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Analytical Frameworks and Toolkits in IMF Financial Surveillance

Olivier Jeanne

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Prepared by Olivier Jeanne*

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* Professor, Johns Hopkins University.

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ABBREVIATIONS

BIS	Bank for International Settlements
CDS	credit default swap
CIMDO	Consistent Information Multivariate Density Optimizing (methodology)
CFSM	Country Financial Stability Map
DSGE	Dynamic Stochastic General Equilibrium (model)
ECB	European Central Bank
EDO	estimated dynamic optimization
ESCB	European System of Central Banks
FRB	U.S. Federal Reserve Board
FSAP	Financial Sector Assessment Program
FSGM	Flexible System of Global Models
FSI	Financial Soundness Indicator
FSSA	Financial Sector Stability Assessment
GaR	Growth-at-Risk
GDP	Gross Domestic Product
GEM	Global Economy Model
GFC	Global Financial Crisis
GFM	Global Macrofinancial Model
GFSM	Global Financial Stability Map
GFSR	*Global Financial Stability Report*
GIMF	Global Integrated Monetary and Fiscal Model (IMF)
MCM	Monetary and Capital Markets Department (IMF)
RES	Research Department (IMF)
SPR	Strategy, Policy and Review Department (IMF)
STA	Statistics Department (IMF)
WEO	*World Economic Outlook*

EXECUTIVE SUMMARY

This paper reviews and evaluates the analytical tools used by the IMF in its financial surveillance. National authorities have considerably developed their tools for analyzing and monitoring financial risks after the global financial crisis and the IMF should focus on the areas in which it has a comparative advantage. The paper is organized around three sets of tools: (i) macrofinancial models; (ii) financial risk indicators; and (iii) the analytical tools used in IMF bank stress testing. Our conclusions can be summarized as follows.

Macrofinancial modelling

- **Recent academic research has not produced a unified macrofinancial framework.** Central banks and the IMF continue to rely mostly on macroeconomic models where the financial risks and vulnerabilities are added on an ad-hoc basis.

- **The IMF macrofinancial modelling capacity lags behind that of the main advanced-economy central banks.** The IMF must invest more in this area if it wants to remain a key contributor to debates about macrofinancial issues.

Risk indicators

- **The IMF staff uses a growing battery of indicators to monitor financial risks at the global and country levels.** The IMF toolkit now contains more than 20 risk indicators that are used in multilateral surveillance and in Article IV consultations.

- **The IMF risk indicators and tools could be streamlined through a formal internal and external evaluation process.** The IMF should deepen and improve the use of its most relevant indicators, in particular those related to the credit cycle.

Stress testing

- **Member countries have considerably strengthened their stress testing capacity relative to the IMF.** New stress testing tools were developed in areas where the IMF does not have a natural comparative advantage.

- **IMF stress testing tools need to evolve with an eye to filling gaps in the international financial surveillance architecture.**

- **The IMF could develop tools to stress test the global financial system.** This could take the form of a "global liquidity stress test."

I. INTRODUCTION

1. The purpose of this paper is to evaluate the analytical tools used by the IMF in its financial surveillance. These tools come in many shapes and forms, from dynamic general equilibrium models to early warning indicators of macrofinancial risk. There is also great diversity in the way that the tools are used by the IMF staff. They can be used in bilateral surveillance or in multilateral surveillance and some tools are used for both. Some tools are the preserve of specialists while others are used more widely by fungible macroeconomists. Furthermore, the tools have evolved, as the Global Financial Crisis (GFC) compelled the IMF to upgrade the analytical tools used in its financial surveillance and to better analyze macrofinancial linkages.

2. What is the set of tools to be reviewed? This paper defines a financial surveillance analytical tool as an instrument that IMF staff uses recurrently across countries and over time to assess risks to financial stability. Most of the tools reviewed in this paper have been used multiple times in the *World Economic Outlook (WEO)*, the *Global Financial Stability Report (GFSR)*, Article IV consultations and Financial Sector Stability Assessments (FSSAs). They can be found in the "toolboxes" that are made available to Fund economists on the intranet websites of the Monetary and Capital Markets (MCM), Research (RES), Strategy, Policy and Review (SPR), and Statistics (STA) departments.[1]

3. Against which benchmark should the IMF's tools be evaluated? The ideal criterion is how well these tools identify and measure financial risks and vulnerabilities in member countries or the global financial system. This is a difficult criterion to implement in practice because the nature of financial risks changes over time and the objective of financial surveillance is a continuously moving target. The analytical tools used by the IMF have evolved in the last 10 years reflecting new research on causes of the GFC, but the next crises will inevitably be different. Financial crises are relatively rare events, and 10 years is a relatively short time to evaluate how much better the IMF's tools are at identifying financial risks looking forward.

4. Another benchmark of comparison is provided by analytical tools used by other policy institutions often central banks in charge of financial stability and surveillance. This is also an imperfect benchmark because what the IMF is trying to achieve with its financial surveillance is in some sense unique. The IMF runs bilateral surveillance with a wide and diverse set of member countries, and tends to favor tools that can be transposed across countries relatively easily. In its multilateral surveillance the IMF focuses on the international aspects of financial stability, a broader and more global focus than most national policy institutions.

5. With these considerations in mind, this paper takes a relatively eclectic approach and relies on a variety of inputs including the views of economists in charge of financial surveillance

[1] Most of the tools can be found on the MCM Quantitative Methods Gateway. See Appendix 1 for a list.

at the IMF and other policy institutions,[2] academic researchers, and the author's own evaluation of the tools used by IMF staff in financial surveillance. The paper draws on previous reviews and evaluations of IMF financial surveillance, selected FSSAs, Article IV staff reports, *WEOs* and *GFSRs* between 2013 and 2017, IMF reviews of its own tools and practices such as Blancher and others (2013) on indicators of systemic risk, IMF (2014a) on stress testing, and IMF (2017a) on macrofinancial surveillance in Article IV staff reports. This paper is not meant to be an exhaustive and detailed review of all the analytical tools used by the IMF in its financial surveillance, but rather tries to bring out a few important facts and ideas to bear in mind when thinking about how these tools have evolved and should be improved looking forward.

6. Several caveats should be mentioned at the outset. First, this paper does not cover all the techniques that are used directly or indirectly by IMF staff in its analysis of financial issues. For example, this paper does not assess the data and econometric techniques utilized to analyze systemic spillovers in the GFSR. Second, this paper is more about the quality of the tools than about the ability of IMF staff to use them or "think macro-financially," i.e., on their usability rather than on their use. Finally, I assess the tools in their contribution to financial surveillance rather than other functions of the IMF, such as technical assistance.

7. The paper is organized around three sets of tools. The first part is about models of macrofinancial linkages. The second part focuses on indicators or early warning signals that are used by the IMF to assess financial vulnerabilities at different time horizons. The third part discusses the frameworks and tools used in bank stress testing. The three sections are exclusive for the most part.[3]

II. MACROFINANCIAL MODELLING

8. There were many calls after the GFC for rethinking macroeconomics and developing new models that would better capture the linkages between macroeconomics and finance. Some progress was made and new macrofinancial models were developed in academia and policy institutions. After reviewing the evolution of macrofinancial research over the past 10 years, this section compares the macrofinancial models and frameworks used by central banks and the IMF.

Recent research has not produced a unified macrofinancial framework.

9. Considerable progress in macrofinancial modelling has been made in response to the GFC. Economic theorists have produced new models that captured, at least in a stylized way, the main destabilizing amplification mechanisms underlying systemic financial crises. Some

[2] Interviews were conducted at the U.S. Federal Reserve Board, the Bank for International Settlements (BIS), the Bank of England, and the European Central Bank (ECB).

[3] They are not completely exclusive because some tools are used both as financial soundness indicators and in stress testing, for example.

mechanisms operate inside the financial sector and move very fast, for example fire sales by financial institutions leading to generalized panic and runs on various forms of demandable liabilities. Other mechanisms involve the real sector and operate more slowly, for example a fall in aggregate demand caused by deleveraging in the household sector. Box 1 provides a brief and selective review of the theoretical literature.[4]

Box 1. Theoretical Literature on Macrofinancial Linkages

Financial frictions were introduced into macroeconomic models before the GFC, generally to study financial amplification in the real business cycle or the financial channels of monetary policy (Bernanke and Gertler, 1989; Bernanke, Gertler, and Gilchrist, 1999). These models featured a financial accelerator whereby the net worth of small firms or households influence their spending, but they did not explain systemic financial crises. There was an inconclusive debate before the crisis about the extent to which models with more complex financial amplification could generate scenarios with more costly forms of financial instability (Kiyotaki and Moore, 1997; Kocherlakota, 2000).

The post-crisis literature began to model systemic financial crises by granting a more important role to financial intermediation and liquidity risks. Gertler and Karadi (2011) studied a New Keynesian model in which the financial accelerator applies to banks. Brunnermeier and Sannikov (2014) and Gertler and Kiyotaki (2015) presented DSGE models in which banks are subject to runs on their short-term liabilities associated with "fire sales" of their assets. This new literature had to negotiate a trade-off between analytical tractability and incorporating the non-linearities that are important to explain amplification in financial crises. Non-linear models remain challenging to solve except at the cost of drastic simplifications that make them unsuitable for policy making.

Another, more normative, branch of literature clarified that both the build-up and the realization of systemic risk could be analyzed in terms of externalities whereby individual agents do not internalize the contribution of their leverage to systemic risk. According to this perspective the appropriate macroprudential policy actions can be viewed as optimal Pigouvian taxes to deal with these externalities (Jeanne and Korinek, 2010b; Korinek and Simsek, 2016; Farhi and Werning, 2016).

Finally, another branch of literature focused on modelling excessive volatility in international capital flows. Open-economy models had incorporated the kind of financial frictions faced by emerging markets before the GFC (see, e.g., Céspedes and others, 2004). These models were extended to the analysis of optimal capital flow management by Jeanne and Korinek (2010a) and Bianchi (2011) among others.

10. This research program has achieved several of its goals. By construction, the new macrofinancial models describe equilibria in which the two-way feedbacks between the real sector and financial sector are taken into account. Small shocks can have large effects because of non-linear amplification mechanisms. On the normative side, the theoretical literature has clarified that macroprudential policy can be viewed, in reduced form, as a system of Pigouvian taxes to mitigate negative externalities associated with excessive leverage.

11. However, this line of research has not produced a unified framework for macrofinancial analysis. This is by contrast with the New Keynesian research program of the nineties, which led to workhorse frameworks presented in Gali (2008) or Woodford (2003) and underpins many models used by central banks for monetary policy. As stated by Haldane (2017): "… we are still

[4] More detailed reviews can be found in Brunnermeier and others (2013) and Claessens and Kose (2017).

probably in the foothills when developing a unified framework […] that could capture the rich feedback and amplification mechanisms that operate in practice and a model which could then serve as a test-bed for each of the three arms of policy. Indeed, it could be that a single, Holy Grail, framework is infeasible…."[5]

12. There are several reasons for the failure to achieve a unified macrofinancial framework. First, whereas the New Keynesian models focused on one type of friction (nominal stickiness in prices and wages), the financial frictions that matter for financial stability are manifold and can hardly be all incorporated into one model without making it intractable. Another impediment is the technical difficulties that modellers still face when solving macroeconomic models with financial frictions. One reason for the success of New Keynesian models in policymaking is the tractability offered by linearization, but linearization removes the nonlinear amplification mechanisms that are so important in financial crises.

13. The macroeconomic models used by central banks to quantify economic scenarios for monetary policy have thus remained largely free of financial frictions. For example, banking or real sector balance sheets play no role in the U.S./FRB model or in the estimated dynamic optimization (EDO) model used by the U.S. Federal Reserve ("U.S. Fed"). This also applies to models of the global economy used at the U.S. Fed, such as the FRB-Global and SIGMA models. In SIGMA, for example, the key risks from international conditions are modelled as exogenous fluctuations in risk premia (Chung and others, 2010). The same applies to the Bank of England's central forecasting model, COMPASS, although it is complemented by a suite of 50 separate models, some of which incorporate financial sector channels. The Christiano-Motto-Rostagno (CMR) model, which is used by the ECB for monetary and financial scenarios and for cross-checking, introduces financial frictions into a Dynamic Stochastic General Equilibrium (DSGE) model (Smets and others, 2010). The new ECB multi-country (MC) model is a semi-structural framework that is close to the U.S./FRB model but contains more macrofinancial linkages and more advanced endogenization of financial variables.

14. This does not mean that financial considerations have not become more important in the determination of monetary policy, but they have suffused policymaking through eclectic channels rather than being embedded in one single model. Monetary policy decisions are based on many inputs other than the simulation of a macro-model. For example, the U.S. Fed baseline forecast is the product of a bottom-up process aggregating the views of analysts in charge of different sectors of the U.S. economy.[6] To the extent that these analysts are more attuned to financial factors this will be reflected in the baseline forecast. The staff of the Bank of England uses a suite of models (Burgess and others, 2013) but the quarterly forecasts are the "best

[5] A statement anticipated by the IMF staff 10 years earlier "the quest for a common macrofinancial template that fungible IMF staff could apply to all countries is probably futile" (IMF, 2007).

[6] The U.S./FRB model is used for the alternative scenarios around the baseline forecast. See Fischer (2017) for a description of the monetary policymaking process at the U.S. Fed.

collective judgement" forecasts of the nine independent members of the Monetary Policy Committee.

15. Similarly, there is relatively little finance in the large models used by the IMF in the *WEO* to make global projections or study global crisis scenarios. The IMF framework that has the most financial content is the Global Macrofinancial Model (GFM). This model is used to study global economic scenarios in the first chapter of the *GFSR* and to produce macroeconomic scenarios underlying IMF banking stress tests (see Box 2).

Box 2. The Global Macrofinancial Model

The GFM is a model of the world economy that has been used in the *GFSR* to quantify scenarios with financial spillovers (Vitek, 2018). The model is specified and calibrated to match the structure and policy regimes of the 40 largest economies. The model includes a real estate sector and a banking sector in addition to households and productive firms. The model has a rich array of frictions, with a financial accelerator in the corporate and banking sectors in addition to nominal stickiness in wages and prices. Defaults on loans affect the net worth of banks. The national authorities are in charge of monetary policy, fiscal policy, and macroprudential policy, the latter being implemented through a regulatory bank capital requirement and loan-to-value ratio limits. Policies are modeled as state-contingent rules plus shocks.

Some limitations of the framework should be noted. Portfolio allocations are derived from ad hoc investor preferences rather than the trade-off between risk and return as in standard portfolio theory. The model is linearized, implying that it does not capture nonlinear amplification mechanisms that can transform small shocks into large crises. The spillovers are driven mainly by an assumed cross-country correlation between risk premia rather than being derived from the model's micro-foundations. From that perspective it is unclear how different in reduced form the GFM is from counterparts (such as the GIMF) where financial frictions consist of shocks to risk premia.

The GFM has been used to study global macroeconomic scenarios in the first chapter of the *GFSR*. In the October 2015 *GFSR* the GFM is used to assess the global macrofinancial effects of global asset market disruption and normalization scenarios involving different assumptions about risk premia, market liquidity, and growth. The October 2016 *GFSR* simulates a financial stagnation and protectionism scenario triggered by risk-off reactions in financial markets to protectionist initiatives driven by political developments in Europe and the United States. In the October 2017 *GFSR* the GFM is used to assess the consequences of a continued buildup in debt and an extended rise in risky asset prices. The GFM is also used to produce macroeconomic scenarios underlying the banking stress tests implemented in the context of Financial Sector Assessment Programs (FSAPs) for the countries it covers (for other countries FSAPs often use the FSGM model maintained by the Research Department).

16. The baseline models used for the *WEO* are the Global Economy Model (GEM), the Global Integrated Monetary and Fiscal model (GIMF), and the Flexible System of Global Models (FSGM). The GEM and GIMF are open-economy DSGE models derived from the complete optimization problems facing households and firms. Both GIMF and GEM are complex structural models that are difficult to solve numerically for more than six countries or regions. The FSGM is a suite of macroeconomic models that correspond to different ways of breaking down the global economy

and can contain up to 24 regions or countries (G20MOD, for example, represents the G20 economies, and EUROMOD can be used for the euro area).[7]

17. These models have been augmented with fluctuating risk premia in order to run scenarios with a financial dimension in the first chapter of the *WEO*.[8] For example, the FSGM (G20MOD), with time-varying risk premia, was used in the April 2014 *WEO* to explore the implications of faster recovery in the U.S. coupled with slower growth in emerging markets, in the October 2015 *WEO* to quantify the impact of a structural slowing in emerging market economies, and in the April 2017 *WEO* to study the impact of a permanent U.S. fiscal expansion. In addition, GIMF was used in the April 2013 *WEO* to look at the impact of a rise in interest rates in major advanced economies and FSGM (EUROMOD) was used in the October 2013 *WEO* to quantify a downside scenario for the euro area.

18. The GFM is perhaps the only example—inside or outside the IMF—of a large macrofinancial model used to produce global economic forecasts and quantify scenarios. The GFM includes financial frictions in the form of collateral constraints in the corporate and real estate sectors and capital adequacy requirements in the banking sector (see Box 2). This model has been used to study international spillovers associated with global stress scenarios in several issues of the *GFSR* since 2015, as well as the macroeconomic scenarios underlying stress tests conducted in the context of the FSAP.

19. There is much to be lauded in the GFM, but the model does not seem to be well known outside of the IMF, and IMF staff indicated that there is insufficient understanding of the mechanisms of international transmission at work in the model. The model is presented and explained in several working papers (the latest one being Vitek, 2018) that render well the complexity of the framework but could do a better job at explaining the transmission mechanisms. Finally, there has been little peer review of the GFM outside of the IMF, for example in the form of publications of refereed articles based on that model. Given the importance that the model is taking in the *GFSR* and bank stress tests, it would make sense for the IMF to invest more resources in making the GFM better understood both inside and outside the IMF.

The IMF lags the major central banks in developing "suites" of macrofinancial models to study specific questions at the intersection of macroeconomics and finance.

20. Although a unified framework capturing all the main financial frictions remains out of reach, major central banks have invested in the development of "suites" of models focusing on different macrofinancial linkages. These are tailor-made small-scale research models used to study

[7] These models, which have been developed by RES, were evaluated by a panel of outside experts in the context of the 2014 Triennial Surveillance Review (see Annex II of IMF, 2014b).

[8] Andrle and others (2015) introduced banks with a financial accelerator in GIMF. In the resulting GIMF-BANKS model, banks have endogenous net worth, which (together with capital adequacy regulation) impacts bank lending. This model has not been used in the *WEO* or *GFSR*.

particular linkages. These models can be used to analyze the interlinkages between financial policy and the macroeconomy. An example is the 3D model developed as part of the European System of Central Banks (ESCB) Macroprudential Research Network (Clerc and others, 2015; Mendicino and others, 2018). Other examples are the models developed by Kiley and Sim (2014) and Iacoviello (2015) at the U.S. Fed to analyze the macroeconomic impact of countercyclical capital buffers.

21. The economists developing these macrofinancial models are part of a network of specialists who interact in professional associations and conferences such as the Dynare conferences, DSGE-net, the conferences on Computing in Economics and Finance, or the annual meetings of the Society for Economic Dynamics. Few researchers involved in this effort expect it to lead to a unified macrofinancial framework. Their goal is rather to build collective knowledge about the best way of using a suite of models capturing different frictions.

22. Some aspects of this approach to macrofinancial modelling can be found in the IMF work. For example, the MAPMOD framework is a model that was developed in RES to study credit booms and busts as well as macroprudential policy (Benes, Kumhof, and Laxton, 2014a; b). MAPMOD was specifically designed to study vulnerabilities associated with excessive credit expansions and asset price bubbles, and the consequences of different macroprudential policies that attempt to guard against such vulnerabilities. MAPMOD has so far been used in the context of technical assistance for inflation-targeting countries rather than in IMF financial surveillance.

23. IMF staff outside of RES have developed small-scale macrofinancial models that have been used in bilateral surveillance. In its review of the approaches to macrofinancial surveillance in Article IV staff reports, IMF (2017a) mentions a few cases where macrofinancial models were used. For example, 2016 Article IV surveillance for Canada used a DSGE model to examine how the impact of a housing price correction could be magnified if combined with tighter financial conditions. Another interesting example is Krznar and Matheson (2017a), who study the interplay between banking stability and the macroeconomy in Brazil using a model that combines standard macroeconomic relationships with the stress testing approach. The model of Krznar and Matheson is included in the MCM toolbox (see Appendix 1) but has not been applied to countries other than Brazil. In addition, MCM economists are working on a new suite of macroeconomic models with financial intermediaries and endogenous risk as well as new semi-structural models building on the Forecasting and Policy Analysis System (FPAS) methodology developed at RES to support technical assistance on inflation targeting.

24. These efforts have not yet coalesced into a toolkit that could be used systematically in IMF financial surveillance. Furthermore, interviews with outside experts confirmed the author's impression that the IMF is not perceived to be a leader in the network of specialists that develop and maintain macrofinancial models in other policy institutions. Linked to this is the fact that the IMF is not very present in the research network dedicated to macrofinancial issues. The IMF presence in research on macrofinancial issues is compared, in Appendix 3, to that of the U.S. Fed and the ECB based on the number of papers on macrofinancial topics presented in selected

conferences. The IMF presence is substantial but lags behind that of the U.S. Federal Reserve Board and the ECB.[9]

25. Should the IMF make more efforts to be at the frontier of macrofinancial modelling? The answer is not obvious because the IMF does not have the same objectives as other institutions in charge of financial surveillance. On the one hand, it may be difficult for the IMF to keep up with the significant increase in resources that advanced economy central banks have dedicated to research in this area since the GFC. Another difficulty is that the IMF approach to analytical tools (which often presumes that tools should be simple and universal enough to be applied by fungible economists across countries) is ill-suited to developing and maintaining a suite of tools that are complex, to some extent country-specific, and used by specialists.

26. On the other hand, not making this effort has a reputational cost for the IMF's macrofinancial analysis. It may lead to limitations in its ability to contribute to important debates on monetary and financial policies, e.g., on the macroeconomic impact of changes in financial regulation or the impact of various forms of unconventional monetary policy on financial stability. Developing its macrofinancial modelling capacity might also help the IMF to further develop its methodology for financial stress test exercises (discussed below). The IMF would seem to have a strong comparative advantage in modelling at the nexus of macroeconomics and finance with an international dimension. Finally, given the research efforts already under way and the flow of PhD economists hired by the IMF, it might be possible to improve the quality and visibility of IMF macrofinancial modelling without a major increase in resources.[10]

III. RISK INDICATORS

27. The IMF staff uses a battery of indicators to monitor financial risks (Blancher and others, 2013). These indicators are selected for their ability to capture salient developments in the financial sector, but generally are not grounded in the type of structural models reviewed above. Some indicators attempt to monitor the vulnerability of the financial system to fast-moving liquidity crises while others focus on medium-term risks, such as credit booms and busts.

[9] The comparison does not capture other ways that the IMF can showcase its research, for example by organizing its own conferences and workshops.

[10] MCM noted that despite tight resource constraints, it is developing macrofinancial models to study specific issues related to the intersection of macroeconomics and finance. For example, a suite of macroeconomic models with financial intermediaries and endogenous risk to further the goal of making the analysis of macrofinancial linkages part of the Fund's surveillance toolkit. Having resources comparable with those of many advanced economy central banks would, of course, contribute to bridging gaps that may exist between the Fund's and those central banks' research efforts.

The IMF staff uses a growing battery of indicators to monitor financial risks at the global and country levels.

28. Appendix 1 reviews the tools that are available to IMF economists on the MCM, RES, SPR, and STA intranet web sites. The MCM toolkit counts more than 20 tools to construct financial risk indicators including Financial Stability Maps, Financial Soundness Indicators (FSIs), indicators of the state of the credit cycle, of price misalignments in equities or real estate markets, of the health of individual banks or of the whole banking system, and market-based indicators of systemic risk. These indicators are used both in multilateral surveillance and Article IV consultations.

29. The Global Financial Stability Map (GFSM, or "Spidergram") was used for many years to describe the evolution of financial risks at the global level as a basis for the narrative overview provided in the first chapter of the *GFSR*. The GFSM was introduced in the April 2007 *GFSR* and continued to be used until 2017—see Dattels and others (2010) for details about the construction. The spidergram shows four categories of risks (Macroeconomic, Emerging Market, Credit, and Market and Liquidity) and two conditions (Monetary and Financial, and Risk Appetite). It is meant to capture risks over a 6- to 24-month horizon. It aggregates a large amount of quantitative information and some elements of judgment. It is built from 29 economic, market, and survey-based indicators, which are listed in Appendix 2. Some of these indicators are themselves composite indicators constructed by the private sector. IMF staff relies on judgment based on market intelligence to adjust the weights of the underlying indicators.

30. Financial risk indicators are also increasingly used in Article IV staff reports. In late 2014, the IMF launched a new initiative to mainstream macrofinancial work in Article IV surveillance. The initiative started in 2015 with a group of 24 countries and was expanded to 66 countries in 2016. As part of this effort it was decided that functional departments would "develop and refine new and existing toolkits and disseminate knowledge to country teams through workshops, brainstorming, training, and the internal review process" (IMF, 2017a).

31. An increasing number of Article IV staff reports include a financial stability map and discussions of the country's FSIs, which are routinely included in an appendix table. Teams have measured the position of the country in the credit cycle to refine their growth forecast and assess the surrounding risks. Credit cycle analysis has been used to identify credit booms and the likelihood that they end up in a bust. This analysis was sometimes associated with small-scale solvency stress testing of the banking sector as in Article IV surveillance for Brazil in 2016. The overall impression from the Article IV staff reports reviewed in IMF (2017a) is that use of the tools was eclectic and tailored to country circumstances.

32. A number of other tools are utilized in different risk assessment exercises. For example, the credit cycle indicator, the equity market overvaluation metrics and the residential real estate indicator are used twice-yearly as part of the Vulnerability Exercise for Advanced Economies.

The set of risk assessment tools could be streamlined to allow IMF staff to deepen its analysis based on core indicators.

33. A large number of tools have been accumulated in the toolkit and it might be useful to get a better sense of how they compare in terms of usefulness and use. The utilization of the different tools by IMF staff is difficult to assess because there is no systematic monitoring of the frequency with which the tools are used in Article IV consultations. There may be a case for paring down the toolbox to a core set of indicators while keeping room for experimentation with new tools. Such an assessment goes beyond the scope of this paper, which will limit itself to the two following observations.

34. First, the indicators that aggregate a wide array of information, such as financial stability maps, seem less informative than their more targeted counterparts. The notion of aggregating complex financial information to monitor the evolution of risks in a consistent and synthetic way over time is undoubtedly appealing. However, informed readers of the *GFSR* have expressed scepticism that this is achieved by the GFSM.

35. The reports published by financial stability authorities generally do not have a fixed recurring template like the GFSM. For example, the Financial Stability Report published bi-annually by the Bank of England contains an assessment of the global environment but does not attempt to monitor risks through the recurrent use of a financial stability map. The U.S. Fed does not publish a financial stability report, but the risk indicators used by its staff, as described in Adrian, Covitz, and Liang (2013), focus on financial sector balance sheet variables and do not aggregate this information with macroeconomic variables in the way that the GFSM does.[11]

36. Objections to the GFSM include that (i) it mixes information that is relevant at very different frequencies, from high-frequency variables measuring systemic risk once it has already erupted to medium- to long-run indicators detecting the build-up in systemic risk before crises; (ii) the allocation of variables to risk categories sometimes seemed arbitrary; (iii) the GFSM incorporates too much information, lacks transparency and reflects judgment calls that are not made explicit; and (iv) the changes in the risks identified by the GFSM are generally small.

37. The April 2018 *GFSR* replaced the GFSM with an analysis based on the Growth-at-Risk (GaR) approach. This new approach was presented in the third chapter of the October 2017 *GFSR* and MCM staff intends to use it as the main conceptual framework for its global financial stability assessment going forward. The GaR links current financial conditions to the distribution of future growth outcomes. It allows an assessment of whether a tightening or an easing of financial

[11] On the other hand, the stability report produced by the U.S. Office of Financial Research does feature a heatmap.

conditions is on balance macro-critical and may, therefore, put financial stability and future growth at risk.[12]

38. The GaR improves upon the GFSM in several ways. First, it measures GDP at risk at different horizons, capturing the idea that factors that reduce the risk of crisis in the short run could increase it in the medium to long run. Second, the financial indicators underlying the GaR are partitioned in three groups (domestic price of risk, credit aggregates, and external conditions) that make more sense than the six groups that were used in the GFSM. Finally, the GaR does not rely on opaque judgment calls on the weights attributed to the different indicators. This being said, the GaR aggregates a lot of information through a statistical treatment of the data that is conceptually clear but may remain somewhat opaque to the average GFSR reader.

39. Second, the toolbox could be further prioritized based on the empirical evidence. The empirical literature on crisis prediction has made considerable advances since the GFC and suggests that some indicators are more effective at identifying risk than others. For example, the long-run historical evidence does not support the notion that bank capital ratios have strong power to predict financial crises in advanced economies (Jordà and others, 2017).[13] By contrast, there is a substantial body of research suggesting that credit growth is a robust early indicator of future economic financial trouble. The BIS was a pioneer in this research and its measure of the credit gap is widely used (see Drehman and Tsatsaronis, 2014). The IMF research in this area, which forms the main basis for credit cycle analysis in bilateral consultations, is authoritative (Dell'Ariccia and others, 2012; 2016). Dell'Ariccia and others (2016) report that one in three credit booms is followed by a banking crisis and two in three booms are followed by financial or macroeconomic problems, such as low growth.

40. The credit cycle tool provided in the MCM toolbox deems credit growth to be excessive if it exceeds a threshold based on IMF (2011) and Dell'Ariccia and others (2012).[14] A difficult question, and an area in which Article IV staff reports still vary considerably in the quality of their

[12] MCM staff is working on further operationalizing the GaR framework and refining the presentation of the results with the aim to fully phase in the new operational framework over the next few *GFSR* cycles. In addition, MCM is working on deepening and broadening the application of the GaR approach by applying it to other contexts where the measurement and forecasting of downside risks is critical. For example, there is ongoing research using this approach on capital flows, bank capital, credit, and the intertemporal tradeoff between financial conditions and downside risk.

[13] Jordà and others (2017) find that lower bank capital does not increase the probability of a financial crisis (although it raises the output cost of a crisis when it occurs). There is evidence that banks with better balance sheets performed better during the GFC (Huang and Ratnovski, 2009; Vazquez and Federico, 2015) but this result is about the performance of individual banks, not the probability of a crisis. Bank balance sheet ratios may reveal useful information and it is not suggested here that they should be discarded from the IMF toolbox, but rather that perhaps they should not be included in the frontline instruments for Article IV consultations.

[14] Credit risks are deemed to be high when the year-on-year growth in the credit-to-GDP ratio is 5 percentage points or greater (IMF, 2011), or, if the credit-to-GDP ratio is away from the backward looking quadratic trend by 1.5 standard deviations or higher and credit-to-GDP is growing by more than 10 percent.

analysis, is how to respond to a signal of possibly excessive credit growth. High credit growth could reflect healthy financial deepening: credit booms do not always turn into busts. Some research was dedicated to the question of distinguishing good credit booms from bad ones, but the answer remains largely elusive (Dell'Ariccia and others, 2016). Another question is how to respond to a credit boom that has been determined to be bad. The IMF has been at the frontier of cross-country empirical research on macroprudential policy (Cerutti, Stein, and Laeven, 2015), which has helped to identify the most effective instruments of macroprudential policy. But it is not clear, for example, how the authorities should respond to mature credit booms that have already raised debt to very high levels.

41. To use a medical analogy, the credit cycle analysis is not at a stage where a clear diagnostic process and a mapping from diagnosis to treatment are readily available. This is an area in which there seems to be no simple rule and informed judgment must still be exercised on a case-by-case basis. Although cross-country empirical research remains useful, the most effective way of improving the quality of the staff's credit cycle analysis is probably to develop and accumulate carefully-crafted case studies.[15]

42. More generally, the IMF dashboard of financial risk indicators has reached a stage where the priority seems to be deepening the use of existing indicators rather than expanding the set of indicators. Developing a jurisprudence of well-argued cases based on the existing risk indicators is probably more important at this stage than adding new indicators to the IMF toolkit.

IV. STRESS TESTING

43. The IMF uses a wide panoply of analytical tools in the stress test exercises that are implemented in the context of the FSAP. From its inauguration, stress tests have been a central component of the FSAP. The analytical tools used in IMF stress tests are reviewed in IMF (2014a).

44. The core stress test exercise implemented in the context of the FSAP is a top-down bank solvency stress test estimating the impact of alternative macroeconomic scenarios on banks' non-performing loans and losses and capital requirements for credit and market risk.[16] This exercise can be complemented by liquidity stress tests, which have become more frequent in recent years. Liquidity stress tests focus on faster-moving mechanisms such as bank runs or debt rollover crises and lead to estimates of liquidity shortfalls. The IMF staff has also started to implement new tools to assess the systemic risk created by non-banks, including insurance companies, mutual funds, and the nonfinancial corporate sector. In addition, the IMF toolkit includes a range of other tools, such as network analysis, CoVaR, and contingent claims analysis

[15] As an example, see the analysis of the dangers posed by the ongoing Chinese credit boom in "Credit Booms—Is China Different?" in the 2017 Article IV consultation Selected Issues Paper (IMF, 2017b).

[16] In a top-down stress test, the stress tester defines a set of macroeconomic scenarios that are taken as given by the banks. This is by contrast with the bottom-up approach, in which the banks set their own scenarios.

(CCA), which are used in some but not all stress test exercises. Some analytical chapters of the *GFSR* rely on these tools to assess systemic risks. Several of these market-based tools are reviewed in Box 3.

While the IMF was an early starter, member countries have considerably strengthened their stress testing capacity relative to the IMF since the GFC.

45. The IMF's approach to stress testing and its associated tools were shaped by the environment in which they evolved. The IMF and the World Bank pioneered the practice of stress testing in the early 2000s motivated by the emerging market crises of the late 1990s (Dent and Westwood, 2016). The IMF approach to stress testing blended financial surveillance and technical assistance. There was a strong element of technical assistance before the GFC because stress testing was new for most countries, including advanced economies. Also, an important consideration for FSAP stress tests was to ensure equality of treatment and comparability across countries. This is one reason that the common core of the IMF stress testing exercise was a top-down, solvency stress test. The macroeconomic scenarios underpinning a top-down stress test can be calibrated based on historical data using econometric techniques that can be applied consistently across countries.

Box 3. Market-Based Measures of Spillovers and Systemic Risk

These measures estimate the contribution of an evolution in risk in one part of the financial system to the risk in another part of the system. They are based on observed co-movements between market prices (e.g., bank equity prices or credit default swaps (CDS)) at high frequencies and do not identify the channel through which the spillovers occur. Widely used tools in this class include Diebold and Yilmaz's (2015) measures of market volatility spillovers, Adrian and Brunnermeier's (2016) CoVaR, and the SRISK measure developed by Brownlees and Engle (2015) and Acharya and others (2012). The CoVaR measures how the value at risk in one part of the system is affected by distress in another part of the system. The SRISK measure calculates capital shortfall of individual institutions conditional on market stress.

Most of these measures are included in the MCM toolkit (see Appendix 1). In addition, IMF staff has developed and maintained other in-house indicators, most notably the Contingent Claims Analysis (CCA) and various applications of the Consistent Information Multivariate Density Optimizing (CIMDO) methodology.

The CCA applies option pricing theory to the valuation of firm equity based on the principle that equity is a residual claim on the cash flow of a firm after the payment of its debt (Bodie and others, 2007). CCA makes it possible to infer fluctuations in the value of a firm's assets from changes in the value of its equity. This information can be used to estimate spillovers across institutions and their contribution to systemic risk. Deviations between the default probabilities implied by the CCA and by CDS provide information on the contingent transfer (bailout) that a firm is expected to receive in a default. The CCA approach requires financial market data that are often available only in advanced economies.

The CIMDO methodology is a statistical technique to measure the spillovers between financial assets or institutions in environments where the lack of data makes it difficult to make assumptions about statistical distributions (Segoviano and Padilla, 2014). This technique is applied to measuring the distress dependence between banks by Segoviano and Goodhart (2014) and Cortes and others (2018).

46. A major shift occurred after the GFC, when more and more countries started to conduct their own stress tests. The first prominent examples of this new wave of stress tests were the U.S. Supervisory Capital Assessment Program (SCAP) conducted by the U.S. Fed in early 2009 and the first EU-wide stress test conducted by the ECB in late 2009. This shift led to considerable increase in the resources dedicated to stress testing and evolution in the analytical tools used by the stress testing community. Stress testers developed new models to make stress tests more macroprudential, i.e., better capture how systemic risk results from the spillovers between individual financial institutions.[17] Some models assume forward-looking rational agents but remain very stylized (Cont and Schaanning, 2017). Agent-based models, which are based on behavioral assumptions on how individual institutions respond dynamically to changes in their environment, may better capture the heterogeneity and complexity of advanced financial systems (BCBS, 2015; Demekas, 2015). In both types of models, the spillovers can occur through networks of asset and liability exposures or through fire sales in asset markets. On the empirical side, stress testers have used more and more granular data to model these networks. Stress tests have increasingly relied on a capillary use of granular data on banks' balance sheets with big-data econometric techniques.

47. This research agenda still faces important open questions (Tarullo, 2016). One challenge is to better capture the interactions between different forms of risk, such as solvency and liquidity risk or credit and market risk. Another challenge is to incorporate the contribution to systemic risk of non-bank financial institutions, e.g., mutual funds or insurance companies, and to extend the perimeter of stress tests to the two-way linkages between the financial sector and the macroeconomy. Finally, stress tests need to better take into account international spillovers.[18]

The IMF stress testing tools need to evolve with an eye to filling gaps in the international financial surveillance architecture.

48. National stress tests have evolved in directions where the IMF does not always have a comparative advantage. National stress testers generally have access to much more granular data than the IMF and have more resources to exploit them, limiting the value added of some IMF stress testing.[19] In other areas, such as market-based indicators of systemic risk, the IMF staff has stayed close to the frontier and its analytical tools are viewed as state-of-the-art. However, it

[17] By contrast with the models reviewed in the first part of this paper, these models focus on the financial sector and do not incorporate the feedbacks between the financial sector and the macroeconomy.

[18] As noted above, MCM has developed novel stress testing frameworks to assess non-banks, including insurance companies, mutual funds, and the nonfinancial corporate sector. Stress tests of insurance companies, have been performed in about 15 percent of FSAPs (e.g., Sweden, Japan, and Belgium).

[19] An important exception is that in recent FSAPs in the euro area, teams had access to the Single Supervisory Mechanism's granular supervisory data, which allowed them to provide greater value added.

is not enough for the IMF tools to be only as good as the local authorities in order to bring value added to its membership.

49. This raises the question of the appropriate place for the IMF in the international stress testing architecture. It makes sense for the IMF to maintain its basic stress testing approach and tools in order to provide technical assistance to less advanced economies that do not yet have a well-established stress testing framework. However, the more systemic advanced economies and large emerging markets generally have their own state-of-the-art stress-testing frameworks. There is an increasing perception among national officials that for these countries IMF stress tests are redundant, potentially burdensome, and sometimes not as insightful as those conducted by national authorities (see Murray, 2018, for the U.S.; and Miles, 2018, for the U.K.). Furthermore, the frequency of IMF stress tests (every five years for the jurisdictions with systemic financial sectors, and less frequent for others) seems insufficient to appropriately monitor the largest and more systemic financial systems.

50. How should the IMF stress testing approach and analytical tools evolve in response to these challenges? First, it has been suggested that the IMF could move towards validating the stress tests of the domestic authorities rather than implementing its own stress tests, in the same way as domestic authorities validate the internal risk-management systems of individual banks. This author agrees with a common concern expressed by IMF staff that it might lead to the IMF losing its existing expertise in the implementation of stress tests and confining itself to checking that national stress tests satisfy certain formal requirements. Furthermore, such validation would need to be structured to meet the IMF mandate to monitor financial stability.

51. Second, the IMF could become a center of expertise in certain areas of research at the frontier of stress testing. For example, Caprio (2018) argues that there is room for the FSAP to make greater use of market-based measures, especially for the high-income and emerging markets. This idea is worth exploring, keeping in mind the limitations of market-based indicators. In particular, these indicators might underestimate risks during episodes of low market volatility and therefore miss the build-up in underlying fundamental risks. Alternatively, the IMF could reinforce its expertise in making stress tests more systemic, extending their scope to non-banks and better integrating financial sector analysis with the macroeconomy. Some tools developed at the IMF already fall in that category but following this strategy would require a significant investment in new research. Central banks are actively researching these areas where, again, the IMF does not necessarily have a natural comparative advantage.[20] This being said, following this strategy in selected areas would not necessarily require a major amount of extra resources and would certainly be congruent with the objective of beefing up the IMF's macrofinancial modelling capacity that was mentioned in the first part of this paper.

[20] An impediment is the IMF's lack of access to granular data. For this reason, Caprio (2018) finds it implausible that the IMF can get to and maintain a position at the frontier in this area although it could have a role in some jurisdictions where national supervisors in different financial sectors are not well coordinated.

The IMF should develop tools to stress test the global financial system as opposed to individual countries.

52. An area where the IMF would seem to have a natural comparative advantage is the international aspects of stress testing. Existing stress tests—including those of the IMF—incorporate external shocks and changes in external financial conditions, but they take a national perspective rather than that of the global financial system. Arguably there would be value added from stress tests taking a more global perspective. The rest of this section offers some tentative thoughts on how the IMF could do this and the implications for its analytical tools.

53. As argued by Shin (2017), taking a national perspective does not capture how stress builds up and gets resolved in the global financial system. The structure of the global financial system leads to powerful mechanisms of contagion that were acute during the GFC but also play a role in less extreme times. A few currencies (mostly the U.S. dollar) play a key role as funding currencies in wholesale funding markets linking banks and non-banks, as well as advanced economies and large emerging markets. This leads to a complex web of sometimes very large stocks of cross-border assets and liabilities denominated in dollars and of short maturity.

54. On the cyclical side, movements in U.S. monetary policy, risk appetite and leverage influence gross (and to a lesser extent net) capital flows and exchange rates (Miranda-Agrippino and Rey, 2018). This system can be subject to more extreme forms of stress. The international contagion observed at the peak of the 2008 global banking crisis involved runs in the wholesale dollar (and to a lesser extent euro) funding market as well as fire sales. As noted by Tarullo (2013), relatively little has been done to change the structure of wholesale funding markets so as to make them less susceptible to damaging runs, and significant vulnerabilities remain. The liquidity of this system was stressed to the extreme in 2008 but milder fluctuations have an important global impact in more normal times, for example in the taper tantrum.

55. These features are broadly known but the fact is that no institution is specifically in charge of stress testing the global financial system *as a system* as opposed to pieces of it. This is an area where the IMF and the BIS would seem to have a natural role to play. To be sure, limitations to access to granular data on even globally systemic institutions currently make this difficult, but appropriate safeguards could be designed to protect confidentiality concerns.[21]

56. Implementation would call for several innovations in the analytical tools of stress testing. A full discussion of these issues goes beyond the scope of the paper but a few preliminary considerations on the type of analytical tools that would be required are presented here. First,

[21] There are different views among IMF staff and outside experts about the extent to which assessing global systemic risk needs to rely on granular data. On one hand, Avdjiev, Berger, and Shin's (2018) retrospective study illustrates that much progress could be made in gauging the fluctuations in externally-induced systemic risk by using the BIS international banking and financial statistics. On the other hand, IMF staff generally took the view that global stress tests of liquidity require access to much more disaggregated data at least for globally systemic institutions.

the tools should put more emphasis on liquidity (rather than solvency) stress testing. Although liquidity and solvency problems are often interlinked, the approach of a typical solvency stress test, which is to look at the impact of exogenous macroeconomic developments on bank solvency in the medium term, does not seem the most appropriate for understanding the mechanisms at work in the global financial cycle, in which the shocks are mainly financial and transmitted relatively quickly into the system. The relevant time frequency is that of liquidity stress tests. For this reason, the exercise could be called a "global liquidity stress test" (although it would focus not only on large-scale rollover crises but also on milder liquidity shocks).

57. Second, the scope of the stress test would have to incorporate macroeconomic variables such as gross capital flows and exchange rates. One domain of application of the enhanced IMF macrofinancial modelling capacity advocated in other parts of this paper would be to integrate liquidity stress testing with macroeconomic analysis in the open economy.[22]

58. Third, one benefit of a global liquidity stress test would be to yield insights on reserve adequacy and the need for international liquidity provision. At the national level, a bank fails a liquidity stress test when emergency liquidity assistance from the central bank is necessary for the bank to cover its liquidity shortfall. The question, in a global liquidity stress test, is the extent to which a liquidity shortfall at the country level is covered by the reserves held by the central bank, and the implied residual burden on the global financial safety nets—of which the IMF is an important part.

59. To conclude, a global liquidity stress test should be viewed as a complement rather than a substitute to the country stress tests currently performed by the IMF. It would produce a different kind of information because it would focus on liquidity rather than solvency, and on international spillovers rather than domestic linkages. A global liquidity stress test would produce useful information for calibrating the external financial shocks to be taken into account in national stress tests.

V. CONCLUSIONS AND RECOMMENDATIONS

60. National authorities have considerably developed their tools for monitoring financial risks after the GFC. Thus, it has been a challenge for the IMF to continue to be a thought-leader in financial surveillance and the question for IMF management increasingly becomes how the IMF fits in an international financial surveillance architecture in which other institutions are increasingly better tooled. The IMF approach to analytical tools (which often presumes that tools should be simple and universal enough to be applied by fungible economists across member countries) is sometimes at odds with developing and maintaining a suite of tools that are increasingly complex and to some extent country-specific. The challenge that I have tried to

[22] The IMF approach to liquidity stress testing is presented in Catalan (2015). It is centered on individual banks, although the calibration of funding pressures involves assumptions about the number of banks that are affected.

address in this paper is to identify the areas of financial surveillance in which the IMF has a natural comparative advantage and can fill gaps with its analytical tools.

61. The main recommendations of this paper can be summarized as follows.

- The IMF must develop further its macrofinancial modelling capacity in selected areas if it wants to remain a key contributor in debates about macrofinancial issues.

- The IMF should streamline its battery of risk indicators and deepen the use of selected core indicators, especially those related to the credit cycle.

- The IMF should develop tools to stress test the global financial system. This may require getting access to more granular data on globally systemic financial institutions with appropriate safeguards.

APPENDIX 1. MCM, RES, SPR, AND STA TOOLKITS

This appendix reviews the analytical tools for macrofinancial analysis available to Fund staff on the MCM, RES Macro Financial Division (RESMF), SPR and STA intranet web sites (accessed in July 2018).

MCM QUANTITATIVE METHODS GATEWAY

The MCM web site includes Guidance Notes on various topics that are not reported here. Including these notes, there are 37 items in the MCM toolbox.

MACROFINANCIAL (for Area Departments)

Baseline

1) MCM Spidergram: A Macrofinancial Environment Tool (Ms. Muffet)

Ms. Muffet generates the Country Financial Stability Map (CFSM) for all IMF member countries along the lines of the *GFSR*'s Global Financial Stability Map (GFSM). The CFSM consists of four categories of macrofinancial risks (macroeconomic, inward spillover, credit, market and liquidity) and two risk conditions (risk appetite, monetary and financial). To produce the map the user must refresh the country data, which takes a few minutes.

2) Financial Soundness Indicators (FSIs) Heatmap

FSIs are indicators of the current soundness of the financial system in a country, and of its corporate and household counterparties. FSIs include both aggregated individual financial institution data and indicators that are representative of the markets in which the financial institutions operate. The tool based on the FSIs produces a heat map of the credit cycle and key FSIs to inform IMF staff and authorities whether corrective policies are needed or not.

The tool provides a snapshot of three basic properties of the financial sector: credit cycle, balance sheet risks, and loss-absorbing capital buffers. An indicator is marked as red (policies needed) if the upper range of the threshold is breached; as yellow (on alert) if the indicator is between the lower and the upper thresholds; and green (no policies) if the indicator is below the lower threshold. The thresholds are based on analyses in Chapter 3 of the September 2011 *GFSR* (IMF, 2011), Dell'Ariccia and others (2012), and IMF (2013), on the Basel III leverage ratio, and informed by MCM's experience with FSAPs.

Credit risks are deemed to be high when the year-on-year growth in credit-to-GDP ratio is 5 percentage points or greater (IMF, 2011), or, if the credit-to-GDP ratio is away from the backward looking quadratic trend by 1.5 standard deviations or higher and credit-to-GDP is growing by more than 10 percent. The bank balance sheet risk is deemed to be high if more than 40 percent of loans or liabilities are in foreign currency, or if the ratio of deposits to loans is lower

than 85 percent. The loss-absorbing buffers are deemed insufficient if the (non-risk weighted) leverage ratio is below 3 percent (Basel III threshold). The underlying data required to construct the FSIs are provided by a separate tool.

3) Estimating Credit and Business Cycle

This tool is a semi-structural model that can be used to jointly estimate business and credit cycles allowing two-way linkages between the financial sector and the real economy. The approach is presented in Krznar and Matheson (2017a). The Matlab code for the model is provided.

4) BIS-based Credit Gap

This Excel-based tool can be used to calculate an indicator of the credit cycle by computing the credit-to-GDP gap as a percentage of deviation from the trend.

5) Equity Market Misalignment

This category includes three tools based on different approaches to measuring equity market misalignment. The first tool relies on a combination of simple equity valuation multiples (e.g., price-to-book ratio, price-to-forward earnings ratio). The current values are then compared to the historical averages to determine the extent of deviation. The second approach is based on the Arbitrage Pricing Model (APM), which relates equity risk premia to economic and financial fundamentals. The third approach (under development) relies on a suite of about 20 models that estimate Equity Risk Premia (ERP).

The web site provides a PDF file reporting the estimates of equity market misalignment for selected advanced economies and major emerging markets over the recent period.

6) Bond Market Valuation Metrics: Term Premia Tool

Estimates the term structure of global yields and produces various indicators (including term premia, forward yields and risk-neutral yields) using affine term structure model.

Risks

7) Corporate Sector Stress Test

This tool allows users to stress-test the balance sheet of the corporate sector of emerging market countries to shocks in interest rates, exchange rates and earnings. It uses firm-level data from a number of sources. The methodology is based on Chow (2015).

The Vulnerability Exercise Securities Database (VESD) allows charting and downloading of data on bond, syndicated loan and equity issuance, maturing volumes and outstanding stocks by country and sector (Government, Financial and Non-Financial Corporate). It includes a

breakdown by currency. The database uses data from Dealogic and covers about 170 countries. It is being updated on a monthly basis.

8) Two-Way Stress Testing (Including Second-Round Effects)

This tool relies on a model developed by Krznar and Matheson (2017b) that captures the two-way relationship between the real economy and the financial sector. The model embeds a standard stress-testing framework based on individual banks' data in a semi-structural macroeconomic model. The framework captures the macro feedback effect from bank solvency to bank credit and output. The Matlab code for the model is provided.

9) Bank Health Assessment Tool (HEAT!)

HEAT! calculates simple CAMELS-type ratings (capital adequacy, asset quality, earnings, liquidity, leverage) for each bank in a defined sample and derives an overall Bank Health Index (BHI) from the ratings. The information about individual banks is represented in the form of heatmaps. The tool is an Excel spreadsheet that must be filled with individual bank data from Bankscope (the user must download the data). The tool is presented in Ong and others (2013).

10) Bank Analysis Template (BAT)

The BAT was originally designed for monitoring 115 systemically important financial institutions (SIFIs). It allows the download of standard, comparable and most up-to-date information on individual banks. The tool may only be used for any listed bank currently subject to disclosure requirements. The approach is accounting-based (financial statements and ratios) using Bloomberg data.

11) Stress Tester 3.0

This tool is an Excel workbook showing how one can run a stress test using bank-level data. The purpose of the workbook is to illustrate basic solvency stress test techniques that can be used to assess risks in a small and relatively non-complex banking system. The stress test considers credit risk, interest risk, foreign exchange risk, interbank and liquidity risks. The tool is presented in Čihák (2014).

SYSTEMIC RISKS (for FSAP and Technical Assistance)

Credit and Market

12) Portfolio Simulation Tools (PST)

The Portfolio Simulation Tool (PST) simulates expected and unexpected losses of individual banks and the banking system for financial surveillance and stress testing purposes. It is based on the

consistent information multivariate density optimizing (CIMDO) methodology presented in Segoviano and Padilla (2014) and discussed in Box 3 of this paper.

13) CreditRisk+

CreditRisk+ is an application that enables users to derive an individual bank's distribution of credit losses. Originally developed by Credit Suisse First Boston, it was replicated at the IMF by a team of MCM and Technology and General Services staff.

Liquidity

14) Liquidity Coverage Ratio (LCR) Template

This is a self-contained tool for performing cash-flow based stress tests for funding and market liquidity risk. Includes an Excel file for performing the stress test.

15) Net Stable Funding Ratio (NSFR) Template

This Excel-based tool enables the computation of the Net Stable Funding Ratio (NSFR) in the spirit of Basel III liquidity regulation.

16) Cash-Flow Mismatches Templates

This Excel-based tool is a stress testing template used under stressful liquidity scenarios.

Sovereign

17) Sovereign Funding Shock Scenarios (FSS)

The Sovereign Funding Shock Scenarios (FSS) is an Excel-based tool that enables the application of forward-looking scenarios for assessing sovereigns' vulnerability to sudden investor outflows. It uses information about a sovereign's gross financing needs, investor base, and domestic institutional investors to assess the impact of a sovereign funding shock on the domestic banking system. The tool may be used along with standard debt sustainability analysis (DSA). The methodology is based on Arslanalp and Tsuda (2012).

18) Sovereign Bond Risk Analysis Tool

This is an Excel add-in that gives users multiple measures of sovereign bonds market, credit, and liquidity risk from the perspective of a sovereign debt manager.

19) Sovereign Risk Haircut Tool

This Excel-based tool calculates bond haircuts for application to stress tests of sovereign risk.

20) Medium-term Debt Management Strategy (MTDS)

This Excel-based tool enables forward-looking scenario analyses to assess the robustness of debt management policy decisions. The tool comprises an 8-step framework that helps users to comprehensively assess the cost and risk consequences of alternative debt management strategies under different shock scenarios.

21) Sovereign Portfolio Risk Analyzer and Optimizer (SoPRAnO)

This tool is an Excel add-in that computes the risk indicators and debt profile for a given country.

22) Strategic Asset Allocation of Sovereign Wealth Funds (SAA)

This Excel-based tool helps to determine the appropriate asset allocation of sovereign wealth funds based on country specific data.

23) Sovereign Debt Metrics (SDM)

Software interface giving access to data on about 50,000 sovereign bonds.

24) MCM Term Structure Tool

Excel add-in that estimates the term structure of interest rates based on several term structure models used by central banks and commercial banks.

25) MCM Debt Manager

Excel add-in that computes bond prices and bond portfolio values based on current market yields.

Interconnectedness

26) Bank Network Analysis (BNA)

This Excel add-in allows the user to trace a spillover path from one institution's insolvency and/or funding difficulties to others. The methodology can be applied to inter-institution exposures to measure domestic interconnectedness, or to international spillovers. This tool is presented in Espinosa-Vega and Solé (2014), who illustrate how it can be used to estimate international banking contagion using consolidated cross-border banking statistics from the BIS.

27) Analysis of Systemic Risk and Interconnectedness (SyRIN)

SyRIN allows a comprehensive assessment of systemic risk by quantifying the impact of risk amplification mechanisms and interaction between financial sectors. The tool produces various metrics to evaluate systemic risk from complementary perspectives. It is based on probability of distress (PoDs) of individual entities estimated from market-based indicators or publicly available

supervisory data. The tool is designed to identify vulnerability from a top-down perspective that can lead to deeper analysis in specific sectors. The approach is described in Cortes and others (2018). This tool relies on the conditional probability of default (CoPoD) and the CIMDO methodologies presented in Segoviano and Padilla (2014).

28) CoVaR

The methodology is presented in Adrian and Brunnermeier (2016).

29) Distress Spillover Indicator

This is an indicator of outward spillovers of institutions or markets during extreme times—the potential contribution of one institution to systemic risk during crisis. The model estimates the distance-to-default of each institution based on market data on credit default swap (CDS) spreads or equity prices. It then estimates the probability that a particular bank will experience a large negative shock in the distance-to-default as a result of a shock to another bank in the sample. The approach is presented in Chan-Lau and others (2014). The Eviews codes are available upon request.

30) Diebold-Yilmaz's Returns Spillovers

This tool estimates the spillover measure proposed by Diebold and Yilmaz (2009). It is a time-varying indicator of outward returns-spillovers of institutions, based on market data on returns (CDS spreads or equity prices). The tool estimates average contributions and does not focus on extreme events. The Eviews codes are available upon request.

RES TOOLBOX

1) Bank Contagion Module

The Bank Contagion Module (BCM) analyzes spillover effects arising from the connections among international banks. It primarily uses BIS cross-border bilateral banking exposures for BIS reporting banking system. Through simulations it analyzes how credit exposures and funding risks could spread internationally and predicts which countries could be most affected under different scenarios.

The module has two components: (i) measurement of credit risks through downstream exposures (capturing a country's exposure to crises in countries that borrow from its banks) and upstream exposure (measuring a borrowing country's funding/rollover risk to crises in its creditor countries); and (ii) bank contagion analysis, which captures the cross-border propagation of shocks to international banks' balance sheets due to their deleveraging. The module is updated twice a year, in January and June. Country teams contact RESMF with the scenarios analysis they would like to perform, and RESMF produces the output subject to resource availability.

2) Corporate Vulnerability Utility

The Corporate Vulnerability Utility (CVU) is aimed at economists engaged in ongoing corporate surveillance. Now covering 74 countries, the CVU provides through an Excel add-in corporate sector vulnerability and efficiency measures. To further facilitate surveillance, an analysis module (Corporate Sector Monitor) is also available. Both it and the CVU are updated semi-annually.

3) Real Estate Markets Module

The real estate markets module, which is updated twice a year (in June and January), aims to assess vulnerabilities to adverse developments in the residential real estate market. The likelihood of a downturn in the real estate market is assumed to depend on: (i) price misalignment, (ii) household debt burden, and (iii) mortgage market characteristics, based on Crowe and others (2013) and Cerutti, Dagher and Dell'Ariccia (2015). The user can obtain house price data, historical data on real house prices and price-to-rent and price-to-income ratios and the final vulnerability scores. The data and documentation related to the module include an essential methodology document and the Excel and Stata files.

4) Excel-based Toolkit to Assess Consistency Between Real Sector and Financial Sector Forecasts

This toolkit helps country desks formulate the macroeconomic scenario taking into account developments in the financial sector in a consistent way. Because the relationship between real and financial variables is usually elastic, the tool provides a probabilistic check between the two based on historical data. The tool provides distributions of real variables (e.g., GDP, consumption and investment growth, and inflation) conditional on certain realizations of critical financial measures (e.g. credit growth, housing and stock prices, and capital flows).

5) Credit Boom Tool

This tool uses the high-yield share of bond issuance as a proxy for lending standards to separate good credit booms from bad credit booms. The approach is presented in Kirti (2018).

SPR TOOLS in Databases, Tables and Calculators

1) Assessing Reserve Adequacy

The Reserve Adequacy Measure compares reserve holdings and alternative metrics of reserve adequacy. It also permits such comparison for multiple countries.

2) External Sector Assessment

This website provides operational guidance, tools, references, and links to useful resources to conduct external sector assessments. This includes current account, real exchange rate, external balance sheet, foreign exchange intervention, and reserve adequacy.

STA TOOLS

STA maintains a suite of statistical tools for macrofinancial surveillance.

1) Balance Sheet Approach (BSA) Matrix Tool

This Excel-based tool uses official macroeconomic statistics to track cross-sectoral (including external) exposures. The BSA tool supplements the flow-based analysis of the macro-framework with stocks counterparts and may help to track the build-up of sectoral imbalances and linkages over time.

The tool generates a standard monetary sector file and table for Article IV Staff Reports. It is based on a dataset that covers the balance sheets of the central bank, commercial banks, money market funds and depository corporations and other financial corporations.

2) Financial Soundness Indicators (FSIs) Template for Staff Report

This template provides a one-stop shop for FSI users. The template automatically refreshes the selected FSIs and provides a sample Staff Report FSI table and panel chart. The dataset covers mainly banking ratio indicators.

3) Credit Gap Tool

This Excel-based tool allows users to estimate the credit-to-GDP gap for 182 countries with STA credit data. The gap is estimated by detrending credit-to-GDP time series with a Hodrick-Prescott filter.

4) Integrated Monetary Database (IMD) tool

This tool allows users access to all the STA monetary statistics sectoral presentations.

5) Currency Substitution Tool

This tool tracks currency substitution on a monthly basis. Fast growing currency substitution may reveal underlying financial system vulnerabilities.

6) Government Finance Data Template

7) This Excel refreshable file covers the main fiscal aggregates for the different levels of government on transactions (flows) and balance sheets (stocks).

8) BOP and IIP Data Tool

This Excel-based tool generates standard balance of payments (BOP) and international investment position (IIP) tables and charts for Article IV Staff Reports. It also includes full details of BOP and IIP data officially reported from country authorities. Users can customize the tables and charts to country-specific needs.

APPENDIX 2. INDICATORS USED IN CONSTRUCTION OF GLOBAL FINANCIAL STABILITY MAP (SPIDERGRAM)

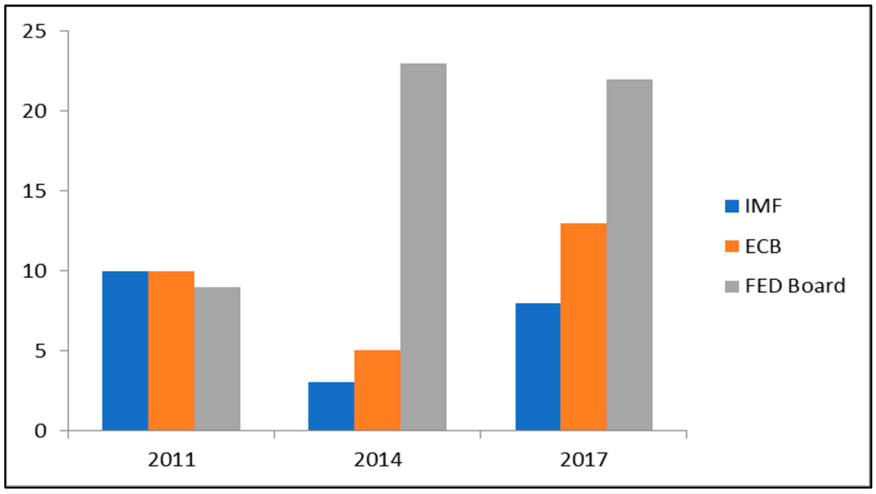
Monetary and financial conditions	- G-7 Real Short-Term Interest Rate - G-3 Excess Household and Corporate Liquidity (difference between broad money growth and estimate for money demand) - Goldman Sachs Global Financial Conditions Index (weighted combination of the real short- and long-term interest rates, real effective exchange rate, and market capitalization of equities in relation to GDP) - Growth of Custodial Reserve Holdings at the Federal Reserve Bank of New York - G-3 Bank Lending Conditions (based on loan officer surveys)
Risk appetite	- Merrill Lynch Investor Survey of Risk Appetite - State Street Investor Confidence Index - Total Net Inflows into Emerging Market Bond and Equity Funds
Macroeconomic risks	- Projection of Global Real GDP Growth in the *World Economic Outlook* - G-3 Confidence Indicators - OECD Composite Leading Indicators (GDP-weighted sum of confidence indices across Germany, Japan, and the U.S.) - Global Trade Growth - Global Breakeven Inflation Rate Index (expected inflation based on differential between nominal and inflation-indexed bonds) - Cost of Protection Against Default on Mature Market Sovereign Debt
Emerging market risks	- Estimated Fundamental Emerging Market External Debt Spreads - Emerging Market Sovereign Credit Quality (based on credit ratings) - Inflation Volatility - Corporate Credit Spreads
Credit risks	- Merrill Lynch Global High Yield Index Spread - Share of Low-Quality Corporate Debt - Moody's Speculative Grade Default Rate - Banking Stability Index (Segoviano and Goodhart, 2009) - Loan Delinquency Rate - Household Obligation Payment Ratio
Market and liquidity risks	- Hedge Fund Leverage Proxy - Average Net Speculative Positions in U.S. Futures Markets - Estimated Common Component in Asset Class Returns - Equity Risk Premia - Composite Volatility (implied volatility across a range of assets, including equity, fixed-income, and currency) - Funding and Market Liquidity Index (based on interest rate spreads, bid-ask spreads, return-to-volume ratios of equity markets)

APPENDIX 3. IMF PRESENCE IN RESEARCH ON MACROFINANCIAL ISSUES[1]

The presence of IMF research on macrofinancial issues is compared to that of the Board of the U.S. Fed and the ECB in Figure 1. The figure reports the number of papers with authors from those three institutions presented at three annual conferences, the Computing in Economics and Finance (annual conference of the Society of Computational Economics), the annual conference of the Society of Economic Dynamics, and the Dynare conferences (Dynare is a software platform for handling a wide class of economic models that are used by various public bodies and some private financial institutions for performing policy analysis and forecasting exercises). The papers with macrofinancial content or relevant for financial stability were selected based on their titles. For the U.S. Fed we included only papers authored by staff of the Board (consistent with the fact that we did not include papers from national central banks in the euro area). Including the regional Feds would significantly increase the gap with the ECB and the IMF (the total number of Fed papers would be multiplied by a factor of almost 3). The three institutions covered here have comparable staff sizes (Board of Governors: 2,800; IMF: 2,500; ECB: 2,500).

The Figure A.3.1 shows that the three institutions had about the same number of papers in macrofinance after the GFC. But the U.S. Fed built up its research presence in the following years to a much greater extent than the ECB or the IMF. The IMF presence seems to have reached its peak in 2011 and is now behind both the Board of the Fed and the ECB.

Figure A.3.1. IMF, ECB, and Fed Board Presence on Macrofinancial Topics in Selected Conferences



Source: IEO staff estimates based on programs from annual conferences of the Society of Computational Economics, the Society of Economic Dynamics, and Dynare.
Notes: ECB = European Central Bank; FED Board = U.S. Federal Reserve Board

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