance, the greater is the potential shock. Therefore, systemic financial stress tends to increase with the rise in adverse imbalances. Other imbalances are defensive: systemic stress tends to decrease with the rise in defensive imbalances. Across institutions, the EWS distinguishes excessive exposures for adverse imbalances and sufficient exposures for defensive imbalances based on its historical association of imbalances with stress. In addition, the EWS establishes and updates thresholds for each imbalance that are associated with stress migration across distinct grades of systemic stress. The EWS is also a learning environment, in a sense that these excessive and sufficient exposures change over time as the financial system adapts over time. In each temporal regime (long run and short run), the EWS highlights imbalances that have strong positive and negative associations with financial stress. This enables a focus on imbalances that are sensitive to the financial agents' contributions to systemic risk across time.

4.2. Macroprudential EWS Use for Time-Dimension Objectives

4.2.1. Time phases and policy

Tactical applications of a systemic risk EWS in the time dimension reflect the fundamental aspects of supervisory financial stability policies as a function of the time varying level of financial stress. Policymaker's possible actions are, therefore, predicated by two conditions: first, their existence in the space of available macroprudential strategies[62], and second, their ability to identify stress concurrently. Thus, the key feature of a systemic EWS

62 The strategies in turn have to exist in the space of financial stability objectives.

driving any tactical policy applications is its capacity to differentiate stress aggregation across time. In particular, the EWS should be able to differentiate the various phases of a stress cycle.

From a purely conceptual standpoint, it is reasonable to distinguish four time phases of stress cycle: ex-ante stability, ex-ante escalation, systemic stress, and ex-post (see Fig. 3). Each phase is characterized by a specific pattern within certain ranges of stress values.

Insert Fig. 3 about here

The ex-ante stability phase is characterized by fluctuations of stress within a historically normal range of stress values. Occasionally during this phase, stress may also decline into the below-normal range. This may be due to a number of factors like financial system growth, technology changes, financial agent optimism and expectations, etc. Generally, the episodes of below-normal stress tend to be brief, as financial agents find it profitable to increase their risk appetites quickly with a corresponding elevation of stress into the normal range. In this hypothetical stress cycle, the ex-ante stability phase should immediately follow the ex-post phase and be followed by the ex-ante stress escalation phase. The latter is characterized by dual increases in the *level* and *rate* of financial stress. During this phase, stress migrates from normal to moderate range of stress values.

The critical—systemic stress—phase is characterized by movement of stress within moderate to significant range of historical stress values. The ex-post phase generally follows the systemic stress phase and exhibits stress anywhere from normal to below normal range. This phase may or may not be distinctly different from the stability phase. To the extent that differences exist, the ex-post phase is characterized by the “rough landing” pattern of stress following a period of systemic stress, when small “after-shocks” may have inordinately amplifying effect on stress until the financial system settles into the new stability phase.

Thus, a macroprudential tool forming a basis for tactical actions in the time dimension should be able to identify a phase of relative stability, an ex-ante phase of stress increase, a critical phase, as well as an ex-post phase of reestablished stability. Considering this, it is clear that the policymakers' choice of policy actions in the time dimension is assisted by establishing the decision rules defining the ranges and the thresholds corresponding to the ranges of systemic stress. The decision rules then allow differentiation of stress phases among the volatile time patterns of stress, while stress thresholds facilitate the identification of systemic stress episodes among the phases.

To proceed, it becomes operationally convenient to consider the zones between thresholds as grades of stress. Given an imbalance-based systemic risk EWS, it can be shown[63] that policymakers' decision process is assisted by finding stress target policies and imbalance action thresholds. Accordingly, a similar approach of retrospective EWS forecasts in a series of historical stress episodes can establish the stress targets and action thresholds useful for supervisory policy. When the forecast of concurrent stress is below a target action level, this approach supports a policymakers' *laissez-faire* decision to let the markets' self-resolve. When forecast of stress exceeds the target level of stress, this approach enables a policymakers' risk management process to weigh the economic costs of regulatory action against economic costs of a shock.

The architecture of a systemic risk EWS provides policymakers two time horizons (short-term and medium-term) and two channels for macroprudential actions in the time dimension. The first channel includes actions related to the measure of financial stress.[64] The second channel

---

63 See Oet et al. (2012), who investigate the choice of stress grade targets and action thresholds based on the US empirical evidence.

64 The Cleveland Financial Stress Index (CFSI) in the SAFE EWS

includes actions related to the EWS model of institutional imbalances. While the index measures current stress in the markets, the model forecasts future stress. Both channels are the product of the common design objective of systemic risk EWSs: that of contributing to financial system stability through the development of tools that inform monetary policy and supervisory policy actions. Accordingly, a financial stress measure seeking to aid macroprudential policy should effectively differentiate among areas and factors of stress origination.[65] This financial stress measure (FSI) includes the time pattern of systemic stress and finds, based on probit regression, that the pattern optimally corresponds to four stress grades matching the conceptual time phases of a systemic stress cycle (see Fig. 4).[66]

Insert Fig. 4 about here

As shown on the right-hand-side vertical axis of Fig. 4, the FSI provides the probabilities of a systemic stress episode, given the particular level of stress. For example, the May 2012 FSI level is very close to zero, falls into the normal stress grade, and implies that the probability of this stress being a part (e.g. being the "on-ramp") of a systemic stress episode is no greater than 8.7%. The vertical bars in the chart represent incidents of well-known stress episodes.[67] The four identified stress grades serve to establish thresholds that differentiate among the time phases of stress (see Table 6).

Insert Table 6 about here

65 CFSI currently differentiates among six financial market sectors (credit, foreign exchange, equity, interbank, real estate, and securitization) and sixteen origination factors. See Oet et al. (2011 CFSI, 2012) for discussion of the Cleveland Financial Stress Index and comparative discussion of other US financial stress measures. These measures show alternative allocations of sectors and factors of the US financial system.

66 By comparison, Bordo et al. (2000) suggest a five-category differentiation of distress, with a refinement of the below normal stress grade into two categories: "moderate expansion," and "euphoria."

67 Oet et al. (2011 CFSI, 2012) find the index to be responsive to stress episodes and a reasonably good identifier of systemic financial stress.

Using the observable market phenomena, FSI informs the policymakers and the public about the aggregate level of financial stress in the system. In addition, the index is useful for structural monitoring.[68] Lastly, the risk management aspect of central bank policies is helped by the EWS strategic capacity of forecasting of stress across time. Specifically, the EWS estimates stress in the financial system at a future point in time with a medium-term (12 to 18 months) forecasting horizon, enabling the regulators to weigh the risk-management implications of proposed policies. In addition, the EWS provides an additional set of near-term forecasts for verification of policy actions.[69] The typical graphic output from the EWS out-of-sample forecast is shown in Fig. 6. The graph compares the actual realized stress index (solid line) against the two sets of EWS forecasts: near-term using short lag imbalances (dashed lines) and medium-term using long lag imbalances (dotted line).

Insert Fig. 5 about here

Insert Fig. 6 about here

Consideration of the macroprudential strategies in the time dimension in various macroprudential mandates reveals a great degree of consensus (see Table 3). The set of strategies includes in the descending order of frequency: time-varying limits (5), time-varying targets (5), time-varying risk weights (3), disclosure (2), communication (1), identification of stress phase (1), guidelines for monitoring (1), distribution restrictions (1), time-varying charge (1), and asset rate rules (1). These strategies are stated broadly and allow policymakers further refinement. For example, guidelines for monitoring can specifically include stress level and rate of change

68 See Section 3.4. Oet et al. (2012, p. 29) analyze US FSI series for structural breaks using Quandt likelihood method (Quandt, 1960). They find of evidence of two breaks (see Fig. 5): “The first break, indicated likely in August 1998, corresponds to the announcement of Financial Services Act passage by the U.S. Senate, leading up to the U.S. Financial Services Modernization Act later in the year. The second break, indicated likely in July 2007, corresponds to mounting frictions in the financial markets that would result in the financial crisis.”

69 See Oet et al. (2013a, 2013b) for the discussion of out-of-sample accuracy of EWS forecasts.

monitoring (Oet et al., 2013a, 2013b), or time-varying targets can include countercyclical buffers, time-varying provisioning, and time-varying reserve requirements (Frait and Komárková, 2011).

In general, macroprudential policies in the time dimension seek a set of remedial actions to “create built in mechanisms that attenuate the impact of procyclical behavior.”[70] Further tactical details emerge in consideration of the strategic objectives that arise during the distinct time phases of stress cycle. In the stability, ex-ante, and ex-post phases, the principal responsibility of regulators will be the prevention of systemic stress increase. To the extent that the regulators can influence the propagation of stress from an ex-ante phase to the critical phase, their macroprudential actions would be designed to inhibit stress increase. In the critical phase, the principal responsibility of policymakers is mitigation. Thus, in the time phases following the prevention strategy, the macroprudential actions focus particularly on instruments that enable careful monitoring and disclosing levels of stress and imbalances. In the critical phase, following the mitigation strategy, the macroprudential actions focus on instruments that enable reduction of adverse stress impacts.

4.2.2. EWS instruments in the time dimension[71]

Short–term macroprudential EWS tactics ought to be exercised during the ex-ante escalation, critical, and ex-post phases. The corresponding EWS-based instruments support the relevant strategies of disclosure and stress and imbalance identification. Based on the current EWS capacities, the use of seven instruments in the ex-ante escalation stress phase is suggested: 1) disclosure of stress grade, 2) disclosure and identification of stress phase, 3) stress level and rate of change monitoring, 4) disclosure of public forecasts, 5) disclosure of public imbalances,

[70] Cukierman (2011), p. 30.
[71] See Table 8 and Table 9.

6) guidelines for monitoring short run imbalances, and 7) communication of private imbalances and macroprudential limits.

Critical phase tactics emphasize disclosure of instruments that ameliorate existing stress and communication of adverse imbalance limits and defensive buffers. The population of adverse imbalances is dynamic and time-dependent. In addition to the seven ex-ante escalation instruments, a number of defensive imbalances may be targeted for policy instruments besides the capital and liquidity buffers. Four additional instruments are suggested to help reduce stress: 1) appropriate interest rate defensive exposures and plain vanilla hedges, 2) credit risk distance targets, 3) solvency targets, and 4) institutional liquidity targets. The supervisors would utilize macroprudential EWS analysis to establish pre-targeted minimums that institutions must maintain in systemic stress phase.[72] Ex-post phase continues to emphasize the disclosure instruments 1 through 5.

Long-term macroprudential EWS tactics can be exercised during the stability and ex-ante escalation phases and utilize instruments based on the long run institutional imbalances. The seven short-term policy instruments suggested above are also used for the long run objective. However, given the long run objective, these instruments would use different long run limits and targets to encourage countercyclical risk management. Specifically, long run EWS instruments could include four new instruments of recommended targets for 1) positive-relative-to-inflation interbank currency exposures, 2) balance sheet liquidity under adverse stress scenarios, 3) institutional interest rate defensive exposures, and 4) credit risk distance measures.

[72] Perhaps subject to prompt corrective action.

Through its specific design for the prudential objectives of monitoring, alerting, and forecasting[73], the FSI acquires strategic capacities important for policymaking. These capacities reflect its functions to: 1) improve supervisory monitoring of emerging stress in the financial system, 2) produce alerts when stress reaches certain thresholds,[74] 3) aid short-term systemic stress projections. Additional useful capacities also stem from the intrinsic design features of the FSI: its continuity and transparency to the underlying market components.

Potential EWS instruments of identification—EWS identification instruments include stress components, stress grade, stress grade thresholds, stress level, one period rate of change, and two period rate of change.

The initial step in determining the potential response of supervisors to financial market stress ought to be an *analysis of the degree of stress*. The FSI offers continuous and contemporaneous identification of financial stress. Further, the construction of the FSI stress grades helps supervisors to address the question of stress severity. It is important that policy response to financial stress not be mechanical but well considered. Among others, these considerations can include the following three FSI features: current stress grade, FSI signaling, FSI rate of change trends, and FSI projections.

First, the policy response should anchor to the current specific grade. For instance, only twice has the financial system been in Grade 4. These periods were unique and the policy responses (both monetary and supervisory) necessitated extraordinary measures. Historically, policy responses during the times of moderate stress (Grade 3) have been both more common

[73] See Oet et al. (2012).

[74] For example, chosen thresholds can include grade boundaries with established standardized distance measures or be based on targeted implied systemic stress probabilities.

and less aggressive then crisis policies. Thus, it would be more appropriate to expect that the bulk of regulatory policies would be undertaken tied to specific observations of moderate stress.

Second, it is also beneficial for the supervisor to monitor the origin of stress by analyzing the components of the FSI. This is rather difficult, because systemic financial stress generally exists concurrently in multiple markets. Stress in an individual market has the potential to become systemic by influencing other markets, i.e. propagating. The combined information from the stress components of the FSI gains value as "systemic stress-related events are more likely to affect spreads in multiple markets. Observing conditions in a number of markets allows for the potential identification of a common factor, that is, financial stress."[75] Any consideration of specific policy actions should carefully consider the particular markets affected and stress origins within these markets. Here, a signaling rule provides a valuable roadmap: for example, "systemic stress is two consecutive periods of distress above previous period thresholds, or concurrent distress in at least two distinct markets. This operational guide enables the supervisor to observe significant stress alerts both within a particular market and in the system, as stress signals that begin propagation through several markets. This identification offers … significant time advantage in the interpretation of observations of the financial system stress."[76] Fig. 7 shows a sample application of such a signaling rule to FSI. In addition, *current trends* in the FSI, which include the rate of change of FSI with respect to time, $\dot{FSI} \stackrel{\text{def}}{=} dFSI/dt$, provides useful information.[77] If the supervisor identifies the current episode, or its features (e.g. $\dot{FSI}$ and $\ddot{FSI}$) as systemic, the finding could be sufficient to warrant further careful consideration of policy responses. To illustrate, consider the FSI series from 4Q 1991 to 4Q 2011. Analysis of FSI trends

75 Bianco et al. (2012), pp. 1-2.
76 Oet et al. (2012)
77 Oet et al. (2012) consider $\dot{FSI}$ over one period, $\dot{FSI}$ over two periods, and FSI acceleration (steepness of the rate of change—$\ddot{FSI} \stackrel{\text{def}}{=} d\dot{FSI}/dt$).

would alert policymakers to the significant developing stress in the 3Q 1998 (the advent of LTCM crisis) and the 3Q 2007 (the advent of Subprime crisis). The two-period intertemporal rate of change of FSI ($\dot{FSI}_2$) at these points showed a movement of 1 standard deviation or more: 1.0 std and 1.3 std respectively (see Fig. 8 and Fig. 9). However, the finding of systemic stress[78] on its own may not constitute a necessary condition for policy action.

Insert Fig. 7 about here

Insert Fig. 8 and Fig. 9 about here

Although FSI is designed for prudential applications, it also gives the public a set of dynamic strategies. Therefore, supervisory uses of FSI should consider its different potential users and, in turn, its dynamic effects, including the potential positive and negative feedbacks induced by the FSI information. Its *direct* users may include supervisory and monetary policymakers. *Indirectly*, FSI[79] informs the financial market authorities, the financial institutions, as well as government fiscal policymakers. The dynamic effects in this setting would stem from the relationship of the financial institutions' strategies to the expectations of direct and indirect policy actions. The policymakers can further explore the resulting information feedback to amplify or balance desired policy actions.

Potential EWS guidelines for monitoring—Potential EWS monitoring guidelines can serve to establish consistent standards of interpretation of the EWS results and to form a basis for further disclosure and communication instruments. In addition to clarifying the stress level and rate of change, these guidelines could include short run imbalances and transition matrices.

[78] The finding of systemic stress may be triggered by the rate of change of stress vis-à-vis its historical pattern or some specific grade threshold of stress.

[79] Including overall FSI observations, its components, and its signals of systemic or individual markets' stress.

It can be shown that FSI exhibits important autoregressive properties and that different Granger property patterns of interaction exist between institutional imbalances and financial stress (see Table 7).[80] The patterns of association of institutional imbalances with financial markets' stress allows the EWS to establish and utilize several basic monitoring models, including an FSI-based benchmark model, and some basic short and long run models based on publicly available data (see Table 8).

Insert Table 7 about here

Insert Table 8 about here

Monitoring thresholds for each imbalance associated with stress in the short run enables policymakers to consider risk management of systemic stress. In addition to their use in internal monitoring, the policymakers can make the monitoring guidelines available to the public through disclosure. This disclosure would in turn allow the financial system agents to improve the short-term risk management of their exposures to avoid system-wide stress.

The EWS basis in the interaction of institutional imbalances and financial stress also provides the corresponding transition matrices as an additional instrument for monitoring. A typical monitoring transition matrix describes the change of a particular aggregate imbalance that is associated with transition of stress from one grade to another, all else held equal. A sample transition matrix for leverage is shown in Table 9. The monitoring transition matrices may be integrated into 1) the assessment of overall level of stress, where transition of stress components may be observed; 2) the analysis of the contributions of individual stress components and institutional imbalances to overall stress; and 3) the design of policy actions (whether any action is warranted, in what area of exposure, and how to act).

[80] Oet et al. (2012, 2013a, 2013b).

Insert Table 9 about here

Potential EWS time-varying limits and targets—the EWS provides a number of models that explain financial stress as a function of certain aggregate institutional imbalances. Because of the dynamics of the interaction of these imbalances with financial stress, the sensitivity of the contribution of individual imbalances does not remain static, but varies in time as the series changes. Therefore, the instruments tuned to specific aggregated imbalance need to be considered flexibly and beyond a pre-imposed static countercyclical schema. Specifically, the instruments should recognize the varying weight of the imbalance's contribution to overall predicted financial stress. Fig. 10 shows a 1Q 2012 example of that the actions of the financial agents result in varying sensitivities of the long-lag imbalances to financial stress. As this example illustrates, among the imbalances with consistent Granger properties to financial stress that enter the EWS models (see Table 7), recent evidence emphasizes those imbalances with particularly high stress interaction sensitivities. [81]

Insert Fig. 10 about here

Similarly, the defensive imbalances can also become the source of time-varying policy targets, where policymakers can target financial institutions to maintain certain defensive aggregate exposures at a certain level. For example, as Fig. 10 suggests, recent EWS analysis supports the beneficial effect of the post-crisis institutional deleveraging on financial stress. Based on this evidence, current forecasts retain this defensive impact of deleveraging, assuming that the interaction sensitivity with financial stress is maintained at its present level. EWS-suggested time-varying targets include solvency level, solvency distance, capital buffer,

[81] Based on recent analysis, the suggested EWS time-varying limits would include liquidity index, aggregate expected default frequency, interbank concentrations, and leverage. The time-varying limit instruments are also relevant in the cross-sectional dimension, as policymakers further attribute imbalances to specific institutions and form detailed microprudential limits.

leverage, interbank currency, interest rate hedging, interest rate distance, institutional liquidity, liquidity buffer, and credit risk distance.

Potential EWS instruments of disclosure—The tactical importance of prudential disclosure instruments lies in their ability to reduce market uncertainty. However, given the considerable variation in disclosure practices (FSB-IMF-BIS, 2011), the considerable burden of excessive disclosure, and its information overload (Kohn, 2011)[82], it may be particularly important to clarify which exposures should be disclosed in pursuit of macroprudential objectives.

In an important early study of "Prudential supervision to manage systemic vulnerability," Guttentag and Herring (1988) consider policy options to counteract financial agents' behavioral factors such as cognitive bias and Knightian uncertainty. They strongly advocate the use of systemic application of *supervisory stress testing*. Herring (1999, p. 77) emphasizes that "the systematic application of stress tests is perhaps the most effective defence against disaster myopia. … By specifying the kinds of shocks and magnitudes of shocks that banks should be prepared to sustain, the regulatory authorities can ensure that low-probability, high-severity hazards are not simply ignored." Among alternative policy options, Herring (1999, p. 77) also suggests that *information releases* may be useful in reducing procyclicality: "Ex-ante public disclosure of exposures to credit risk may exercise some **constraining influence**.[83] And even if disclosure fails to constrain the build-up of concentrations of credit risk ex ante, at least it is likely to reduce collateral damage when disasters occur, by reducing the destructive uncertainty

---

82 Considering the retrospective impact of disclosure on the 2007-2009 Subprime Crisis in the United States, Kohn (2011, p. 8) argues that "For some instruments, even if disclosure had kept up it would have been futile – instruments were so complex that the required information to appropriately monitor risks was overwhelmingly large. Indeed excessive complexity and information overload may be limiting factors on the effectiveness of disclosures."

83 Emphasis added.

about which institutions have sustained damage from the shock." Bernanke (2004) emphasizes the significant policy role of regulatory disclosure and communications: "Central bank communication and transparency are important precisely because of the role of private-sector expectations in determining the effectiveness of monetary policy." [84]

Disclosure instruments feature prominently among the instruments of the recent macroprudential mandates (see Table 4 and Table 5). However, the lack of model basis, as well as the regulatory caution over pursuing empirically unproven instruments limits the prudential toolbox to those instruments that have already been effectively tried. Bank of England (BOE, 2011) cites the empirical evidence of the US and EU stress test disclosures to support the use of its macroprudential instrument recommendations for targeted disclosure requirements "to reduce likelihood of information contagion" and "to enhance resilience by limiting uncertainty about specific exposures or interconnections."[85] At the same time, the authors warn that the use of liquidity disclosure instruments should be weighed against the risks of "spooking the market or making buffers less usable."[86] Correspondingly, the Bank of England proposed disclosure instruments reflect this cautious approach: in addition to stress test disclosures, Bank of England suggests ongoing enhanced disclosure of sovereign and banking sector exposures, combined with "occasion[al]…disclosure of exposures to specific risks."[87]

The Bank of England's careful approach to disclosure certainly parallels the caution urged by the present study (see Section 3.4) against unguarded introduction of policy instruments. Nevertheless, the systemic EWS model basis enables additional detail and clarifies the design intent in the consideration of potential time-varying disclosure instruments.

---

[84] For additional discussion of information value of disclosure see Morgan et al. (2010), Tarullo (2011), and Kohn (2011).
[85] BOE (2011), p. 5.
[86] BOE (2011), p. 19.
[87] BOE (2011), p. 29.

Specifically, the EWS continuity permits consideration of variable instruments for the four different temporal regimes of policy: a time of stability, ex-ante to episode formation, within a stress episode, and ex-post.

Systemic risk EWS-based disclosure instruments can include various information components of the analytical framework: 1) *stress identification measures* (stress grade, stress phase, stress level, stress rate of change), 2) *prudential guidelines* (guidelines for short-term limits, guidelines for short run imbalances, transition matrices, and guidelines for long-term targets), 3) *risk warnings* (short-term and long-term public imbalances, short-term and long-term public forecasts), and 4) *stress testing*.

Policymakers may elect not to disclose certain information components when their risk management assessments show that the benefits of transparency are likely to be outweighed by the risks of adverse behavioral feedbacks in the markets ("spooking the markets"). However, increased understanding of the potential disclosure instrument choices clearly benefits the policymakers' capacity in pursuit of financial stability in the long run.

Disclosure of prudential guidelines and risk warnings is intended to "increase accountability" and "transparency of internal decision-making processes" "creat[ing] commitment on the part of the macroprudential authority or its constituent agencies to take follow-up action."[88] In addition, disclosure of risk warnings serves to enhance the capacities of the financial agents to manage systemic risk and imbalances across the time dimension without creating "the impression that the authority is attempting to predict crises."[89] Importantly, the disclosure of the EWS public imbalances and forecasts "can in and of itself lead to changes in behavior of markets and institutions, potentially reducing the need for more intrusive

---

88 IMF (2011), p. 41.
89 Ibid.

intervention."[90] Finally, disclosure of EWS-based stress testing components[91] serves to reduce uncertainty dynamically by the linking of systemic risk EWS identification measures with the ongoing stress-testing activities and information releases to the public.

Potential EWS instruments of communication—Macroprudential communication instruments can contain the full set of EWS-based public disclosure instruments, including 1) stress identification measures, 2) prudential guidelines , 3) risk warnings, and 4)stress testing. In addition to these public EWS instruments, the regulators can also select private instruments, such as those based on institution-specific exposures, or exposures that concern only a certain group of institutions. By choosing to communicate regarding these instruments privately, the policymakers both address specific microprudential concerns and avoid the transmission of baseless anxiety to other financial agents that are not similarly exposed. Thus, by definition, communication instruments should include those that tend to time-vary dynamically across different groups of institutions. This approach is consistent with other current macroprudential mandates. For example, Frait and Komárková (2011) mandate incorporates"[a]ctive communication with the financial markets and the public, including disclosure of stress tests results, in order to reduce the level of uncertainty about the stability of the financial sector."[92] Based on the above premises, the EWS-based communication instruments can also include 1) private imbalances, 2) macroprudential limits, 3) macroprudential targets, and 4) stress testing. Policymakers' actions based on these instruments would include communication of findings based on private supervisory observations of imbalances directly with the institutions and

[90] Ibid.

[91] In the SAFE EWS, stress-testing measures include the scenario-based sets of solvency distances, liquidity index distances, credit risk distances, and interest-rate risk distances (see Oet et al. 2013a, 2013b).

[92] Frait and Komárková (2011), p. 105.

provision of specific guidance when the institutions approach the individual institutional limits and targets.

The preceding discussion explained the conceptual alignment of the new systemic risk early warning tools with the functional requirements of regulatory policies. The design of these early warning tools is directed to facilitate the prudential objectives of monitoring, alerting, and forecasting systemic stress. These functions correspond precisely to the preemptive, structural monitoring, and risk-management requirements of the central bank policies.

4.3. Macroprudential EWS Use for Cross-Sectional Objectives

Tactical applications of a systemic risk EWS in the cross-sectional dimension reflect the macroprudential policy objectives of limiting failure across institutions and strengthening infrastructure resilience. The key features of a systemic EWS driving its tactical applications cross-sectionally are the EWS capacities to distinguish imbalances across institutions and to respond sensitively to systemic risk posed through the intricate interconnections of the financial system.

4.3.1. Cross-sectional directions and policy

A macroprudential tool with a capacity to limit severity of failure should in particular be able to subdue the imbalances that amplify financial stress and result in excessive stress propagation. In other words, the tool should be able to differentiate imbalances that are common across institutions and associated with increases in systemic risk and to limit them. Doing so would control those aggregate institutional imbalances that are able to amplify the propagation of systemic stress. Tactically, reducing such common exposure imbalances can provide some protection to limit the severity of failure.

Furthermore, to lower the probability of systemic failure, the macroprudential tool should also be able to differentiate those uncommon imbalances that have some potential to propagate financial stress across institutions. Put differently, the tactics should include identification and monitoring of adverse cross-sectional imbalances. A financial system may consist of a set of institutions that are diversified cross-sectionally.[93] Despite the relative absence of common aggregate imbalance, the presence of several institutions with individual exposures that interact with financial stress with significant correlation (adverse exposures) enables a potential for a shock-triggered ripple through the correlated group of institutions. In this system, the adverse exposures subjected to a shock can increase the probability of systemic failure. Conceptually, the macroprudential tactics would include identification and monitoring of these adverse exposures, as well imposition of exposure limits to decrease the vulnerability of the affected group of institutions to a damaging run, reducing the probability of systemic failure.

A macroprudential tool with a capacity to strengthen infrastructure resilience should be able to distinguish sensitively the effects of direct and indirect interconnectedness of financial institutions. As discussed above, to the extent that common or even simply correlated exposures exacerbate the potential for systemic failure, uncorrelated exposures across institutions and time help mitigate this potential and increase the overall system resilience. In addition, infrastructure resilience to potential shocks is enhanced to the extent that the financial system accumulates sufficient defensive exposures (e.g., capital, liquidity, etc.). Therefore, the tactics to strengthen infrastructure resilience can be twofold: first, promoting uncorrelated exposure and behavior and second, promoting defensive exposures. It follows that the resilience tool should possess both macroprudential and microprudential capacities: macroprudential—because it considers systemic

[93] That is to say, at each point in time, this set of institutions maintains tends to maintain internally offsetting exposures. A perfectly diversified set of institutions would maintain a zero net imbalance.

risk aggregations across institutions, and microprudential—because it considers exposures within an institution at each point-in-time. First, the resilience tool should be able to identify uncorrelated behavior across institutions and provide regulators with tactical instruments to encourage uncorrelated behavior. Second, the resilience should distinguish those exposures that consistently reduce financial stress for both prudential perspectives, that is for the institution and the system. A classic example of such defensive exposure is capital. To an individual institution, accumulation of capital is a defensive mechanism to reduce vulnerability to failure. To the financial system, accumulation of capital acts as protective buffer against systemic stress. However, capital is not the only defensive exposure. The resilience tool should be able to identify several of these and provide regulators with tactical instruments to encourage defensive exposures, strengthening infrastructure resilience.

As discussed for the time-dimension tactics, the EWS analysis of Granger properties of short-lag and long-lag institutional imbalances (Table 7) provides a foundation for further modeling of time-varying adverse and defensive imbalances (Fig. 10). These imbalances can also anchor the tactics in the cross-sectional dimension as aggregate time-varying limits (for adverse imbalances) or targets (for defensive imbalances). In addition, the EWS allows consideration of the microprudential aspects of cross-sectional objectives through analysis of individual firm contributions to financial stress. As Fig. 11 shows, the cross-sectional risk topography of the EWS is informative and allows the study of change in aggregate risk across various markets and across time. Furthermore, the EWS provides the analytical perspective that allows common exposure analysis for tactics to limit severity of systemic failure (see Fig. 12). In fact, Fig. 12 provides clear visual evidence of the structural break of 1998 observed earlier through the structural monitoring capacity of the FSI (Fig. 5).

Insert Fig. 11 about here

Insert Fig. 12 about here

In a further enhancement of cross-sectional analytics, the EWS allows decomposition of financial stress by risk element within a specific financial firm (see Fig. 13). This allows supervisors to distinguish those institutional exposures that are idiosyncratic from those that are systematic. Macroprudential policies of limits (for adverse exposures) or targets (for defensive exposures) can address the exposures that are common across institutions. The idiosyncratic exposures are unique to specific institutions and can be addressed by microprudential means.

Insert Fig. 13 about here

4.3.2. EWS instruments in the cross-sectional dimension[94]

EWS tactics in the cross sectional dimension share common strategies with the EWS tactics used across the time dimension. For example, in both preventive and mitigating strategic sets, the tactics include instruments of public disclosure and private communication:[95] disclosure of 1) stress identification measures, 2) prudential guidelines, 3) risk warnings, and 4) stress-testing; communication of 1) private imbalances, 2) macroprudential limits, 3) macroprudential targets, and 4) stress-testing.

In addition to the common disclosure and communication instruments, EWS tactics to limit severity of failure concentrate on two types of policy instruments: 1) identification of common adverse imbalances across institutions, 2) time-varying limits on these systematic cross-sectional imbalances. The identification instruments are applied by institution and include

[94] See Table 8 and Table 9.

[95] These instruments are common in the preventive and mitigating sets across the time dimension as well. See Section 4.1.1.

monitoring of aggregate adverse imbalances. The time-varying limit instruments are applied to aggregate adverse imbalances. With the transition from preventive to mitigating sets, the EWS tactics refocus from long run imbalances and limits to short run imbalances and limits.

Similarly, EWS tactics to limit probability of failure include common disclosure and communication instruments and focus on instruments of identification, monitoring and limiting the aggregate adverse long run and short run imbalances. Again, the perspective of these instruments changes from the long run to short run perspective, as the strategies change in time from preventive to mitigating.

EWS tactics to strengthen resilience in the event of shock to a particular exposure center on the principal defensive means to withstand the shock. These tactics implement the two types of strategic emphasis discussed above. The first type consists of tactics that encourage idiosyncratic imbalances across significant institutions. In the prevention set, these instruments include building up defensive exposures through time-varying risk weights. In the mitigation set, these instruments include a progressive reduction in required minimum buffers and targets when institutions show certain idiosyncratic imbalances. The second type consists of tactics that encourage defensive imbalances. The instruments include customized versions of short run and long run defensive targets. In addition, in the prevention set, the means of building up defensive imbalances include time-varying risk weights. In the mitigation set, these instruments include a progressive reduction in buffers and limits when institutions exceed defensive targets.

Among these instruments, probably the most challenging set of instrument design issues is raised by the time-varying risk weights. This instrument is not unique to the EWS tactics. In fact, it is common across several macroprudential mandates. Acharya (2011) explains this instrument as implemented by the Reserve Bank of India.

> *"This approach requires horizontal aggregation of financial institutions–balance-sheets and risk exposures to identify over time – say each year – which asset classes are being "crowded in" as far as systemic risk concentrations are concerned. For instance, if mortgages or mortgage-backed securities are increasingly picking up the lion share of all risks on bank balance-sheets, then the regulators could proactively react to limiting any further build-up. This could be achieved for instance by increasing the risk weights on future exposures to this asset class….One advantage of dynamic sector risk-weight adjustment approach is that if it is consistently implemented by regulators and anticipated by the financial sector, then it can act as a valuable countercyclical incentive. Financial firms anticipating the future risk in risk weights may stop adding exposure to an asset class once it is sufficiently crowded in. One disadvantage is that it may create a race to "get in first" and also relies heavily on regulatory discretion turning out to be prescient in identifying risk pockets and having sufficient will in good times to lean against the wind of fast-growing asset classes."*[96]

The EWS provides supervisors a number of imbalance-based defensive policy instruments, in addition to the traditional capital and liquidity instruments. These defensive imbalances tend to reduce stress propagation. Thus, the EWS enables a host of additional policies that encourage institutions to strengthen cross-sectional resilience. For example, in the short run the EWS highlights the benefits of interest rate defensive exposures and plain vanilla hedges, building-up institutional credit risk distance measures, and maintaining strong institutional liquidity. In the long run, the EWS highlights positive-relative-to-inflation interbank currency exposures, strengthening balance sheet liquidity under adverse stress scenarios, as well as building up institutional interest rate defensive exposures and credit risk distance measures.

5. CONCLUSION

How can a systemic risk early warning system (EWS) facilitate the financial stability work of policymakers? The present paper explored this complex topic in the spirit of starting an open discourse. The discussion addresses the conceptual bases for specific types of policy applications first as functions following objectives of financial stability, then as tactical

96 Acharya (2011), pp. 26-27.

supervisory actions. As such, policy actions become enabled by specific macroprudential tools that satisfy the strategic and tactical requirements. These requirements target systemic stress aggregation in two dimensions: across time and institutions. A systemic risk EWS is only one of the tools capable of this role. Yet, it enables a distinct set of policy applications.

This study shows that a systemic risk EWS provides a consistent conceptual basis for the deployment of macroprudential policy applications as a function of systemic stress. It extends the topic of EWS supervisory policy applications, up to now insufficiently developed. This basis further substantiates macroprudential policy choices in contrast to the conventions of microprudential practices.

Strategically, systemic risk EWS focuses on identification of stress and institutional imbalances, in addition to forward looking analytics, differentiation of excessive exposures, sensitivity to systemic risk posed, and capacity for macroprudential risk management. Dealing with stress aggregation across time, potential EWS policy applications in pursuit of two tasks are discussed: prevention and mitigation. One of the principal EWS benefits in this context is discriminating imbalances that have strong positive and negative associations with financial stress. This differentiation allows a rich set of policy applications including use of defensive imbalances as stress buffers, limit setting on common adverse imbalances, and institutional targets for imbalance diversification.

Notwithstanding the potential for these powerful applications, this study also urges two notes of caution. First, care must be taken in the calibration of macroprudential applications, given their reliance on quality of the underlying systemic risk-modeling framework. Second, macroprudential applications should not commence without explicit economic impact analysis of feedback mechanisms involving the new policies.

Overall, the paper explores macroprudential applications for systemic risk in a dynamic institutional context. Appropriate strategies and instruments ground on identifying and disclosing overall stress based on a systemic risk EWS. While this new direction of supervisory applications targets to enhance financial system transparency and strengthen the resilience of infrastructure and institutions, the feedback interaction of policies and the financial system agents also has some adverse potential. Therefore, the dynamic effects of macroprudential applications should be well considered in advance.

REFERENCES

Acharya, V., (2001). ***A theory of systemic risk and design of prudential bank regulation.*** Mimeo, London Business School.

__________ (2009). A theory of systemic risk and design of prudential bank regulation. ***Journal of Financial Stability, 5***: 224-255.

__________ (2011). ***Systemic risk and macro-prudential regulation.*** Mimeo prepared for Asian Development Bank, March 2011, New York University School of Business.

Aghion, P., Howitt, P., (1992). A model of growth through creative destruction. ***Econometrica***, LX, 323-351.

Allen, F., Carletti, E., (2010). An overview of the crisis: Causes, consequences, and solutions. ***International Review of Finance, 10***(1), 1-26.

__________ (2011). ***Systemic Risk and Macroprudential Regulation***. Mimeo

Allen, F., Babus, A., and Carletti, E., (2012). Asset commonality, debt maturity and systemic risk. ***Journal of Financial Economics, 104***(3), 519-534.

Alessi, L., Detken, C., (2009). ***Real time early warning indicators for costly asset price boom/bust cycles: A Role for global liquidity.*** Working Paper Series, No. 1039, March. European Central Bank.

Alessi, L., Detken, C., (2011). Quasi real time early warning indicators for costly asset price boom/bust cycles: A role for global liquidity. ***European Journal of Political Economy, 27***(3), 520-533.

Angelini, P., Neri, S., and Panetta, F., (2011). ***Monetary and macroprudential policies.*** Banca d' Italia Working Paper no. 801.

Arthur, W.B. (1995). Complexity in economic and financial markets. ***Complexity, 1***(1), 20-25.

Arthur, W.B., Holland, J., LeBaron, B., Palmer, R., and Taylor, P. (1997) ***Asset pricing under endogenous expectations, in an artificial stock market.*** In: Arthur, W.B., Durlauf, S., and

Lane, D. (Eds.), The Economy as an Evolving Complex System: II, 15–44. Reading, MA: Addison-Wesley.

Babecký, J., Havránek, T., Matějů, J., Rusnák, M., Šmídková, K., and Vašíček, B. (2013). Leading indicators of crisis incidence: evidence from developed countries. ***Journal of International Money and Finance.***

Bailliu, J., Meh, C., and Zhang, Y. (2012). ***Macroprudential rules and monetary policy when financial frictions matter***, Bank of Canada Working Paper, 2012-6.

Bair, S.C. (2009). Managing the transition to a safer financial system, Special Issue on "The Future of Financial Regulation", ***Financial Stability Review***, September, Banque de France.

Barrell, R., Davis, E.P., Karim, D., and Liadze, I. (2010). Bank regulation, property prices and early warning systems for banking crises in OECD countries. ***Journal of Banking and Finance, 34***(9), 2255-2264.

_________ (2012). Off-balance sheet exposures and banking crises in OECD countries. ***Journal of Financial Stability.***

BCBS – Basel Committee on Banking Supervision (2010a). ***Countercyclical capital buffer proposal.*** Consultative document. Basel.

BCBS – Basel Committee on Banking Supervision (2010b). Basel III: A global regulatory framework for more resilient banks and banking systems. Basel.

Bech, M.L., Atalay, E. (2010). The topology of the federal funds market. ***Physica A: Statistical Mechanics and its Applications, 389***(22), 5223-5246.

Bernanke, B.S, (2004). ***The Logic of monetary policy.*** Speech before the National Economists Club, Washington D.C., December 2.

__________ (2008). ***Reducing systemic risk.*** Speech at the Federal Reserve Bank of Kansas City's Annual Economic Symposium, Jackson Hole, Wyoming.

__________ (2009). ***Financial reform to address systemic risk.*** Speech at the Council on Foreign Relations, Washington, D.C., March 10.

__________ (2011). ***The effects of the Great Recession on central bank doctrine and practice.*** 56th Economic Conference. Federal Reserve Bank of Boston. Boston, MA. October 18, 2011.

Beyeler, W.E., Glass, R.J., Bech, M.L., and Soramäki, K., (2007). Congestion and cascades in payment systems. ***Physica A: Statistical Mechanics and its Applications, 384***(2), 693-718.

Bianco, T., Oet, M.V., and Ong, S.J., 2012. ***The Cleveland financial stress index.*** Economic Commentary, (Mar 21).

Bijlsma, M., Klomp, J., and Duineveld, S., (2010***). Systemic risk in the financial sector – A review and synthesis***, CPB Netherlands Bureau for Economic Policy Analysis document, No. 210, The Hague, July 2010.

BOE - Bank of England, (2009). ***The role of macroprudential policy.*** Discussion Paper, November. Web. <http://www.bankofengland.co.uk/ publications /other/ financialstability/ role ofmacroprudential policy091121.pdf>.

_________ (2011). ***Instruments of macroprudential policy.*** Discussion Paper, December. Web. <http://www.bankofengland.co.uk/publications/other/financialstability/discussionpaper111220.pdf>.

Boivin. J., Lane, T., and Meh, C., (2010). ***Should monetary policy be used to counteract financial imbalances?*** Bank of Canada Review, Summer.

Bordo, M.D., Dueker, M., and Wheelock, D., (2000). ***Aggregate price shocks and financial instability: An historical analysis***. Federal Reserve Bank of St. Louis Working Paper 2000-005B, St. Louis.

Borio, C., (2003). Towards a macroprudential framework for financial supervision and regulation?, ***CESifo Economic Studies, 49*** (2), 181–216. Also available as BIS Working Papers, No. 128, February.

__________ (2006). Monetary and financial stability: Here to stay? ***Journal of Banking and Finance 30***, 3407–3414.

__________ (2009). Implementing the macroprudential approach to financial regulation and supervision. ***Banque de France Financial Stability Review No. 13***, September.

__________ (2010). ***Implementing a macroprudential framework: Blending boldness and realism.*** Paper presented at the HKIMR-BIS conference, Hong Kong, July.

Borio, C., Furfine, C., and Lowe, P., (2001). Procyclicality of the financial system and financial stability: Issues and policy options. In: Marrying the Macro- and Microprudential Dimensions of Financial Stability", ***BIS Papers, No.*** 1, March, 1–57.

Borio, C., Lowe, P., (2002a). ***Asset prices, financial and monetary stability: Exploring the nexus.*** Paper presented at the BIS Conference on 'Changes in risk through time: measurement and policy options'. BIS Working Papers (114), July.

__________ (2002b). Assessing the risk of banking crises. ***BIS Quarterly Review*** (December), 43–54.

__________ (2004). ***Securing sustainable price stability: Should credit come back from the wilderness?*** BIS Working Papers (157), July.

Boyer, R., (1999). ***The variety and unequal performance of really existing markets: Farewell to doctor Pangloss?*** In: Hollingsworth, J. R., & Boyer, R. (Eds.) (1999). Contemporary Capitalism: The Embeddedness of Institutions. Cambridge University Press, 55–93.

Brainard, W.C., (1967). Uncertainty and the Effectiveness of Policy. ***The American Economic Review, 57***(2), 411-425.

Brock, W.A., Durlauf, S.N., (2001). Interactions-based models. ***Handbook of econometrics, 5***, 3297-3380.

Brock, W.A., Durlauf, S.N., and West, K.D., (2003). Policy Evaluation in Uncertain Economic Environments. ***Brookings Papers on Economic Activity***, 2003(1), 235-301.

Brock, W.A., Hommes, C.H., (1997). A rational route to randomness. ***Econometrica: Journal of the Econometric Society***, 1059-1095.

_________. (1998). Heterogeneous beliefs and routes to chaos in a simple asset pricing model. ***Journal of Economic dynamics and Control, 22***(8-9), 1235-1274.

Brown, G., (2010). ***Beyond the Crash: Overcoming the First Crisis of Globalization***. Simon and Schuster.

Brunnermeier, M.K., Goodhart, C.A.E., Persaud, A., Crockett, A., and Shin, H., (2009). The fundamental principles of financial regulation. ***Geneva Reports on the World Economy 11.***

Calvo, S., Reinhart, C.M., (1996). ***Capital flows to Latin America: Is there evidence of contagion effects?*** In: Calvo, G., Goldstein, M., & Hochreiter, E. (Eds.) Private Capital Flows to Emerging Markets. Institute for International Economics: Washington.

CGFS – Committee on the Global Financial System, (2010). ***Macroprudential instruments and frameworks: A stocktaking of issues and experiences.*** CGFS Papers, no 38.

Christensen, I., Meh, C., and Moran, K., (2011). Bank Leverage Regulation and Macroeconomic Dynamic. ***CIRANO-Scientific Publications 2011s***-76.

Cihák, M., Poghosyan, T. (2009). Distress in European banks: An analysis based on a new dataset (Vol. 9). International Monetary Fund.

Constâncio, V., (2012). ***Financial stability: Measurement and policy***. Speech at the Conference of Financial Stability: Methodological Advances and Policy Issues. Frankfurt am Main, June 14.

Crockett, A., (2000). ***Marrying the micro- and macro-prudential dimensions of financial stability.*** Speech at the BIS, http://www.bis.org.

Crotty, J., (2009). Structural causes of the global financial crisis: a critical assessment of the ‘new financial architecture’. ***Cambridge Journal of Economics, 33***(4), 563-580.

Cukierman, A., (2011). Reflections on the crisis and on its lessons for regulatory reform and for central bank policies, ***Journal of Financial Stability, 7***(1), 26-37.

Davis, E.P., Karim, D., (2008a). Comparing early warning systems for banking crises. ***Journal of Financial Stability, 4***(2), 89-120.

_________. (2008b). Could early warning systems have helped to predict the sub-prime crisis? ***National Institute Economic Review, 206***(1), 35-47.

De Bandt, O., Hartmann, P., (2000). ***Systematic risk: A survey.*** Working paper, European Central Bank.

De Nicolò, G., Favara, G., and Ratnovski, L., (2012). ***Externalities and macroprudential policy.*** IMF Working Paper No. SDN/12/05.

De Nicolò, G., Lucchetta, M., (2011). Systemic Real and Financial Risks: Measurement, Forecasting, and Stress Testing. ***Forecasting, and Stress Testing*** (March 15, 2011).

Demyanyk, Y., Van Hemert, O., (2011). Understanding the subprime mortgage crisis. ***Review of Financial Studies, 24***(6), 1848-1880.

Denning, S., (2013, January 8). Big banks and derivatives: Why another financial crisis is inevitable. ***Information for the World's Business Leaders - Forbes.com.*** Web. <http://www.forbes.com/sites/stevedenning/2013/01/08/five-years-after-the-financial-meltdown-the-water-is-still-full-of-big-sharks/>.

Detken, C., (2012, September 13). ***Is early warning against systemic risk feasible?*** Vimeo. Web. <http://vimeo.com/56689254>.

ECB - European Central Bank, (2005). Assessing financial stability: Conceptual boundaries and challenges. In: ***Financial Stability Review***, June, 117-125.

Eichengreen, B., (2009). Globalization and the Crisis. ***CESifo Forum, 11***(3), 20-24.

Ellyatt, H., (2012, December 14). Britain's Queen quizzes central bank on financial crisis. ***Stock Market News, Business News, Financial, Earnings, World Markets - CNBC.*** Web. <http://www.cnbc.com/id/100313755/Britain039s_Queen_Quizzes_Central_Bank_on_Financial_Crisis>.

Elsinger, H., Lehar A., and Summer, M., (2002). ***Risk assessment for banking systems.*** Paper presented at the CESifo Venice Summer Institute 2002 workshop held in Venice, 13-20 July; Austrian National Bank Working Paper, no 79, October.

Ergungor, O.E., (2007, December). ***Foreclosures in Ohio: Does lender type matter?*** Working Paper 07-24. Cleveland Federal Reserve Bank.

ESRB - European Systemic Risk Board, (2012). ***Recommendation of the European Systemic Risk Board of 22 December 2011 on the US dollar denominated funding of credit institutions*** (ESRB 2011/2), Frankfurt 2012.

Farmer, J.D., (1990). A Rosetta stone for connectionism. ***Physica D: Nonlinear Phenomena, 42***(1), 153-187.

_________. (2002). Market force, ecology and evolution. ***Industrial and Corporate Change, 11***(5), 895-953.

Farmer, J. D., Lo, A. W., (1999). Frontiers of finance: Evolution and efficient markets. ***Proceedings of the National Academy of Sciences, 96***(18), 9991-9992.

Farmer, J. D., Patelli, P., and Zovko, I. I., (2005). The predictive power of zero intelligence in financial markets. ***Proceedings of the National Academy of Sciences of the United States of America, 102***(6), 2254-2259.

Frait, J., Komárková, Z. (2011). Financial stability, systemic risk and macroprudential policy. ***Financial Stability Report 2010/2011***, Czech National Bank, 96-111.

French, K.R, Baily, M.N, Campbell, J.Y, Cochrane, J.H., Diamond, D.W., Duffie, D., Kashyap, A.K., Mishkin, F.S., Rajan, R.G., Sharfstein, D.S., Shiller, R.J., Shin, H.S., Slaughter, M.J, Stein, J.C., and Stulz, R.M., (2010). The Squam Lake Report: Fixing the Financial System. ***Journal of Applied Corporate Finance, 22***(3), 8-21.

Friedman, J., Kraus, W., (2011). ***Engineering the Financial Crisis: Systemic Risk and the Failure of Regulation.*** University of Pennsylvania Press.

FSB-IMF-BIS, (2011). ***Macroprudential policy tools and frameworks: Update to G20 Finance Ministers and Central Bank Governors***, 14 February 2011.

Furfine, C.H., (1999). ***Interbank exposures: Quantifying the risk of contagion***. BIS Working Papers, no.70 (Basel: Bank for International Settlements, June).

Galati, G., Moessner, R., (2012). Macroprudential policy–a literature review. ***Journal of Economic Surveys.***

Gonzalez-Hermosillo, B., (1996). ***Banking sector fragility and systemic sources of fragility.*** IMF Working Paper9 6/12. Washington: International Monetary Fund, February.

Goodhart, C.A., (2004). Financial supervision from an historical perspective: Was the development of such supervision designed, or largely accidental. In Mayes, D. G., and Wood, G. E. (2007). ***The Structure of Financial Regulation*** (Vol. 37). Taylor and Francis, 43-64.

Gramlich, D., Miller, G., Oet, M.V., and Ong, S.J., (2010). Early warning systems for systemic banking risk – critical review and modeling implications. ***Banks and Bank Systems, 5***(2), 199-211.

Gramlich, D., Oet, M.V., (2012). ***Systemic financial feedbacks – Conceptual framework and modeling implications.*** Paper presented at the 30th International Conference of the System Dynamics Society on 'Model-based Management', St. Gallen, Switzerland, July.

Greenspan, A., (2004). Risk and uncertainty in monetary policy. ***American Economic Review, 94***(2), 33-40.

Group of Ten, (2001). Report on consolidation in the financial sector, ***Bank for International Settlements***, January.

Guttentag, J.M., Herring, R.J., (1988). ***Prudential supervision to manage systemic vulnerability.*** In: The Financial Services Industry in the Year 2000: Risk and Efficiency, Proceedings of the Conference on Bank Structure and Competition, Federal Reserve Bank of Chicago, 602-33.

Haldane, A.G., May, R.M., (2011). Systemic risk in banking ecosystems. ***Nature, 469***(7330), 351-355.

Hannoun, H., (2010). ***Towards a global financial stability framework.*** Bank for International Settlements (Ed.), Management Speeches, 45th SEACEN Governors' Conference, Siem Reap province, Cambodia, 26-27 February, 1-26.

Hanson, S.G., Kashyap, A.K., and Stein, J.C., (2011). A macroprudential approach to financial regulation. ***The Journal of Economic Perspectives, 25***(1), 3-28.

Hanusch, H., Wackermann, F,. (2009). ***Global financial crisis: causes and lessons; a Neo-Schumpeterian perspective*** (No. 303). Volkswirtschaftliche Diskussionsreihe, Institut für Volkswirtschaftslehre der Universität Augsburg.

Hayashi, F., Prescott, E.C., (2002). The 1990s in Japan: A lost decade. ***Review of Economic Dynamics, 5***(1), 206-235.

Hellwig, M. F., (2009). Systemic risk in the financial sector: An analysis of the subprime-mortgage financial crisis. ***De Economist, 157***(2), 129-207.

Herring, R.J., (1999). Credit risk and financial instability. ***Oxford Review of Economic Policy, 15***(3), 63-79.

Holland, J.H., (1975). ***Adaptation in Natural and Artificial Systems.*** The University of Michigan Press: Ann Arbor, MI.

___________ (1988). ***The global economy as an adaptive process***. In: P.W. Anderson, K.J. Arrow, D. Pines (Eds.) The Economy as an Evolving Complex System, 117-124, Addison-Wesley: Reading, Mass., 1988.

Hollingsworth, J. R., Müller, K. H., and Hollingsworth, E. J., (2005). ***Advancing Socio-Economics: An Institutionalist Perspective.*** Rowman & Littlefield Pub Incorporated.

Hommes, C.H., (2001). Financial markets as nonlinear adaptive evolutionary systems. ***Quantitative Finance, 1***, 149–167.

Howitt, P., Kirman, A., Leijonhufvud, A., Mehrling, P., and Colander, D., (2008). Beyond DSGE models: toward an empirically based macroeconomics. ***The American Economic Review, 98***(2), 236-240.

Ibragimov, R., Jaffee, D., and Walden, J., (2011). Diversification disasters. ***Journal of financial economics, 99***(2), 333-348.

Illing, M., Liu, Y., (2003). ***An index of financial stress for Canada***. Bank of Canada Working Paper No. 2003-14, Ottawa, June.

__________ (2006). Measuring financial stress in a developed country: An application to Canada. ***Journal of Financial Stability, 2*** (4):243–265.

IMF – International Monetary Fund, (2009). ***Global Financial Stability Report 04/2009***, Responding to the Financial Crisis and Measuring Systemic Risks. Washington.

__________ (2011). Macroprudential policy: An organizing framework, Washington.

Kannan, P., Rabanal, P., and Scott, A., (2009). ***Monetary and macroprudential policy rules with house price booms.*** IMF Working Paper No. 251.

Kardar, S.H., (2011). ***Macroprudential Surveillance and the Role of Supervisory and Regulatory Authorities.*** Leeds: Islamic Financial Services Board.

Kashyap, A.K., Stein, J.C., (2004). Cyclical implications of the Basel II capital standards. ***Federal Reserve Bank of Chicago Economic Perspectives, 28***(1), 18-31.

Kashyap, A., Rajan, R., and Stein, J., (2008). Rethinking capital regulation. In Rethinking Capital Regulation. In: ***Maintaining Stability in a Changing Financial System***, 431-71. Federal Reserve Bank of Kansas City.

King, M., Wadhwani, S., (1990).Transmission of volatility between stock markets. ***Review of Financial Studies, 3***(1), 5-35.

Kodres, L.E., Pritsker, M., (1999). ***A rational expectations model of financial contagion.*** Mimeo. IMF and Federal Reserve Board, May.

Kohn, D., (2011). ***Enhancing financial stability: The role of transparency.*** Speech at the London School of Economics. Sep. 6, 2011. Web. <http://www.bankofengland.co.uk/publications/Documents/speeches/2011/speech516.pdf>.

Kurtz, A., (2013, January 18). Federal Reserve was blind to crisis brewing in early 2007 - Jan. 18, 2013 . ***CNNMoney - Business, financial and personal finance news***. Web. <http://money.cnn.com/2013/01/18/news/economy/federal-reserve-transcripts/index.html>.

Lagunoff, R., Schreft, S., (1998). ***A model of financial fragility.*** Mimeo. Georgetown University, September.

Leeper, E.M., Sargent, T.J., (2003). Comments and Discussion. ***Brookings Papers on Economic Activity***, 2003(1), 302-313.

Lim, C., Bhattacharya, R., Columba, F., Costa, A., Otani, A., and Wu, X., (2011a). ***Macroprudential Policy: An Organizing Framework. Background Paper.*** IMF mimeo, Washington, March.

Lim, C., Columba, F., Costa, A., Kongsamut, P., Otani, A., Saiyid, M., Wezel, T., and Wu, X., (2011b). ***Macroprudential Policy: What Instruments and How to Use Them? Lessons from Country Experiences.*** IMF Working Paper 11/238, Washington, October.

Lowe, P., (2001). Maintaining financial stability: Possible policy options. Sveriges ***Riksbank Economic Review 2001***(2), 25-33.

Lucas, R.E., (1976). Econometric policy evaluation: A critique. In ***Carnegie-Rochester conference series on public policy, 1***(1), 19-46.

Masson, P., (1999a). Contagion: Macroeconomic models with multiple equilibria. ***Journal of International Money and Finance, 18***, 587-602.

__________ (1999b). ***Contagion: Monsoonal effects, spillovers, and jumps between multiple equilibria.*** In: Agénor, P.R., Miller, M., Vines, D., and Weber, A.A. (Eds.) The Asian Financial Crisis: Causes, Contagion and Consequences. Cambridge University Press, 265-280.

May, R.M., Arinaminpathy, N., (2010). Systemic risk: The dynamics of model banking systems, ***Journal of the Royal Society Interface, Vol. 7*** (2010), No. 46, May, 823-838.

Mayes, D.G., Wood, G.E., (2007). ***The Structure of Financial Regulation*** (Vol. 37). Taylor and Francis.

Melvin, M., Taylor, M.P., (2009). The crisis in the foreign exchange market. ***Journal of International Money and Finance, 28***(8), 1317-1330.

Morgan, D., Peristiani, S., and Savino, V.,(2010). ***The information value of the stress test and bank opacity.*** Federal Reserve Bank of New York Staff Report no. 460.

Nicolis, G., Prigogine, I., (1977). ***Self-organization in Nonequilibrium Systems: From Dissipative Structures to Order through Fluctuations.*** John Wiley and Sons.

Nier, E., (2011). Macroprudential policy – taxonomy and challenges. ***National Institute Economic Review, 216***(1), R1-R15.

Oet, M.V., Eiben, R., Bianco, T., Gramlich, D., and Ong, S.J., (2011 CFSI). ***The financial stress index: Identification of systemic risk conditions.*** Federal Reserve Bank of Cleveland Working Paper 11-30, Cleveland, November.

Oet, M.V., Eiben, R., Bianco, T., Gramlich, D., Ong, S.J., and Wang, J., (2011 SAFE). ***SAFE: An early warning system for systemic banking risk.*** Federal Reserve Bank of Cleveland Working Paper 11-29, Cleveland, November

__________ (2013a). **Systemic risk early warning system: A micro-macro prudential synthesis.** In: Fouqué, J.-P., Langsam, J., (Eds.). Handbook of Systemic Risk, Cambridge.

Oet, M.V., Bianco, T., Gramlich, D., and Ong, S.J., (2012). ***Financial Stress Index: A Lens for Supervising the Financial System.*** Federal Reserve Bank of Cleveland Working Paper 12-37, Cleveland, December.

__________ (2013b). SAFE: An early warning system for systemic banking risk. ***Journal of Banking and Finance***. <http://dx.doi.org/10.1016/j.jbankfin.2013.02.016.>

Paul, R., (2008, September 23). Commentary: Bailouts will lead to rough economic ride. ***CNN.com - Breaking News, U.S., World, Weather, Entertainment and Video News.*** Web. <http://www.cnn.com/2008/POLITICS/09/23/paul.bailout/>.

Phillips, L., (2011, August 31). ECB turned blind eye to predatory lending, ex-EU-ambassador says. ***EUobserver.com / Headline News.*** Web. <http://euobserver.com/economic/31942>.

Quandt, R.E., (1960).Tests of the hypothesis that a linear regression system obeys two separate regimes. ***Journal of the American Statistical Association 55*** (290): 24–330.

Richter, F., Wahl, P., (2011). The role of the European Central Bank in the financial crash and the crisis of the Euro-zone. In the ***Report based on a Weed expert meeting***.

Roberts, R., (2008). How government stoked the mania. ***Wall Street Journal*** (3 October, A21).

Rochet, J.-C., (2004). Macroeconomic shocks and banking supervision. ***Journal of Financial Stability, 1*** (1), 2004, 93–110.

__________ (2005). Prudential policy. ***Monetary and Economic Studies (Bank of Japan) 23*** (S1), 93–131.

Rose, A.K., Spiegel, M.M., (2011). Cross-country causes and consequences of the crisis: An update. ***European Economic Review, 55***(3), 309-324.

Sabatier, P.A., (1991). Toward better theories of the policy process. ***PS: Political Science and Politics,*** 24(2), 147-156.

Saunders, A., Strock, E., and Travlos, N.G., (2012). Ownership structure, deregulation, and bank risk taking. ***The Journal of Finance, 45***(2), 643-654.

Schinasi, G., (2004). ***Defining financial stability.*** IMF Working Paper No. WP/04/187, October.

Schoenmaker, D., Wierts, P., (2011). ***Macroprudential policy: The need for a coherent policy framework.*** Duisenberg School of Finance Policy Paper no. 13.

Sinha, A., (2011), ***'Macroprudential policies - Indian experience'***, June, address at Eleventh Annual International Seminar on Policy Challenges for the Financial Sector, co-hosted by the Board of Governors of the Federal Reserve System, the International Monetary Fund and the World Bank, Washington DC.

Slingenberg, J.W., de Haan, J., (2011). ***Forecasting financial stress.*** DNB Working Paper, No. 292, Amsterdam.

Soramäki, K., Bech, M.L., Arnold, J., Glass, R.J., and Beyeler, W.E., (2007). The topology of interbank payment flows. ***Physica A: Statistical Mechanics and its Applications, 379***(1), 317-333.

Stulz, R.M., (2008). Risk management failures: What are they and when do they happen? ***Journal of Applied Corporate Finance, 20***(4), 39-48.

Tarullo, D.K., (2011). ***The evolution of capital regulation: A speech at the Clearing House Business Meeting and Conference***, New York, New York, Nov. 9, 2011.

UNCTAD – United Nations Conference on Trade and Development, (2009). UNCTAD Secretariat Task Force on Systemic Issues and Economic Cooperation. ***Global Economic Crisis: Systemic Failures and Multilateral Remedies.*** New York and Geneva: United Nations, 2009.

Wagner, W., (2010). Diversification at financial institutions and systemic crises. ***Journal of Financial Intermediation, 19***(3), 333-354.

Winnett, R., Swaine, J., (2008, December 22). Bank of England failed to foresee financial crisis, admits Sir John Gieve. ***Telegraph.co.uk - Telegraph online, Daily Telegraph, Sunday Telegraph - Telegraph.*** Web. <http://www.telegraph.co.uk/finance/financialcrisis/3902714/ Bank-of-England-failed-to-foresee-financial-crisis-admits-Sir-John-Gieve.html

Yam, J., (2007). Three key challenges for macroprudential surveillance, ***Hong Kong Monetary Authority Quarterly Bulletin***, March, 32-35.

Yue, E., (2001). Marrying the micro- and macro-prudential dimensions of financial stability – the Hong- Kong experience. ***BIS paper, No. 1***, 230-240.

Zhu, K., Liu, D., Wu, J., and Sun, L., (2012). The Research of the Regional Financial Risk Early-Warning Model Integrating the Regression of Lagging Factors. ***AASRI Procedia***, 1, 428-434.

TABLES

Table 1

Macroprudential tools in use among respondents to the 2011 IMF monetary and capital markets department's "financial stability and macroprudential policy survey." Source: Lim et al. (IMF 2011a).

	% of respondents	% of Advanced economies	% of Emerging economies
Early warning models	**35.3**	**26.1**	**42.9**
Asset price/real estate valuation models	41.2	56.5	28.6
Single-institution models	54.9	73.9	39.3
Systematic financial sector risk models	33.3	52.2	17.9
Contagion risk models	39.2	39.1	39.3
Macro-financial linkage models	35.3	43.5	28.6
Stress test	39.2	43.5	35.7

Table 2

Systemic feedbacks typology

Subsystem	Class	Subclass
Structural	1 Composition	– Connectivity
		– Concentration
		– Correlation
	2 Regulation	– Incentive regulation
		– Structural regulation
		– Ex-post crisis intervention
Interconnective	3 Assets and Liabilities transformation	– Balance sheet
		– A/L maturity mismatch
	4 Credit transformation	– Credit chains
	5 Liquidity transformation	– Fire sale
		– Liq adverse selection
		– Liquidity hoarding
	6 FX transformation	– Exchange Rate
Behavioral	7 Uncertainty	– Knightian
		– Cognitive bias
	8 Information	– Asymmetry
		– Spillovers
		– Sensitivity
		– Herding

Table 3

Macroprudential strategies of prevention (stable, ex-ante, and ex-post phases) and mitigation (critical phase)

		Objectives	Oet et al. (2011 SAFE) - FRBC Model Basis: EWS (SAFE)	Frait and Komárková (2011) - CNB[97] Model Basis —	BOE (2011) - BOE Model Basis —	Schoenmaker and Wierts (2011) - DNB Model Basis —	Sinha (2011) - RBI Model Basis —
PREVENTION	Time dimension	T1| Short-term: limit financial system-wide stress	1. identification of stress phase 2. guidelines for monitoring 3. stress level and rate of change monitoring 4. limits 5. targets 6. disclosure 7. communication	1. limits 2. countercyclical margins 3. asset rate rules 4. countercyclical buffers 5. time-varying provisioning 6. time-varying reserve requirements 7. time-varying risk weights	1. limits 2. distribution restrictions 3. margining requirements 4. countercyclical buffers 5. time-varying buffers 6. time-varying provisioning 7. time-varying risk weights 8. disclosure	1. time-varying limits 2. countercyclical buffers 3. time-varying charge	1.countercyclical limits 2. countercyclical provisioning 3. countercyclical risk weights
PREVENTION	Time dimension	T2| Long-term: avoid macroeconomic costs linked to financial instability					
PREVENTION	Cross-sectional dimension	X1.1| Common exposures imbalances: limit severity of failure	1. monitoring / identification of common and adverse cross-sectional long run imbalances 2. limits on common and adverse cross-sectional long run imbalances 3. disclosure 4. communication	1 .time-varying surcharges 2. limits 3. disclosure 4. communication	1. disclosure	1. time-varying limits 2. countercyclical buffers	1 .countercyclical limits 2. countercyclical provisioning
PREVENTION	Cross-sectional dimension	X1.2| Common exposure imbalances: limit probability of failure					
PREVENTION	Cross-sectional dimension	X2| Interconnectedness: strengthening infrastructure resilience	1. encourage idiosyncratic imbalances 2. progressive reduction in required minimum buffers and targets given idiosyncratic imbalances 3. encourage defensive imbalances 4. customized long run defensive targets 5. progressive reduction in required buffers and limits when institutions exceed defensive targets 7. disclosure 8. communication	1. time varying buffers 2. time-varying margins 3. time-varying targets 4. time-varying reserve requirements 5. disclosure 6. active ∆ communication	1. central counterparties 2. trading circuit breakers 3. disclosure	3. time-varying charge	3. countercyclical risk weights
MITIGATION	Time dimension	T1| Short-term: limit financial system-wide stress	1. identification of stress phase 2. guidelines for monitoring 3. stress level and rate of change monitoring 4.time-varying limits 5. time-varying targets 6. disclosure 7. communication	1. release of buffers 2. capital injections 3. disclosure 4. communication	1. limits 2. distribution restrictions 3. margining requirements 4. countercyclical buffers 5. time-varying buffers 6. time-varying provisioning 7. time-varying risk weights 8. disclosure	1. time-varying limits 2. countercyclical buffers 3. time-varying charge	1.countercyclical limits 2. countercyclical provisioning 3. countercyclical risk weights
MITIGATION	Time dimension	T2| Long-term: avoid macroeconomic costs linked to financial instability		1. disclosure 2. communication			
MITIGATION	Cross-sectional dimension	X1.1| Common exposures imbalances: limit severity of failure	1. monitoring / identification of common and adverse cross-sectional shirt-run imbalances 2. limits on common and adverse cross-sectional short run imbalances 3. disclosure 4. communication	1. disclosure 2. communication	1. disclosure	1. time-varying limits	1 .countercyclical limits
MITIGATION	Cross-sectional dimension	X1.2| Common exposure imbalances: limit probability of failure				2. countercyclical buffers	2. countercyclical provisioning
MITIGATION	Cross-sectional dimension	X2| Interconnectedness: strengthening infrastructure resilience	1. encourage idiosyncratic imbalances 2. progressive reduction in required minimum buffers and targets given idiosyncratic imbalances 3. encourage defensive imbalances 4. customized long run defensive targets 5. progressive reduction in required buffers and limits when institutions exceed defensive targets 7. disclosure 8. communication	1. central bank refinancing 2. government guarantees 3. deposit insurance 4. contingency funding 5. living wills 6. disclosure 7. communication	1. central counterparties 2. trading circuit breakers 3. disclosure	3. time-varying charge	3. countercyclical risk weights

Note. Abbreviations used: FRBC = Federal Reserve Bank of Cleveland; CNB = Czech National Bank; BOE = Bank of England; DNB = De Nederlandsche Bank; RBI = Reserve Bank of India.

97 Omitting suggested monetary and fiscal policy tools

Table 4

Macroprudential instruments of prevention (stable, ex-ante, and ex-post phases)

		Objectives	Oet et al. (2011 SAFE) - FRBC	Frait and Komárková (2011) - CNB	BOE (2011) - BOE	Schoenmaker and Wierts (2011) - DNB	Sinha (2011) - RBI
			Model Basis: EWS (SAFE)	Model basis—	Model basis—	Model basis—	Model basis—
PREVENTION	Time dimension	T1| Short-term: limit financial system-wide stress T2| Long-term: avoid macroeconomic costs linked to financial instability	1. identification of stress phase stress components stress grade stress grade threshold stress level one period rate of change two period rate of change 2. guidelines for monitoring short run imbalances transition matrices stress level and rate of change 3. time-varying limits liquidity index EDF interbank concentrations leverage 4. time-varying targets solvency level solvency distance capital buffer leverage interbank currency interest rate hedging interest rate distance institutional liquidity liquidity buffer credit risk distance 5. disclosure a. stress identification measures stress grade, stress phase, stress level. stress rate of change b. prudential guidelines short-term limits, short run imbalances, transition matrices, long-term targets c. risk warnings public imbalances: short and long, public forecasts: short and long d. stress-testing 6. communication a. private imbalances b. macroprudential limits c. macroprudential targets d. stress-testing	1. time-variance monitoring credit spreads and risk premia market liquidity / turnover financial stability indicator credit-to-GDP imbalance asset imbalance asset Δ imbalance loan Δ imbalance 2. limits (household sector): debt-to-assets ratio debt-to-income ratio interest-to-income ratio price-to-income ratio loan-to-value ratio price-to-rent ratio 3. limits (financial sector): leverage ratio 4. countercyclical margins funding haircuts 5. asset rate rules loan reference rates 6. countercyclical buffers: capital adequacy ratio 7. varying provisioning: loan-loss provision rate coverage ratio default rate NPL rate *increased* collateral 8. varying reserve requirements reserve requirements 9. varying risk weights residential loans CRE loans FX loans	1. limits loan-to-value ratio loan-to-income ratio leverage ratio sectoral liquidity asset class funding source funding instrument 2. distribution restrictions fixed/variable dividends fixed/variable buybacks fixed/variable empl. bonuses 3. margining requirements static / time-varying haircuts on secured financing and derivative transactions 4. countercyclical buffers capital liquidity 5. time-varying buffers leverage ratio scalar over LCR / LAR Δ stress for LCR / LAR scalar over NFSR /CFR Δ stress for NFSR /CFR individual stress test anchor 6. time-varying provisioning buffer over acc. provision rule-based capital reserve sector/aggregate buffer 7. time-varying risk weights sectoral capital buffer sectoral risk weights scalar of exposure 8. disclosure sovereign sector banking sector specific risks	1. time-varying limits LTV leverage RE risk-weight 2. countercyclical buffers capital 3. time-varying charge liquidity charge varying NSFR varying LCR	1.countercyclical limits general credit growth sectors by growth and price repo rate reverse repo rate cash reserve ratio flexible LTV by risk weight 2. countercyclical provisioning general credit growth sectors by growth and price capital market exposures housing loans non-housing retail loans CRE loans NBFC exposure 3. countercyclical risk weights general credit growth sectors by growth and price capital market exposures housing loans non-housing retail loans CRE loans NBFC exposure
	Cross-sectional dimension	X1.1| Common exposures imbalances: limit severity of failure	1. monitoring / identification of common cross-sectional long run imbalances 2. limit of common cross-sectional long run imbalance 3. disclosure (see above) 4. communication (see above)	1 .time-varying surcharges capital liquidity 2. limits loans-to-deposits ratio interbank funds ratio AL mismatch ratio liquidity index funding imbalance liquidity imbalance tests activity scale imbalances AL concentration share of large BS exposures leverage ratio capital quality structure foreign debt/asset ratio currency: open FX currency: FX loans share 3. disclosure OBS scale/structure 4. communication composite volatility index govmnt deficit imbalance govmnt debt imbalance CA deficit imbalance external debt imbalance national investment FX reserves external financing reqs currency valuation	1. time-varying surcharge calibrated capital charge calibrated liquidity charge calibrated add'tl instruments 2. disclosure sovereign sector banking sector specific risks	1. time-varying limits LTV leverage RE risk-weight	1.countercyclical limits general credit growth sectors by growth and price repo rate reverse repo rate cash reserve ratio flexible LTV by risk weight
		X1.2| Common exposure imbalances: limit probability of failure	1. monitoring /identification of aggregate adverse long run imbalances 2. limits on aggregate adverse long run imbalances 3. disclosure (see above) 4. communication (see above)				
		X2| Interconnectedness: strengthening infrastructure resilience	1. encourage idiosyncratic imbalances time-varying risk weights 2. time-varying buffers / limits 3. encourage defensive imbalances capital liquidity positive-relative-to-inflation interbank currency exposures liquidity distance stress-testing interest rate hedges credit risk distance stress-testing 4. customized long run defensive targets standard and idiosyncratic exposures by institution 5. disclosure (see above) 6. communication (see above)	1. time-varying margins funding haircuts 2. time varying buffers reserve reqs (home/host) liquidity 3. time-varying targets 4. time-varying reserve requirements 5. disclosure 6. active Δ communication	1. central counterparties tool to mandate CCP use 2. trading circuit breakers defined class trading venue defined class market-maker defined class circuit breaker 3. disclosure sovereign sector banking sector specific risks	3. time-varying charge SIFI capital surcharge	3. countercyclical risk weights general credit growth sectors by growth and price capital market exposures housing loans non-housing retail loans CRE loans NBFC exposure

Table 5

Macroprudential instruments of mitigation (critical phase)

		Objectives	Oet et al. (2011 SAFE) - FRBC	Frait and Komárková (2011) - CNB	BOE (2011) - BOE	Schoenmaker and Wierts (2011) - DNB	Sinha (2011) - RBI
			Model Basis: EWS (SAFE)	Model Basis —	Model Basis —	Model Basis —	Model Basis —
MITIGATION	Time dimension	T1| Short-term: limit financial system-wide stress T2| Long-term: avoid macroeconomic costs linked to financial instability	1. identification of stress phase stress components stress grade stress grade threshold stress level one period rate of change two period rate of change 2. guidelines for monitoring short run imbalances transition matrices stress level and rate of change 3. time-varying limits liquidity index EDF interbank concentrations leverage 4. time-varying targets solvency level solvency distance capital buffer leverage interbank currency interest rate hedging interest rate distance institutional liquidity liquidity buffer credit risk distance 5. disclosure a. stress identification measures stress grade, stress phase, stress level. stress rate of change b. prudential guidelines short-term limits, short run imbalances, transition matrices, long-term targets c. risk warnings public imbalances: short and long, public forecasts: short and long d. stress-testing 6. communication a. private imbalances b. macroprudential limits c. macroprudential targets d. stress-testing	1. release of buffers provisioning (coverage ratio, LLPR) 2. capital injections 3. disclosure profitability PD, NPL ratio change in CAR 4. communication credit spreads market stress test credit risks stress test	1. limits loan-to-value ratio loan-to-income ratio leverage ratio sectoral liquidity asset class funding source funding instrument 2. distribution restrictions fixed/variable dividends fixed/variable buybacks fixed/variable empl. bonuses 3. margining requirements static / time-varying haircuts on secured financing and derivative transactions 4. countercyclical buffers capital liquidity 5. time-varying buffers leverage ratio scalar over LCR / LAR Δ stress for LCR / LAR scalar over NFSR /CFR Δ stress for NFSR /CFR individual stress test anchor 6. time-varying provisioning buffer over acc. provision rule-based capital reserve sector/aggregate buffer 7. time-varying risk weights sectoral capital buffer sectoral risk weights scalar of exposure 8. disclosure sovereign sector banking sector specific risks	1. time-varying limits LTV leverage RE risk-weight 2. countercyclical buffers capital 3. time-varying charge liquidity charge varying NSFR varying LCR	1.countercyclical limits general credit growth sectors by growth and price repo rate reverse repo rate cash reserve ratio flexible LTV by risk weight 2. countercyclical provisioning general credit growth sectors by growth and price capital market exposures housing loans non-housing retail loans CRE loans NBFC exposure 3. countercyclical risk weights general credit growth sectors by growth and price capital market exposures housing loans non-housing retail loans CRE loans NBFC exposure
MITIGATION	Cross-sectional dimension	X1.1| Common exposures imbalances: limit severity of failure	1. monitoring / identification of common cross-sectional short run imbalances 2. limits on common cross-sectional short run imbalances 3. disclosure (see above) 4. communication (see above)	1. disclosure Δ in mkt liquidity measures interbank spreads gov bond spreads CDS spreads joint probability of distress 2. communication liquidity stress test interbank contagion test CoVaR CCA living wills	1. disclosure sovereign sector banking sector specific risks	1. time-varying limits LTV leverage RE risk-weight	1.countercyclical limits general credit growth sectors by growth and price repo rate reverse repo rate cash reserve ratio flexible LTV by risk weight
		X1.2| Common exposure imbalances: limit probability of failure	1. monitoring /identification of aggregate adverse short run imbalances 2. limits on aggregate adverse short run imbalances 3. disclosure (see above) 4. communication (see above)			2. countercyclical buffers capital	2. countercyclical provisioning general credit growth sectors by growth and price capital market exposures housing loans non-housing retail loans CRE loans NBFC exposure
		X2| Interconnectedness: strengthening infrastructure resilience	1. encourage idiosyncratic imbalances time-varying risk weights 2. progressive reduction in required minimum buffers and targets given idiosyncratic imbalances 3. encourage defensive imbalances time-varying risk weights capital liquidity interest rate hedges credit risk distance stress-testing liquidity distance stress-testing 4. customized long run defensive targets standard and idiosyncratic exposures by institution 5. progressive reduction in required buffers and limits when institutions exceed defensive targets 7. disclosure (see above) 8. communication (see above)	3. central bank refinancing 4. government guarantees 5. deposit insurance 6. contingency funding	1. central counterparties tool to mandate CCP use 2. trading circuit breakers defined class trading venue defined class market-maker defined class circuit breaker 3. disclosure sovereign sector banking sector specific risks	1. time-varying charge SIFI capital surcharge 2. structural improvements TTS margins/haircuts defined class trading venue	3. countercyclical risk weights general credit growth sectors by growth and price capital market exposures housing loans non-housing retail loans CRE loans NBFC exposure

Table 6

Probability of systemic stress episode by CFSI grade

CFSI rating grades		Range*	Probability of systemic stress at grade threshold
Grade 1	(expansion period)	$Z_{CFSI} \leq -0.50$	1.9%
Grade 2	(normal period)	$-0.50 < Z_{CFSI} < 0.59$	8.7%
Grade 3	(moderate stress period)	$0.59 \leq Z_{CFSI} < 1.68$	26.3%
Grade 4	(significant stress period)	$Z_{CFSI} \geq 1.68$	53.3%

* *Note:* Range analysis is performed on CFSI standardized distances (z-scores)

Table 7

Lagged contributions to stress of institutional imbalances with significant Granger properties

Imbalances	Short Lag	Long Lag
Return imbalances		
Loan portfolio (cpi)		12
Interbank derivatives		(12)
Interbank currency (cpi)	(2)	
Interbank currency (ta)	5	
Interest rate derivatives		(12)
Liquidity imbalances		
AL gap: 0-3 months	3	
AL gap: 3-12 months	4	
Liquidity index: 1 year forward		(10)
Risk imbalances		
IRR through the cycle	(6)	(12)
IR capital through the cycle	5	12
IR capital in stress	5	12
IR capital in crisis	(6)	(7)
CR capital through cycle	(6)	
EDF		10
Economic value of loans (BankCaR)	(3)	(9)
Solvency through the cycle	(5)	(11)
Solvency in stress	(5)	(9)
Solvency in crisis		(9)
IR distance to crisis	(5)	(11)
IR distance to stress	6	9
CR distance stress to crisis	(4)	
CR distance to stress	(4)	(9)
Solvency distance stress to crisis	(6)	(9)
Solvency distance to crisis	(6)	(8)
Structural imbalances		
Connectivity CoVaR	5	
Currency markets concentration	5	8
FX markets concentration	6	7
Interbank concentration	6	11
Leverage	5	12

Note: Negative values indicate lagged imbalances with negative Granger-based contributions to stress. Positive values indicate lagged imbalances with positive Granger-based contributions to stress. Abbreviations used: ta = deflated by total assets; cpi = deflated by consumer price index; AL = asset liability; IR = interest risk; CR = credit risk; EDF = expected default frequency; BankCaR = bank capital-at-risk; CoVaR = conditional value at risk; FX = foreign exchange.

Table 8

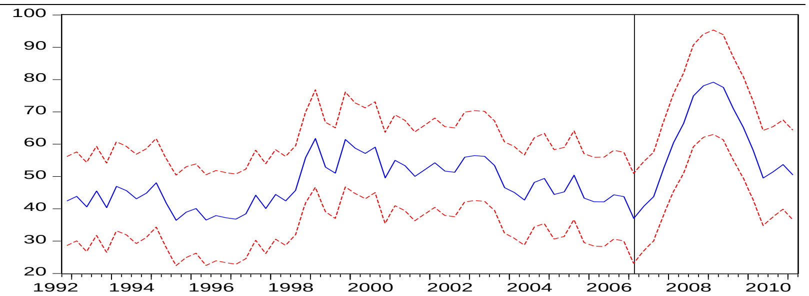
Benchmark and base models out-of-sample static forecasts

Panel A: Benchmark FSI model

$\widehat{FSI} = 7.85 + 0.60FSI_{-1} + 0.24FSI_{-4}$

DF=58 K=2

RMSE[98]	MAPE	Theil U
8.35	12.42	0.081

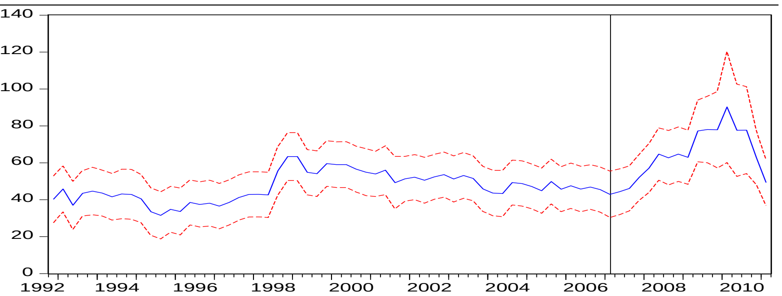


Panel B: Candidate base Model

$\widehat{FSI} = 36.58 + 0.35FSI_{-1} + 1.70GT\_AL3_{-5} + 7.04GT\_LEVN_{-9} + 2.34\Delta PMKTCP_{-5} - 12.62\Delta CRCAP\_NV_{-11}$

DF=61 K=5

RMSE	MAPE	Theil U
11.70	15.24	0.112

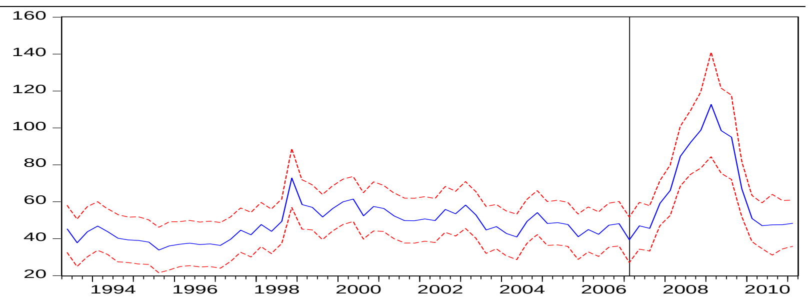


Panel C: Short-lag base model

$\widehat{FSI} = 38.77 + 0.40FSI_{-1} + 2.06\Delta HFX4_{-6} + 8.65\Delta HEQ5_{-8} + 8.15GT\_LEVN_{-5} - 2.94\Delta EQLGDW3_{-7} - 4.55CR\_EVSV_{-8}$

DF=61 K=6

RMSE	MAPE	Theil U
9.04	11.83	0.084

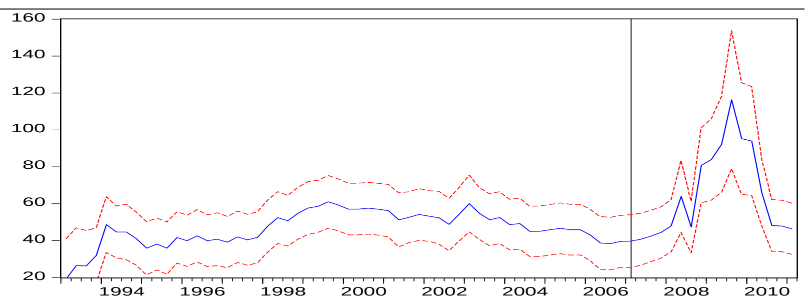


Panel D: Long-lag base model

$\widehat{FSI} = 37.85 - 9.88GT\_ALG3_{-9} + 2.29EDF_{-11} - 2.24CR\_EVNV_{-6} + 4.55GT\_HIB_{-8} + 11.20GT\_LEVN_{-7}$

DF=57 K=5

RMSE	MAPE	Theil U
15.14	18.75	0.143



98 Note that the RMSE errors may not be directly compared across these models due to the differences in their forecasting horizons. The benchmark FSI model forecasts one quarter ahead, candidate base and short-lag base models forecast two quarters ahead, while the long-lag base model forecasts six quarters ahead.

Table 9
Sample transition matrix (leverage).

	Leverage change (std)			
	Grade 1	Grade 2	Grade 3	Grade 4
Grade 1	-	$X_{1,2}$ = 3.5	$X_{1,3}$ = 7.2	$X_{1,4}$ = 10.4
Grade 2	$X_{2,1}$ = (3.5)	-	$X_{2,3}$ = 3.7	$X_{2,4}$ = 6.9
Grade 3	$X_{3,1}$ = (7.2)	$x_{3,2}$ = (3.7)	-	$X_{3,4}$ = 3.2
Grade 4	$X_{4,1}$ = (10.4)	$X_{4,2}$ = (6.9)	$X_{4,3}$ = (3.2)	-

Note: $X_{i,j}$ denotes the change in imbalance, measured in standard deviations, that is associated with transition of stress from grade i to grade j.

FIGURES

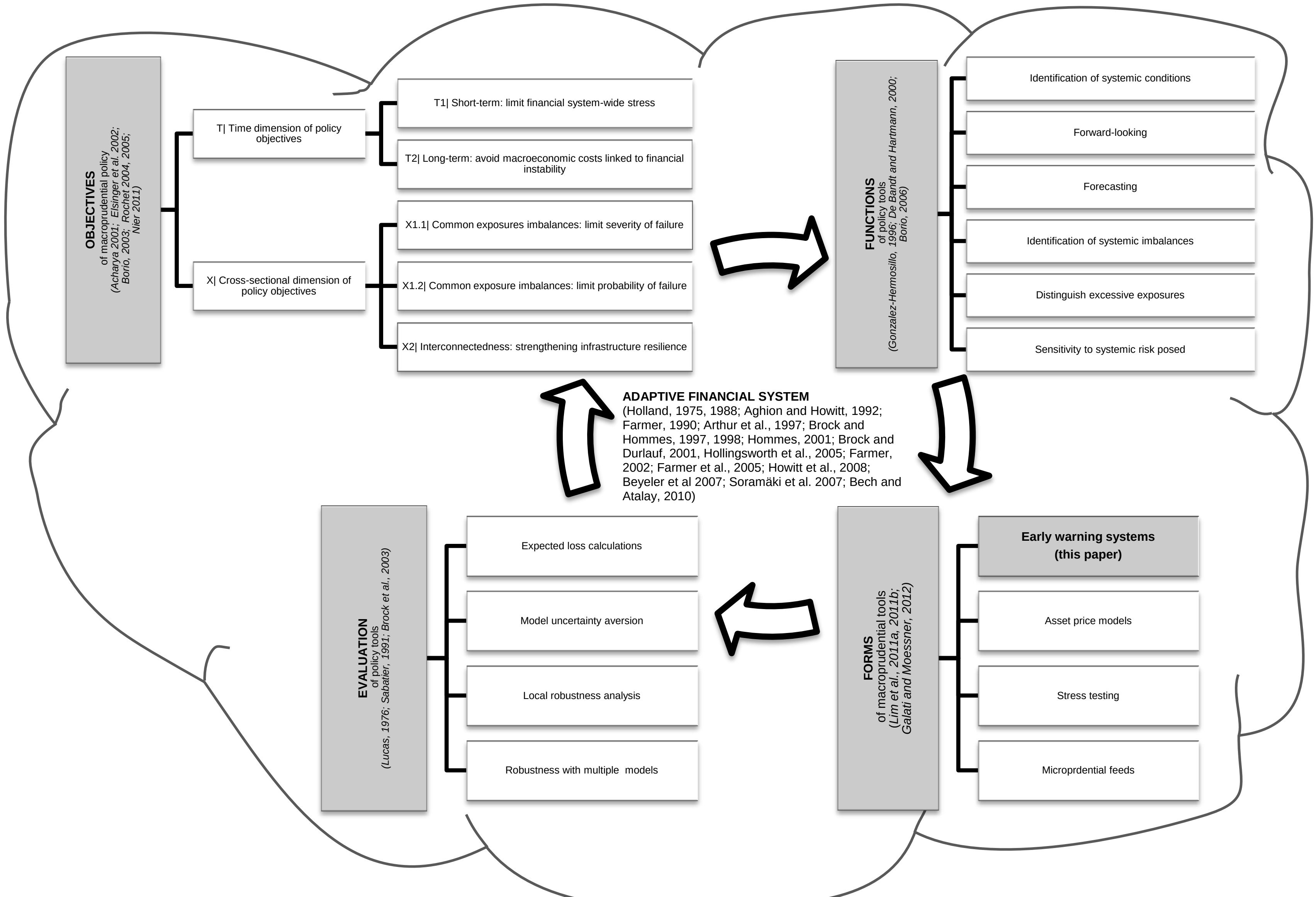
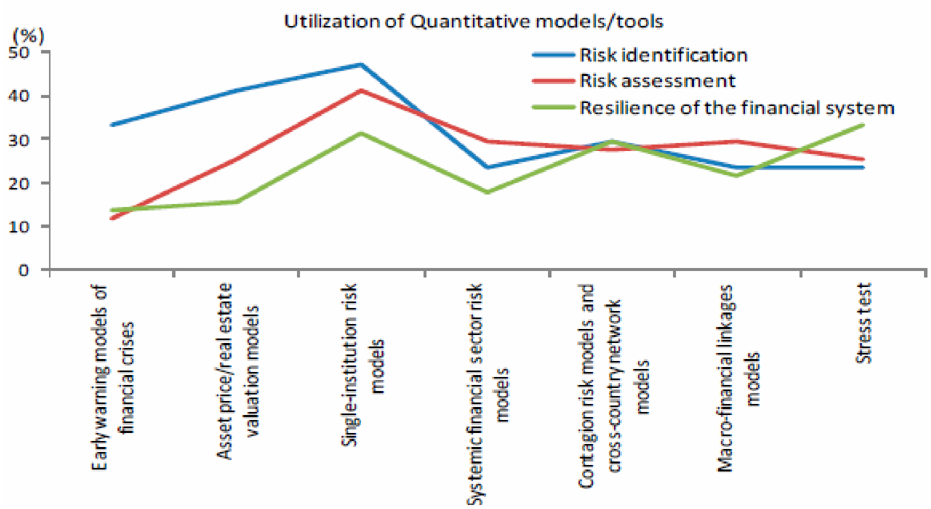


Fig. 1. Conceptual Model: Early Warning Policy Use in Adaptive Financial System.



Note: vertical axis measures percentage of respondents to the 2011 IMF monetary and capital markets department's "financial stability and macroprudential policy survey."

Fig. 2. Utilization of macroprudential tools. Source: Lim et al. (IMF 2011a).

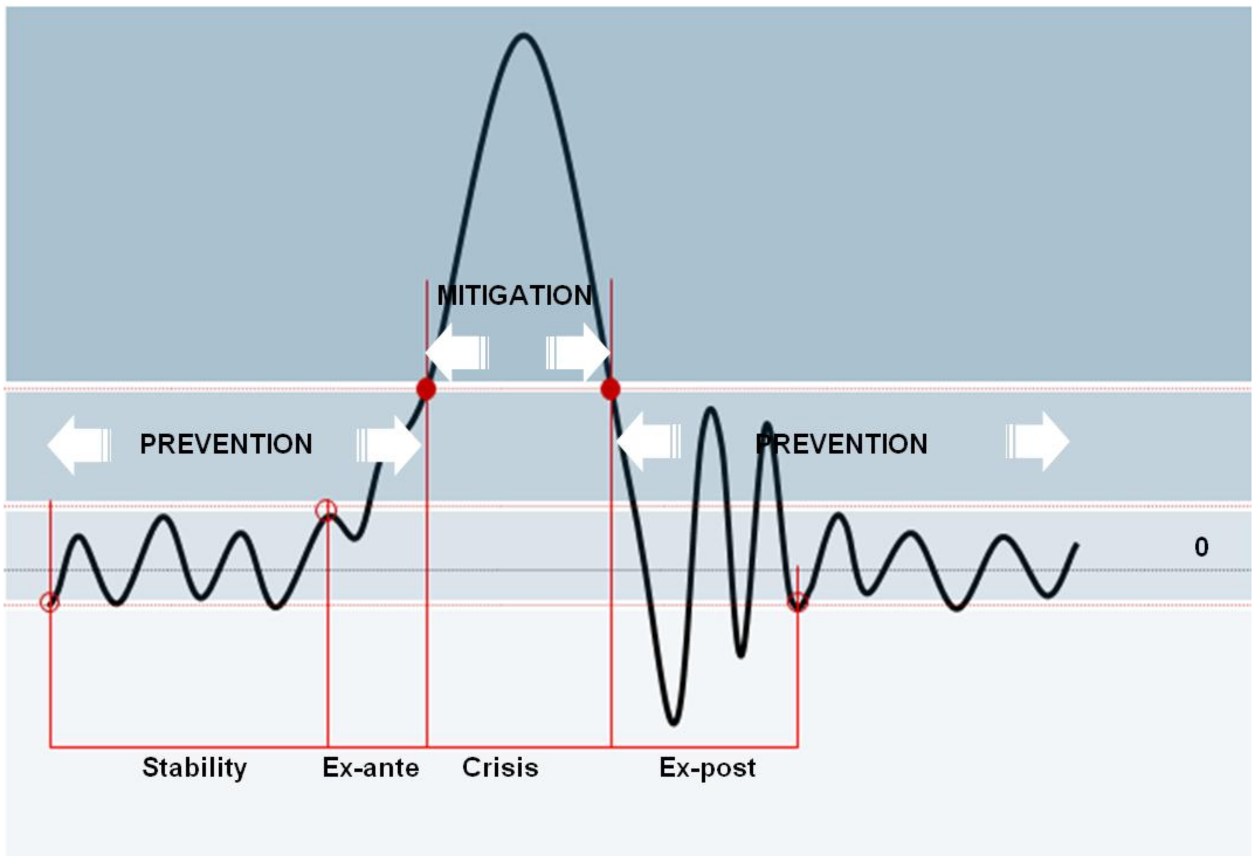
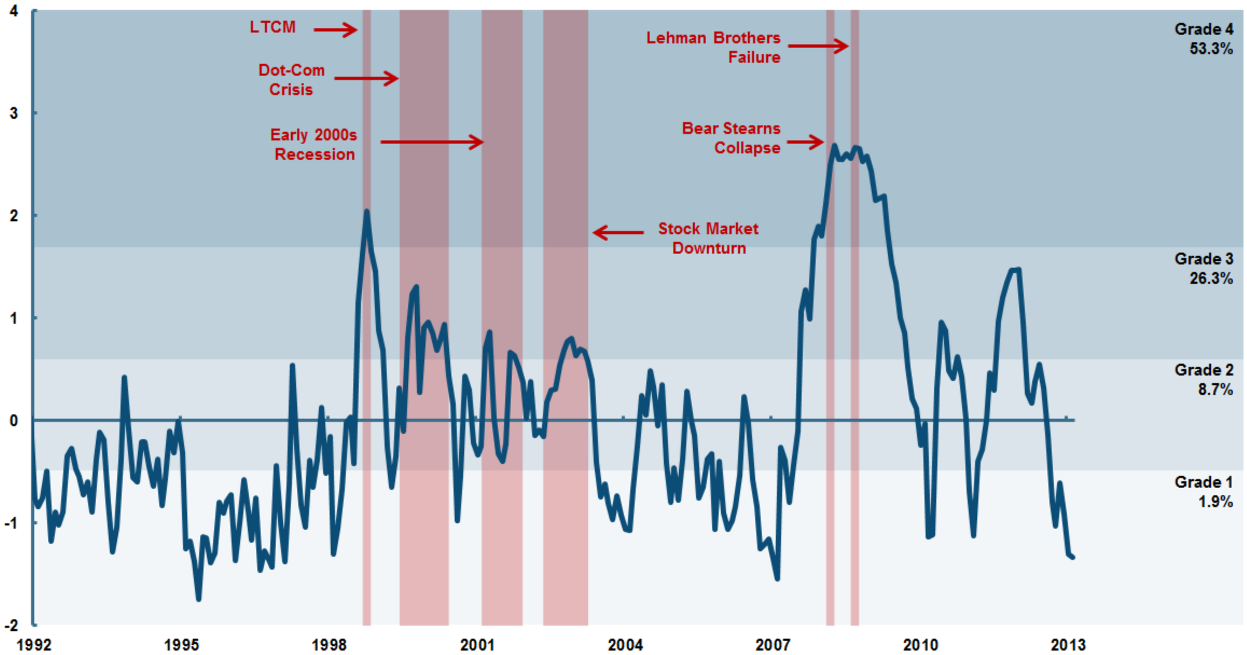


Fig. 3. Conceptual time phases of systemic financial stress



Note: Number of grades optimizes identification of benchmark systemic stress episodes at multiple monitoring frequencies. Grade thresholds separate the range of observed stress into segments of equal size (std). Percentages marked with each grade indicate the probability of stress within given grade being part of a benchmark systemic stress episode.

Fig. 4. Cleveland Financial Stress Index

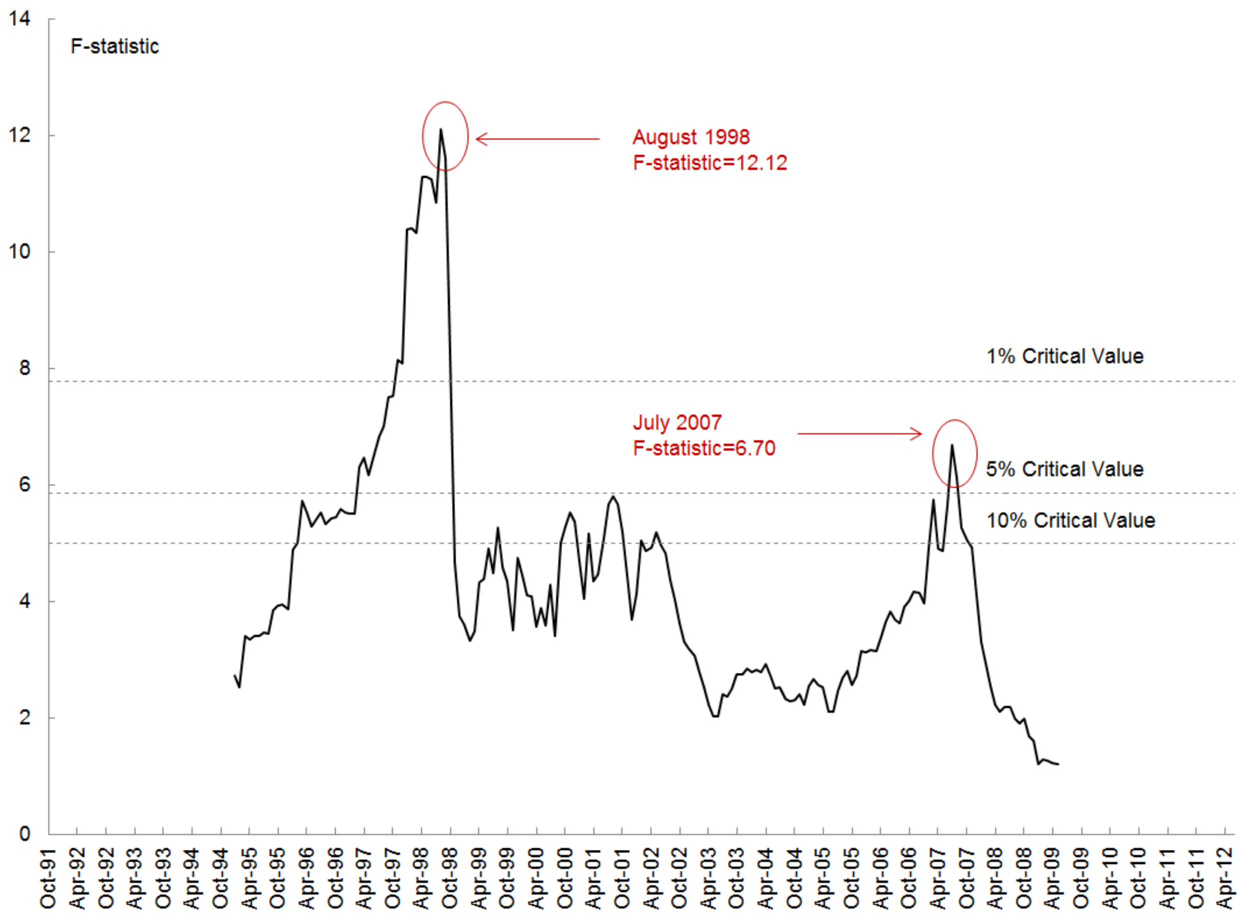


Fig. 5. Quandt likelihood ratio testing for structural break in Z_{CFSI}

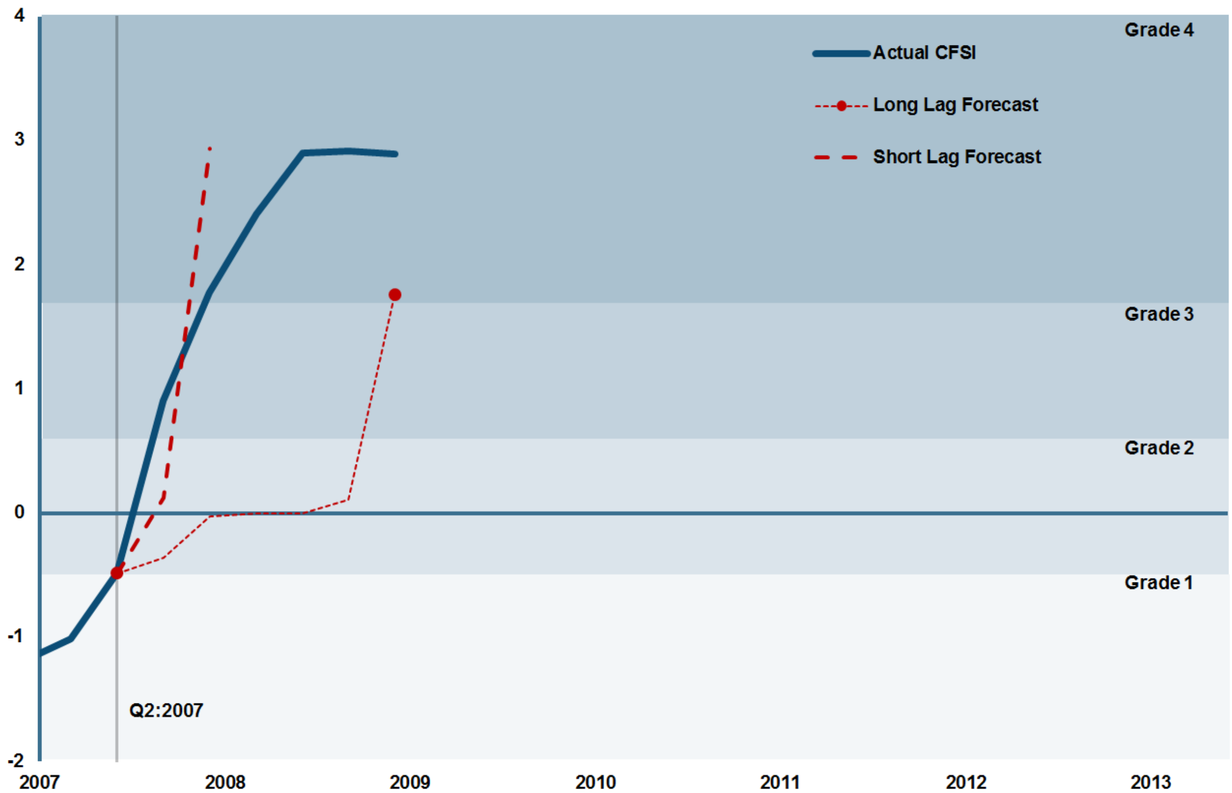


Fig. 6. Out-of-sample SAFE EWS forecast as of 2Q 2007.

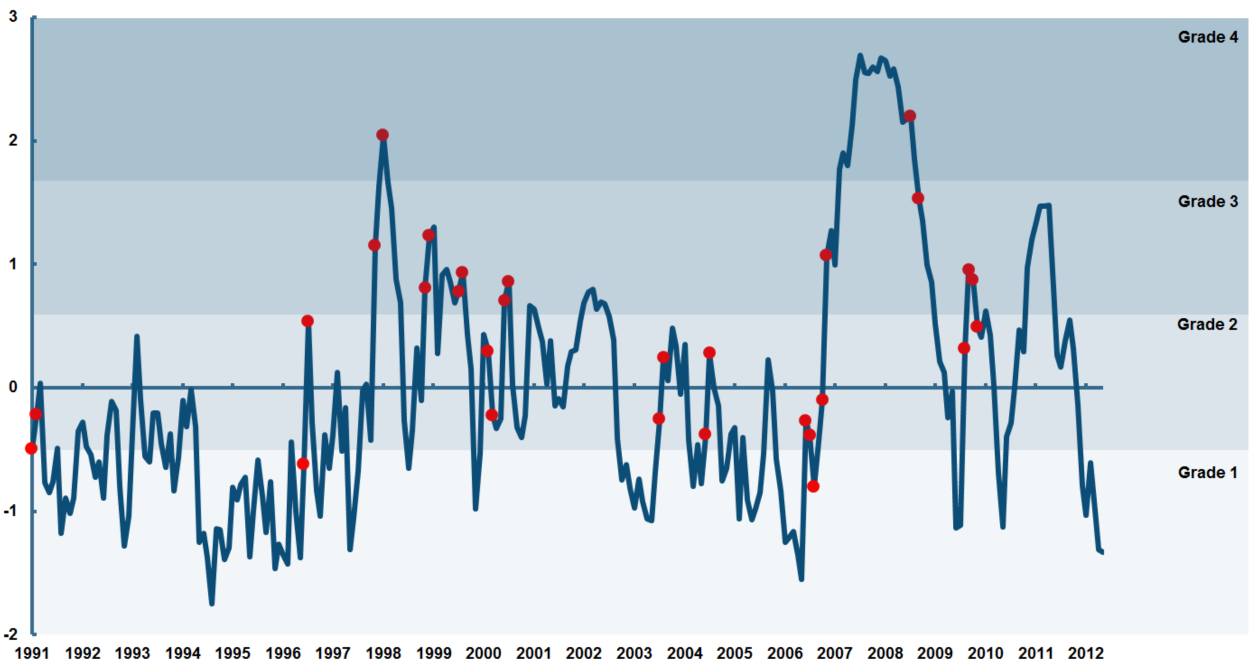


Fig. 7. Signaling rule alerts to significant developing stress.

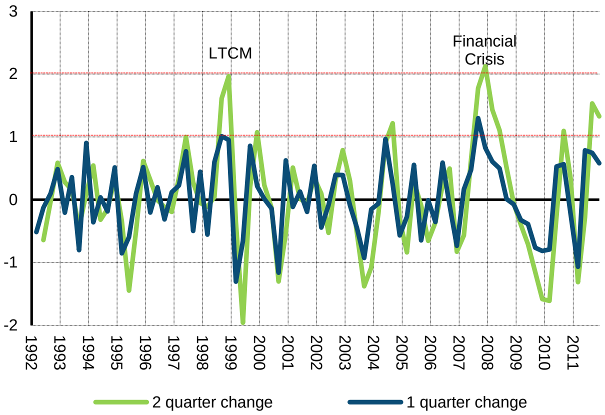


Fig. 8. $\dot{\mathrm{FSI}}_1$ and $\dot{\mathrm{FSI}}_2$ alerts to significant developing stress.

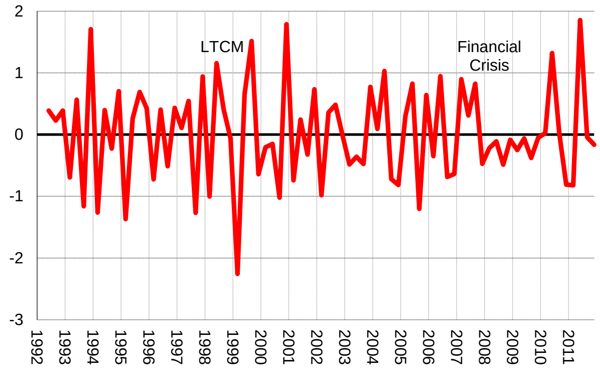
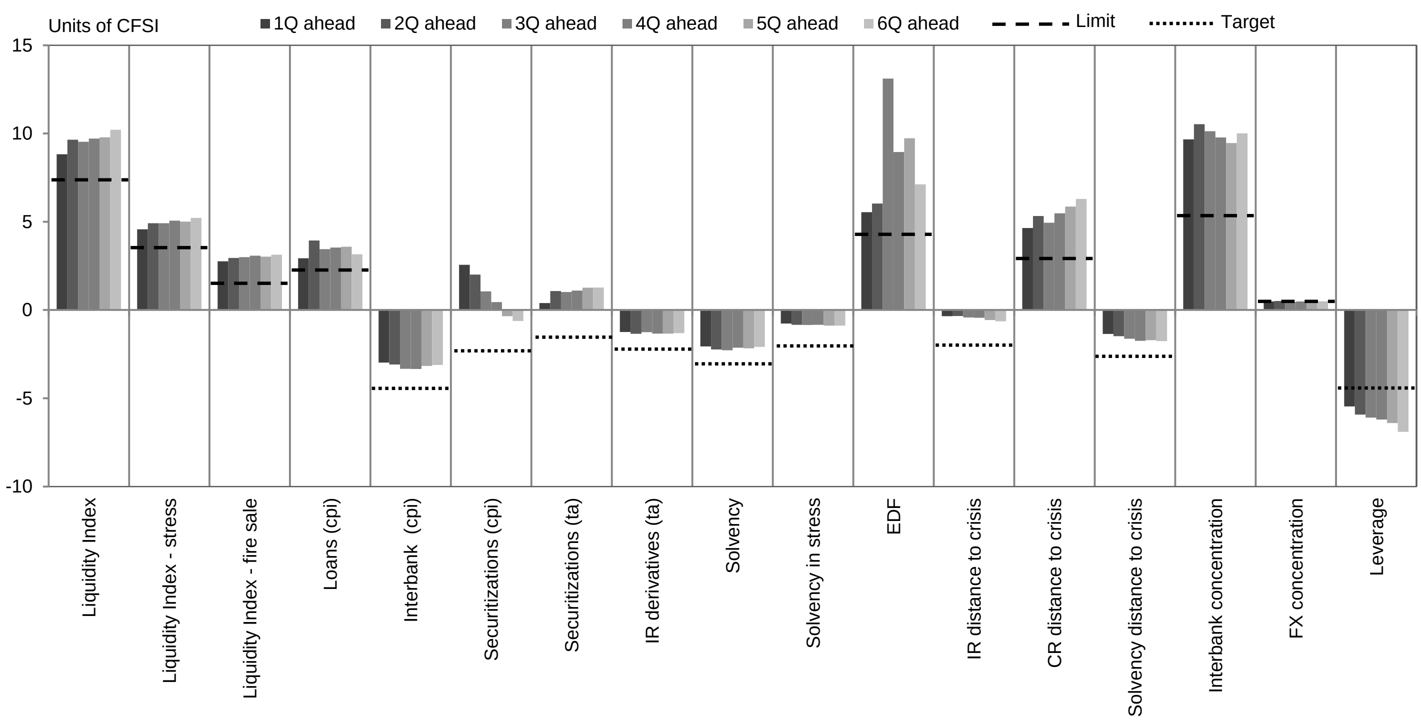


Fig. 9. $\ddot{\mathbf{FSI}}$ alerts to significant developing stress.



Note: The figure describes sample long-lag contributions of a subset of the top twenty five bank holding companies as of 1Q 2012.

Fig. 10. Potential targets and limits through monitoring of imbalance percentage contribution to stress.

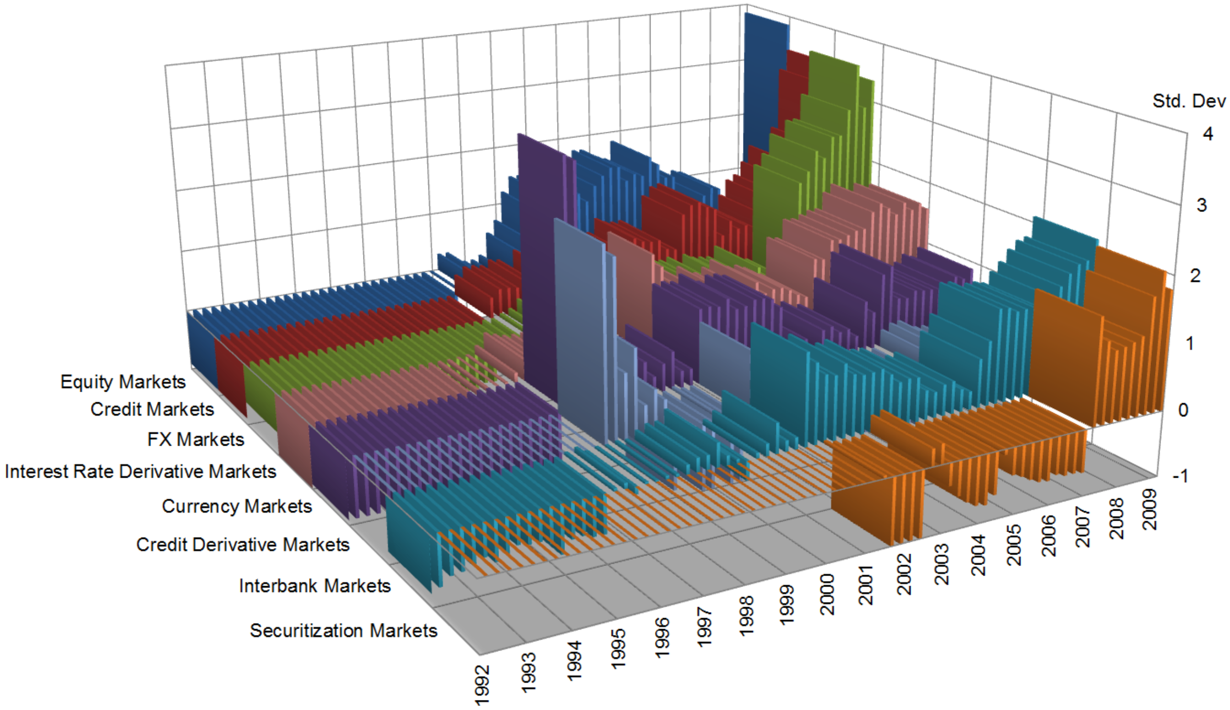


Fig. 11. Risk topography of financial market concentrations of top 25 US BHCs across markets and time.

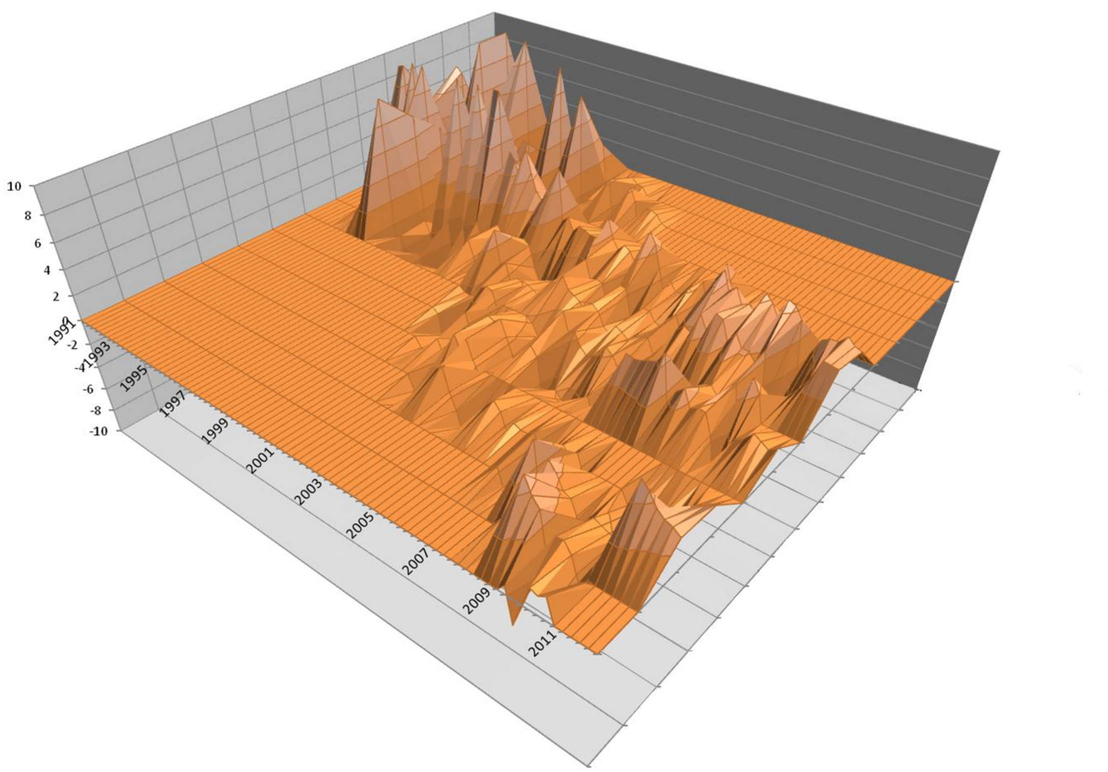


Fig. 12. Individual contribution to systemic financial stress (CFSI) of top five US BHCs: 1991-2011.

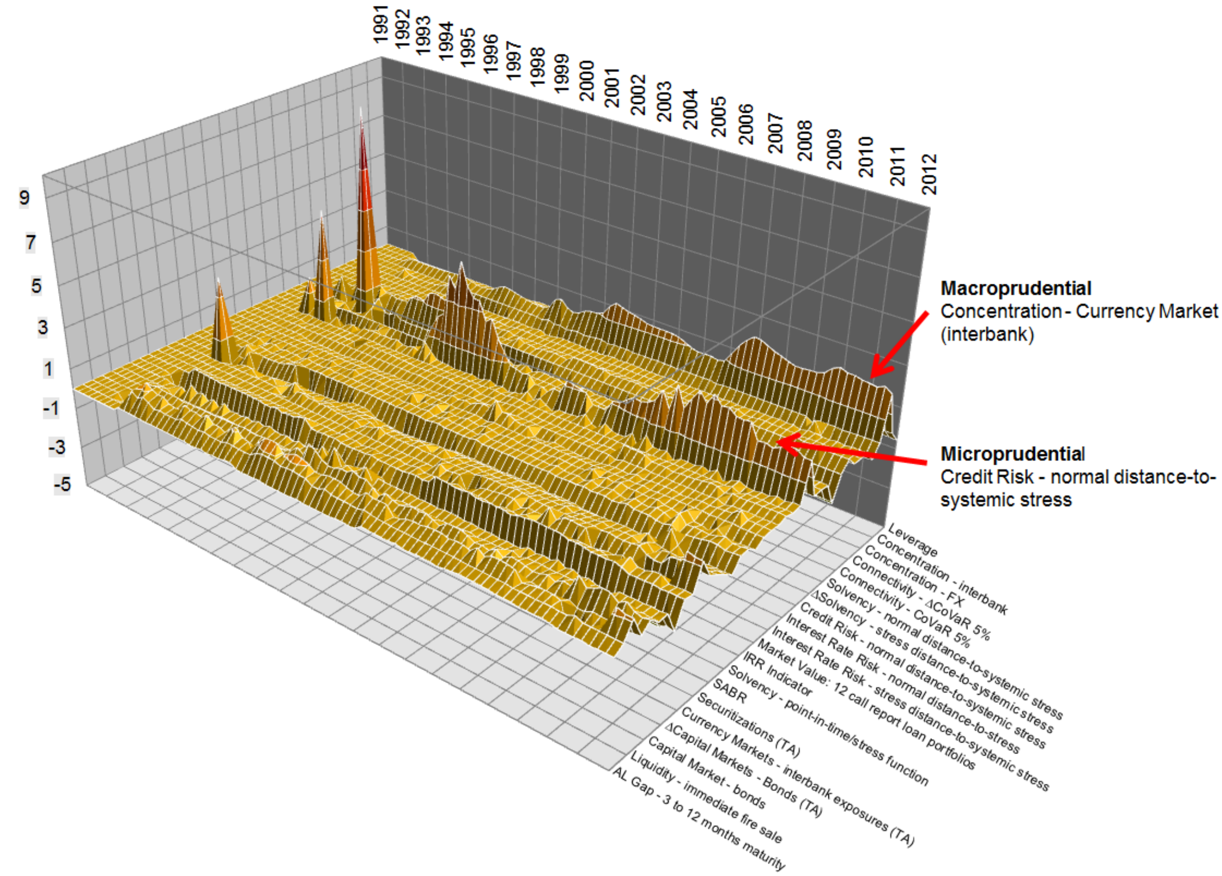


Fig. 13. Sample of imbalances by an individual financial institution: 1991-2011