INTERNATIONAL MONETARY FUND

Assessing Reserve Adequacy

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EXECUTIVE SUMMARY

The dramatic increase in reserves holdings over the past decade has resumed since the global financial crisis, even at an accelerated pace. While the crisis has heightened perceptions of the importance of holding adequate reserves, there is little consensus on what constitutes an adequate level from a precautionary perspective: traditional metrics are narrowly-based and often provide conflicting signals; while newer approaches tend to be hostage to stylized modeling assumptions and calibrations. As a result, assessments tend to rely on comparisons with peers, probably amplifying the upward trend as perceived needs rise in line with actual holdings.

This paper, part of the Fund's ongoing work on aspects of the international monetary system, does not claim to provide definitive guidance on a subject already subject to extensive academic discussion. Instead it reviews recent experience and existing approaches to reserve adequacy, building on which simple new metrics for emerging market economies (EMs) and low income countries (LICs) are proposed, based on broad country characteristics. As basic tests of adequacy that can be applied consistently across countries, these measures appear to have advantages over the traditional rules of thumb. However, in making a full assessment of needs at the individual country level, they can still serve only as a starting point, beyond which detailed examination of risk factors and resources to address these risks—of which reserves are only one element—will be needed. The crisis has also raised new questions about reserve adequacy in advanced-market countries (AMs): while universally applicable metrics would be even harder to identify for this group, the paper briefly reviews considerations that might be taken into account in qualitative terms.

Just as with traditional metrics, the new metrics suggest that most EM countries' reserve levels are adequate, with some countries holding much higher reserves than suggested, and only a few falling short. A separate analysis of reserve demand based on precautionary variables points to similar conclusions in terms of relative reserve holdings among countries. For LICs, the picture is more mixed, with some countries potentially needing to hold higher reserves, according to their particular characteristics.

While reserves have been important in both preventing crises and mitigating their impact, they are costly (at both the national and global level) and subject to diminishing returns. Thus, as reserves increase beyond adequate levels, it becomes increasingly important to focus relatively more on the *other* elements of sovereign risk management frameworks, including contingent financing mechanisms and country insurance, and general macroeconomic and prudential policies.

I. OVERVIEW[1]

Motivation

1.   **The recent crisis has again demonstrated the importance of holding adequate reserves as part of a country's defenses against shocks**. While sound overall policy frameworks were probably the most important factor, liquidity buffers helped smooth consumption during this and past crises, and enabled some countries to manage large outflows without experiencing a costly crisis. Recognizing this, the Fund has moved rapidly to ramp up its own lending and enhance its crisis prevention facilities. But a critical component of country insurance remains the country's own reserve holdings. However, reserve accumulation tends to be costly, subject to diminishing returns, and is potentially distortionary to both the domestic and global economy.[2] Some countries demonstrated a reluctance to use reserves in the crisis, preferring to draw on foreign currency central bank swap lines, or to use liquid assets in their sovereign wealth funds (SWFs), putting into question the usability of large reserve holdings. This experience, combined with the rapid increases in reserves since the early 2000s, also raises the question of whether this accumulation has been "excessive." The significant costs attached to reserve holdings makes understanding what constitutes an *adequate* level of coverage important. In this context, with many countries likely to emerge from the crisis with a strengthened view of the importance of holding high levels of reserves, it is timely to reconsider guidance on reserve adequacy.

2.   **Current approaches to reserve adequacy do not appear to be followed closely by countries in their reserves holding decisions**. *Traditional metrics*, based on simple rules of thumb such as three months of imports or full cover of short-term debt, certainly have relevance and the attraction of simplicity, but are by their nature arbitrary, focus only on a particular aspect of vulnerability, and give disparate results. *Reserves demand regressions* seek to exploit countries' revealed preferences on the basis of precautionary variables and can indicate whether reserve holdings are out of line with peer countries; but using such regressions to provide guidance on the adequacy of individual countries' reserves depends on an assumption that there are no systematic biases towards over- or under-insurance for the sample as a whole. Newer *cost-benefit models* aim to provide a fuller account of "optimal" reserves, but tend to be sensitive to the stylized economic structures assumed.

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[1] This paper was prepared by cross-departmental teams led by James Roaf (SPR) and Era Dabla-Norris (LICs analysis, SPR) and comprising Jukka Pihlman, Yinqiu Lu (MCM), Rex Ghosh, Jun Il Kim, Charalambos Tsangarides (RES), Manuela Goretti, Kai Guo, Mustafa Jamal, Bikas Joshi, Nathan Porter, Manrique Saenz, Ferhan Salman and Kazuko Shirono (SPR), with additional contributions from Valerio Crispolti, George Tsibouris (AFR), Charles Amo-Yartey (WHD), Joonkyu Park, Han van der Hoorn (MCM), Suman Basu, Jaewoo Lee (RES), Trung Bui, Gavin Gray, and Hitoshi Sasaki (SPR), under the guidance of Udaibir Das (MCM), Jonathan D. Ostry (RES), Hugh Bredenkamp and Ranjit Teja (SPR). Analytical work in the paper has benefitted from discussion with Joshua Aizenman, Olivier Jeanne, and Eduardo Levy-Yeyati during an academic seminar in October, 2010, and from feedback from participants in the Third IMF Roundtable of Sovereign Asset and Reserves Managers in January, 2011.

[2] On these issues, see SM/10/116 (5/7/2010) and SM/10/86 (4/13/2010).

3.   **The paper takes account of guidance from past discussions of reserve adequacy**.
While discussing reserve adequacy indicators (SM/00/65, 3/23/2000), Executive Directors
noted the importance of short-term debt as a source of risk but cautioned against excessive
reliance on a single indicator and pointed to the need to consider various "potential sources
of short-term demand for reserves." Subsequent staff papers (SM/01/311, 10/16/2001) also
noted the need to complement indicator-based analyses with stress-testing of the balance of
payments. More recently, the Board has discussed the issue of reserve adequacy in the
context of the international monetary system (SM/10/86, 4/13/2010). During that discussion,
many Directors supported "further analytical work to provide guidance on appropriate levels
of precautionary reserves tailored to country circumstances".

Scope

4.   **The paper focuses on the *precautionary* aspect of holding reserves**. This reflects
the key distinguishing characteristic of reserves—their *availability* and *liquidity* for potential
balance of payments needs. While reserves may also be accumulated or held for non-
precautionary reasons (such as due to exchange rate policy, or for intergenerational savings),
these lie beyond the scope of this paper. In general, sovereign assets that are not required for
liquidity purposes would be more appropriately managed as part of an overall asset-liability
management strategy, taking into account both sovereign debt management strategy and
vehicles like SWFs. Thus issues such as the global macroeconomic consequences of
"reserves accumulation" should more properly be related to accumulation of net foreign
assets (NFA)—to which *gross* reserves holdings are not necessarily directly related. These
issues are covered in separate papers on the international monetary system. Similarly,
countries such as exporters of nonrenewable resources may have every reason to save for
future generations; but this has no bearing on how much *liquid* reserves they might need to
hold. Examination of such precautionary *savings* needs would require a separate paper;
where "precautionary need" is used in this paper it refers to the need for readily available
external liquid assets.

5.   **However, reserves are only one part of a country's defenses against shocks**.
"Adequacy" should be considered against total resources available to meet shocks, a broader
concept than the balance of payments-determined definition of reserve assets. Central bank
swap lines, SWFs and access to financing from the IMF or others could all provide
contingent protection. Gross reserves, however, form the majority of these defenses for most
countries, and the analysis in the paper also necessarily focuses on the officially reported
statistics on reserves for data comparability purposes. Taking a still broader view, a sound
macroeconomic and prudential policy framework is probably more important than reserves in
limiting country vulnerability. Low and sustainable levels of public debt, monetary and
exchange rate policies that maintain both low inflation and an exchange rate near
equilibrium, and effective supervision that limits contingent risks from the financial sector
are all factors that will substantially reduce the probability of a crisis. While there is evidence

that higher reserves can reduce external pressures even when some aspects of the policy framework are weak, strengthening policy is the most direct path to limiting risks.[3]

6.   **The paper aims to provide advice relevant to all country groups**. Although emerging market economies (EMs) have contributed most substantially to reserves growth in recent years, the paper also presents methodologies for assessing adequacy in low-income countries (LICs), and also briefly discusses considerations that may be relevant for advanced-market economies (AMs). For this purpose EMs and LICs are distinguished mainly between market borrowers (where balance of payments shocks are dominated by the capital account) and countries that mostly rely on official financing and remittances (where external current account shocks dominate). But in practice countries lie on a continuum, and their categorization in terms of reserves needs will not necessarily coincide with income levels; judgment is needed on methodologies appropriate for particular countries based on the types of risk they face.

Approach

7.   **Ideally, decisions on reserves should be governed by an analysis weighing the benefits of reserves against their cost.** But in practice there is huge uncertainty about both the utility and cost functions that would inform such an analysis. The various approaches differ in how they tackle this problem. Explicit optimization models postulate functional forms for costs and benefits to provide a complete solution, but are highly dependent on the structure and calibration of the model assumed (and more so for EMs than LICs, where shocks are typically exogenous). Reserves regressions infer the optimization from observed reserves levels, on the assumption that countries are making optimal decisions based on the information available to them—but depend also on assumptions that such decisions are based only on precautionary motivations, and that the analysis is able to capture well these motivations. Metric-based approaches focus on adequacy in the face of potential balance of payments pressures, but require judgment on how far into the tails of the distributions of potential shocks the country would choose to insure. While this judgment necessarily involves an arbitrary element, past experience can be brought to bear, and the approach also has the advantage of simplicity, tractability and transparency.

8.   **Thus the proposed approach to assessing reserve adequacy relies on new metrics for EMs and LICs, complemented by cross-country regression analyses, as well as scenario analysis and engagement with country authorities.** It is clear that any measures that are simple and consistent enough to be operationally useful cannot capture the full range of factors that bear on a country's resilience against shocks. For this, detailed scenario analysis is needed to take account of both specific identified risks and the country's overall risk management resources and strategies, of which reserves are only a part. Discussion of these risks and strategies with reserve managers and other country officials should be a key element of such an approach by IMF country teams. And the work is informed by the

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[3] For further on these issues, see Becker et al., 2007, "Country Insurance: The Role of Domestic Policies," *Occasional Paper* No. 254 (Washington, DC: International Monetary Fund).

priorities expressed by countries themselves, both directly through a survey, and indirectly through analysis of observed reserve demand. These both pointed to countries seeing reserves as needed to meet a range of risks, both externally and domestically generated.[4]

Approaches for emerging markets

9.   **A two-stage "risk-weighted" approach is proposed to develop a broader-based metric.** Past experience shows that balance of payments pressures can arise from a range of sources, in both the current and capital account. But the relatively few crisis observations limit analysis both of how much liquidity might be needed to meet each potential source of outflows or what correlations might exist between them. To make the problem more tractable it is broken into two steps: first, a metric is developed that reflects the *relative* risk levels of different potential sources of balance of payments pressure, based on observed outflows in exchange market pressure events; and second, evidence is brought to bear on how much reserves cover might be needed relative to this risk-weighted measure. The approach is analogous to that used for bank capital requirements, where needs are assessed as a percentage of a risk-weighted asset stock. Put simply, in the first stage the approach aims to provide a "better ruler" with which to measure reserves levels; the second stage asks how much reserves might be needed, measured by this ruler.

10.   **The metric approach is complemented by "peer comparison" regression analysis of observed reserves holdings.** Precautionary variables cannot fully explain average reserves growth in recent years, or the different patterns of holdings across EMs. But the analysis can provide information on the different precautionary factors that may be bearing on countries' reserve decisions, and on countries' holdings relative to their peers based on these factors. In both regards the results are broadly consistent with those from the metric approach.

Optimal reserves for low-income countries

11.   **The proposed approach aims to provide a tractable optimal reserves framework to inform judgment in assessing reserve adequacy in LICs.** The absorption-smoothing benefits of reserves, conditional on adverse external shocks, are empirically estimated using data on past severe shock episodes. Calibrated optimal reserves are then derived using the estimated regression coefficients, reference values for the opportunity cost of holding reserves, and under simplified assumptions about the extent of risk-aversion. The approach relates optimal reserve levels to the structure of the economy and the nature and likelihood of exogenous shocks faced, capturing country circumstances. The interactions between country-specific fundamentals, access to Fund financing in the event of a shock, and optimal reserve holdings are also explicitly accounted for.

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[4] A survey of reserve managers from a range of EMs, LICs, and AMs was conducted in late 2010. Twenty seven submissions were received, a response rate of 53 percent.

Considerations for advanced market countries

12.   **The global crisis and its aftermath in Europe have shown that capital account risks can strike AMs too, putting into question the typical assumption that they need little reserves.** Lack of crisis observations precludes empirical study of the kind carried out for EMs and LICs, but some general issues are considered in qualitative terms.

Implications for individual country reserves levels

13.   **The analysis tends to add to the perception that most EM countries have at least adequate reserves, while providing a more mixed picture for LICs**. Several EM countries hold higher reserves than appear needed for precautionary purposes, while only a few hold clearly less than adequate levels. For LICs, the results point to additional reserves needs for some more vulnerable categories of economies. At the same time, the different strands of analysis in the paper all highlight the limitations of simple "across-the-board" assessments of reserve adequacy across countries: judgment and detailed country information is needed for a full assessment at the individual country level.

Outline

14.   **The paper proceeds as follows:** Section II discusses issues relating to reserves in EMs, including trends in reserves and experience in crises, existing approaches to assessing adequacy, costs of reserves, and reserve management. Section III presents the suggested approach to assessing reserve adequacy in EMs, including the derivation of the new metric and results of reserve demand regressions. Section IV considers how reserves issues differ for LICs, and explains the proposed metrics for these countries. Section V discusses preliminary considerations that may be relevant for AMs. Section VI concludes and suggests issues for discussion. A supplement to the paper contains further technical details of the analysis presented.

II. STYLIZED FACTS AND EXISTING APPROACHES FOR EMERGING MARKETS

A. Trends in Reserve Accumulation and Experience in Crises

15.   **Gross reserves in EMs have increased more than six-fold in the past decade to around US$5 trillion, outpacing traditional measures of adequacy both globally and regionally**. All regions have experienced large increases, although Asia has contributed more than half of the increase, including China whose reserves grew from US$170 billion to over US$2.4 trillion. Moreover, the accelerating pace of reserve accumulation, which slowed during the crisis, seems to have regained speed again since. Most countries—regardless of region—have accumulated more reserves in recent years than suggested by standard rules of thumb, with the median coverage ratios among EMs being around six months of imports, 200 percent of short-term debt and 30 percent of broad money in 2009. Accumulation outpaced the metrics for both fixed and floating exchange regimes, although the pace has been even faster for the former than the latter. Explanations of the rapid and widespread increase are subject to controversy; in the survey reserve managers report a mix of motivations.
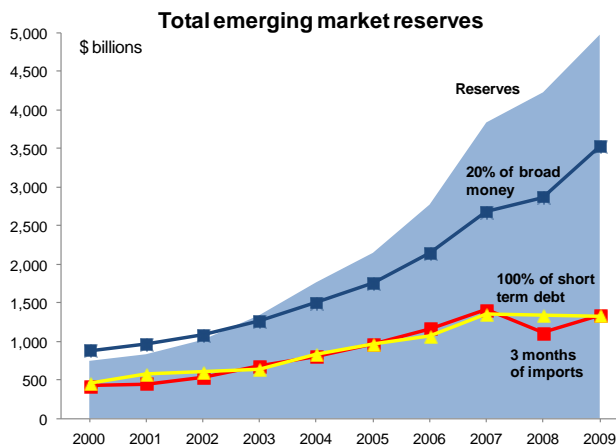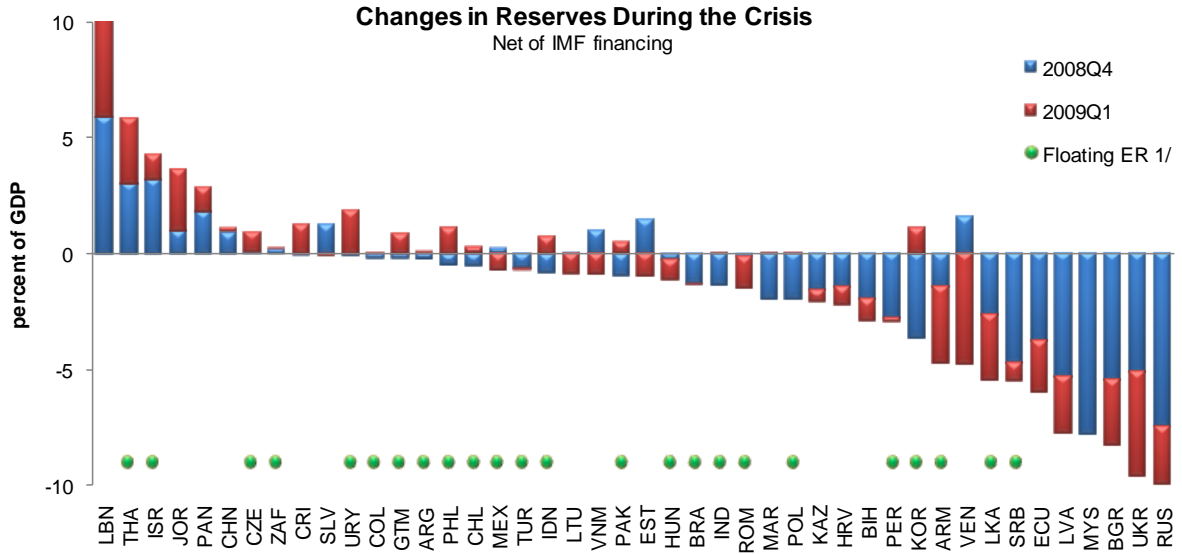

Source: WEO.
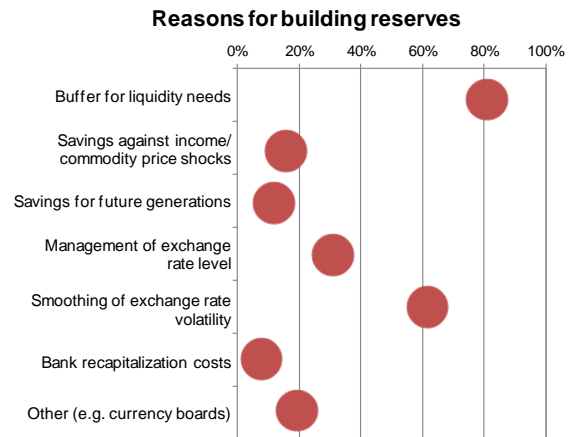
Source: IMF survey of reserve managers.

16.   **Although aggregate reserves increased in both 2008 and 2009 in annual terms, this masks significant use of reserves by individual countries within the crisis.** The chart below shows quarterly reserve losses in the depth of the crisis, as percent of GDP. While a few countries saw reserve increases in both quarters (including some benefiting from "safe-haven" inflows), most lost some reserves, and many saw large falls, including a number of countries classified as having floating exchange rates. Some countries actively deployed their reserves to reduce volatility of foreign exchange markets or to provide foreign currency liquidity to the banking sector. On the other hand, some countries took a cautious approach in using reserves from concern that depleting reserve may signal their weakness in external sector, triggering further pressure on their currencies.

Changes in Reserves During the Crisis
Net of IMF financing

Source: WEO, AREAER and staff calculations.

1/ corresponds to the categories "floating" and "free floating" in the 2009 AREAER de facto classification.

17.   **Experience suggests that reserves have proven useful—though with diminishing benefits—during crises**. In particular, reserves seem to have helped prevent episodes of exchange market pressure from affecting consumption. An event study shows that, during periods of exchange market pressure, EM countries with higher reserve holdings were more able to maintain more stable consumption growth (relative to the pre-event trend) than those with lower reserve levels. They were also more able to expand fiscal policy to help offset the effects of the crisis, whereas low levels of reserves were associated with procyclical fiscal contraction. In both cases the effects were more apparent in moving from low to moderate levels of reserves than in moving from moderate to high levels.
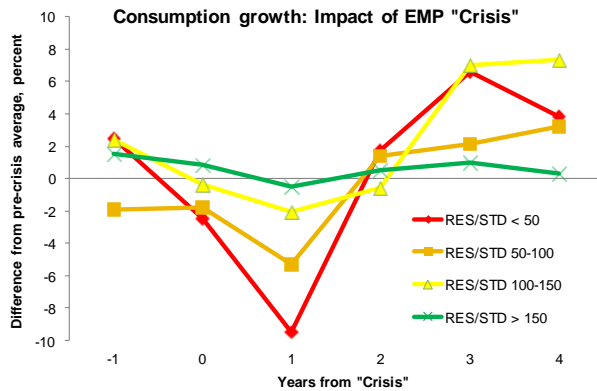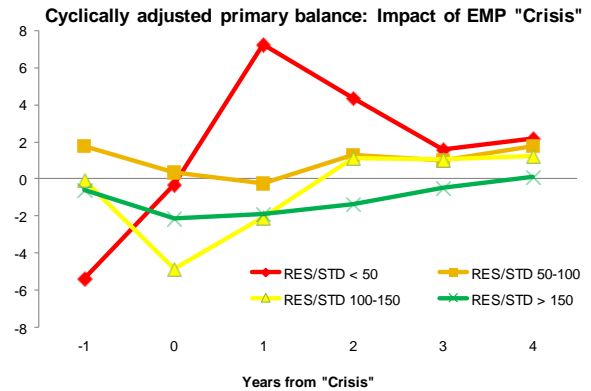
Source: WEO and staff calculations.

Box 1. Definition of Reserves

The definition of reserves does not necessarily coincide with the effective resources available to meet balance of payments shocks. According to the IMF balance of payments manual, reserve assets are those external assets that are readily available to and controlled by monetary authorities for meeting balance of payments financing needs; intervention in exchange markets to affect the currency exchange rate; and other related purposes (confidence in the currency and the economy; basis for foreign borrowing). In principle, the adequacy of reserves is assessed by their capacity to prevent or mitigate external shocks. However, in practice, other types of foreign assets or contingent credit have been used to complement reserves in addressing external shocks. Conversely, not all assets held in reserves may prove liquid and available in a crisis.

Assets in SWFs, particularly the liquid portion, could be employed as reserve complements to meet external shocks. Some countries set up arrangements for assets in SWFs to be used for balance of payment purposes or for assets in SWFs to be explicitly qualified as reserve assets.[1] Typically, commodity price stabilization funds can disburse when commodity prices are weak and thus tend to support balance of payments even when they have no explicit balance of payments support function. During the global financial crisis, some SWFs provided liquidity to the banking sector by depositing their foreign currency assets in domestic banks.[2] Nevertheless, though assets in SWFs could be regarded as reserve complements, using them as reserves carries both economic and political costs. For example, for SWFs with longer investment horizons, fire-sale of assets for short-term liquidity needs is likely to realize losses and jeopardize the rationale and purpose of setting up the SWF.

There are also types of contingent credit that could be used to address shocks while not accounted for as reserve assets. Examples include credit lines, e.g., those provided by the Fund, and a series of central bank swap lines set up during this crisis. However, there are some limits to substitutability. Large central banks tend to extend swap lines only to those countries with which they have strong financial and trade linkages, and which they consider sufficiently creditworthy. The highly selective nature of swap recipients means that a majority of emerging market countries may not have access to swap facilities. In a few special cases, nonconvertible currencies (not counted as reserves) may be more relevant than reserve currencies from the balance of payment perspective, e.g., Indian rupees to Bhutan. Conversely, during a crisis, some assets held as official reserve assets (such as covered bonds, and asset and mortgage back securities) may turn out to be less liquid than envisaged before the crisis.

Despite these considerations, data availability means the analysis in this paper is limited to the standard definition of reserve assets, although the discussion is extended to take account of reserve supplements. And these issues need to be borne in mind as caveats to results and conclusions.

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1/ Some countries include their SWFs in reserves reporting to the Fund while others do not. The latter is usually the case when SWFs assets do not meet the definition of official reserves, but can be true also even if they would meet the definition. There may also be an asymmetry (also arising from the Fund scrutiny) in that countries are careful not to over-report reserves but less attention is paid to under-recording of assets that would meet the definition of reserve assets.

2/ See e.g., Rozanov (2010) in *Economics of Sovereign Wealth Funds: Issues for Policymakers*.

18.   **Countries also made use of reserve substitutes during the crisis, in part reflecting fear of using reserves**. The survey of reserve managers highlights their recognition of these substitutes: most considered central bank swap lines, contingent credit lines from international financial institutions (IFIs), and SWF assets to be able to play the role of reserves, although only a few reported actually using these resources. During the crisis, swap lines were available only for EMs with strong financial and trade linkages to AMs. Users of the Fund's Flexible Credit Line (Colombia, Mexico, and Poland) made use of this contingent financing facility to bolster market sentiments; countries like Indonesia did the same with World Bank resources. Anecdotal evidence suggests a number of countries

made use of SWF assets in place of reserves, probably out of concern that markets would be alarmed by falling reserves numbers.[5] This apparent reversal of the intended roles of reserves and SWFs (since the latter typically hold assets above and beyond those needed for immediate liquidity purposes) also raises issues about the measurement of reserves (Box 1), as well as pointing to the difficulty in establishing firm guidance on reserves in the presence of effective alternative resources.

What can play the role of reserves?

Source: IMF survey of reserve managers.
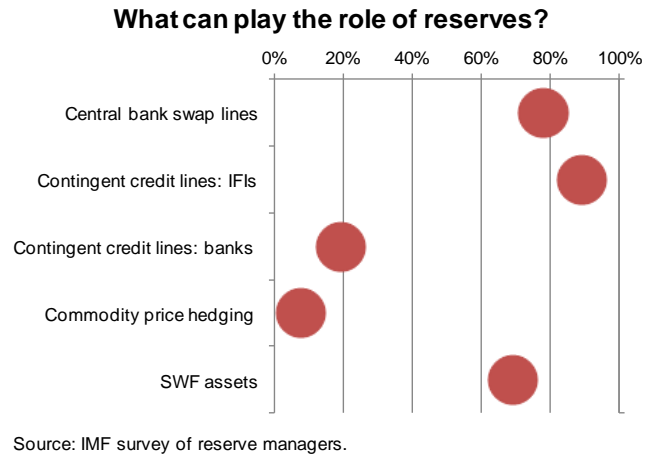
B. Existing Approaches to Reserve Adequacy

19.   **Traditional metrics continue to be widely used and, while relevant, are difficult to interpret clearly**.[6] Notwithstanding the considerable academic literature on precautionary needs (Box 2), the simple rules of thumb are still the most widely cited, including in the survey of reserve managers and in recent Fund staff reports. These metrics have the attraction of being intuitive, simple and transparent, but at the same time are necessarily arbitrary and narrow in scope.

- *Import cover* is often seen as a measure of the number of months imports can be sustained should all inflows (such as export revenue and external financing) cease. Generally applied to countries where shocks arise from the current account (i.e., where capital and financing account transactions may be small or restricted), the assumption of a complete cessation of balance of payments inflows seems rather drastic, except perhaps for the very poorest of countries; however, as a proxy for trade openness the measure does not seem unreasonable for a country whose balance of payments is dominated by the current account. Traditionally, the measure has been based on months of *prospective* imports, with three months' coverage used as a

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[5] See, for instance, the chapters by Kunzel, Lu, Petrova, and Pihlman (2010), and Rozanov (2010) in *Economics of Sovereign Wealth Funds: Issues for Policymakers*.

[6] See SM/00/65 for a comprehensive discussion of many of these metrics.

benchmark; however, there is little empirical support for whether the adequate coverage should be three months, as opposed to say two or six.

- ***Short-term debt*** (STD) has a well-established record as an indicator of crisis risk for market-access countries, and as such has a key role in any assessment of reserve adequacy. The "Greenspan-Guidotti" rule of 100 percent cover of STD—still the most widely-used standard of adequacy for EMs—proposes such a cover for one year. Clearly the cut-off at 12 months is essentially arbitrary, driven mostly by the definition of "short-term" debt itself. As with imports, the common formulation that countries should "be able to stay out of the market for one year" does not have obvious relevance, both because crisis duration could be much longer or shorter, and because typically short-term debt rollover rates do not reduce to anywhere close to zero in crises.

It is also worth noting that, in the crisis, STD did not prove a good predictor of the country reserves falls discussed in Section A above. As shown in the chart, the two showed barely any association. In many countries where the fall in reserves equated to a high percentage of STD (Armenia, Ecuador, Malaysia, and Morocco all lost reserves of over 70 percent of STD), STD was actually low, and the reserve drains appear to have emanated from *other* sources. On the other hand, countries with high STD levels (notably the Baltics and Bulgaria) saw reserve losses averaging less than 10 percent of STD. This experience raises questions as to both the relevance of STD as an exclusive indicator of reserves need, and of 100 percent as the needed level.

Short term debt (2007)

$y = -0.1218x$
$R^2 = 0.032$
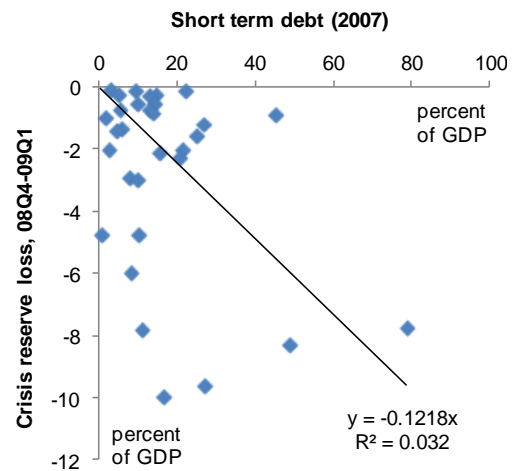
Source: WEO and staff calculations.

- ***Broad money*** *(typically M2)* is less firmly based as an indicator, and there is little orthodoxy either on whether to use it or at what ratio (20 percent is used here as the upper end of the range usually quoted). Given that many recent capital account crises have been accompanied by outflows of deposits of domestic residents, this metric is usually intended to capture this risk of capital flight, though some studies also find perverse correlations and consider it a counter-indicator of crisis risk. It may also be seen as a measure of potential need for bank support in or after a crisis, but unless banks have very large external exposures (which would be more effectively picked up by external debt indicators) it is not clear why highly liquid external resources would be needed in place of available domestic ones, especially for recapitalization purposes. While narrow money typically has a statutory role in the reserve holdings of currency board arrangements (CBAs), most modern CBAs hold reserves well in excess of the monetary base, presumably reflecting a view that coverage of narrow money alone has little relevance to potential balance of payment flows in an economy with a well-developed banking system.

Box 2. Precautionary Models of Reserve Accumulation

The closed-economy literature on precautionary saving has served as a guide to its open-economy counterpart. In the former, where heterogeneous agents accumulate savings for self-insurance against micro-level shocks, most relevant determinants include: (i) shocks to agents' incomes and output, (ii) borrowing constraints, (iii) discount rate, (iv) possible endogeneity of the interest rate, and (v) risk aversion. In the latter, individual countries— analogously to individual agents in the closed economy form—accumulate non-contingent reserves for self-insurance against country-level shocks, with determinants similar to those above.

The optimal level of reserve holdings for a country depends on the shocks it faces:

For *LICs*, given the importance of terms of trade shocks, the focus has been on current account-based measures of reserve adequacy, such as the ratio of reserves to imports. As an alternative to such *ad hoc* metrics, optimal reserve holdings could be derived from a fully calibrated small open economy model—as done by Valencia (2010) for Bolivia, a commodity exporter with little reliance on foreign capital flows. He finds optimal reserves to be 29−37 percent of GDP, far exceeding rule-of-thumb thresholds and consistent with findings by Cashin, Liang and McDermott (2000) and Borensztein, Jeanne and Sandri (2009) on the persistence of commodity price shocks. Additionally, Basu, Bi and Kannan (2010) relate optimal self-insurance to the elasticity of substitution of exports and imports.

In *EMs* with diversified exports and some degree of integration into international financial markets, shocks may originate from the capital account (in the form of sudden stops and currency crises) in addition to those from the current account. Early applications of the "buffer stock model" which postulated reserves as a buffer in managing the exchange rate regime—inter alia Frankel (1983) and Edwards (1983)—have been extended in recent years to account for financial deepening and the probability of sudden stops. Recent empirical contributions have included Aizenman and Marion (2003) and Aizenman and Lee (2007), which provide some regression evidence for precautionary motives in post-Asian Crisis reserve accumulation in East Asia.

Such capital account vulnerability has prompted looking beyond the Greenspan-Guidotti rule. Jeanne and Wyplosz (2003) argue that sudden stops are in practice associated with twin banking and currency crises, where reserves may be needed to insure the domestic banking sector. Wyplosz (2007) further cautions more generally that total external liabilities—and not just short-term debt—are a better measure of risks arising from the capital account, noting that under this metric, reserve holdings for emerging Asia do not look unprecedented. Noting that financial stability and the need to insure against potential capital flight remain important objectives in deciding to hold reserves, Obstfeld, Shambaugh and Taylor (2009) find, examining data up to 2004, that the M2-to-GDP ratio performs better than short-term external debt in accounting for reserve accumulation.

For *AMs*, the literature has typically abstracted away from ad hoc borrowing constraints and the risk of sudden stops. Ghosh and Ostry (1997) calculate optimal precautionary savings for several advanced economies, including the United States and Japan, facing shocks to national cash flow (output less investment and government consumption). On the other hand, AMs that issue debt in a currency that they cannot directly control, which include several European countries currently under stress, may face additional capital account risks such as those described above for EMs.

- *GDP* is sometimes used but has little if any theoretical or empirical backing; probably (as for this paper) it is best used simply as a scaling factor for cross-country analysis.

20.   **Combination metrics seek to reflect a broader range of sources of risk.** The most common of these is an expanded Greenspan-Guidotti rule of STD plus the current account deficit (if it is in deficit), which is intended to reflect the full potential 12-month financing need. However, the asymmetric treatment of the current account implies assuming a larger shock for surplus countries than for deficit countries, whereas if anything the reverse might be more justifiable. From this perspective, a formulation of "STD minus the current account balance" (positive or negative) might be worth considering instead. In practice, the traditional metrics may often be used in combination, for example if practitioners check reserves against the *highest* of three months of imports, 100 percent of STD and 20 percent of M2. Another combination metric is that proposed by Wijnholds and Kapteyn (2001), which uses STD and M2 to model debt repayments and capital outflows as motivations for holding reserves, taking into account exchange rate regimes and country risk. The new combination metric proposed in Section III builds on these ideas to try to develop a more empirically-based index of broad potential needs, while maintaining the simplicity and ease of use of the traditional metrics.

21.   **The metrics discussed above span a broad range and do not appear to be strongly influencing countries' actual reserve holdings**. As shown below, the average range covered by the three "traditional" metrics for EM countries is nearly 15 percent of GDP. Even so, only a third of countries have reserves levels within this range: nearly 60 percent are above all three measures, and only 5 percent below all three.

Reserves vs. traditional metrics
(2009, in percent of GDP)

Source: WEO, IFS and staff calculations.
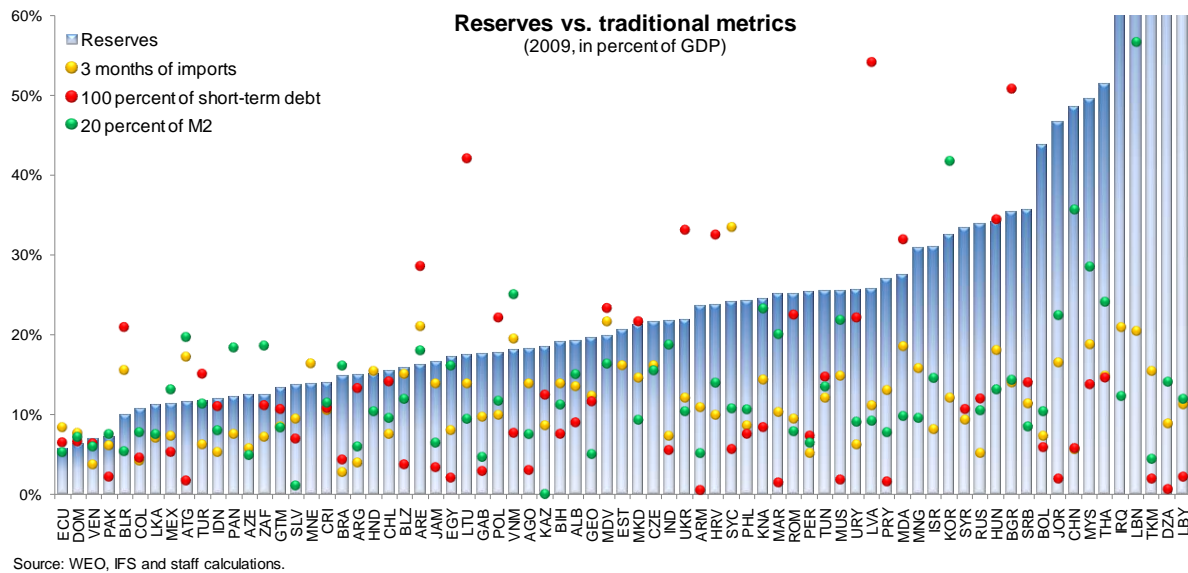
22.   **More recently, cost-benefit models aimed at identifying optimal reserves have also been used**. As described in Box 3, these models describe reserve accumulation explicitly as an optimization problem, with reserves chosen to provide the optimal insurance against a sudden drop in consumption given the costs of holding reserves. However, the optimal level of reserves in such models is very sensitive to the assumptions made about costs and benefits of holding reserves, and the stylized economic structure assumed. The

difficulty in calibrating these parameters in the context of capital market crises—in which output losses are much more endogenous than in the case of externally-driven current account crises as experienced in LICs, and the resulting broad range of "optimal" reserves yielded by such models—may limit their usefulness for EMs.

Box 3. Model-based Approaches to Reserve Adequacy

Several models have been developed in recent years to derive the appropriate level of reserves by solving an optimization problem. These models typically contain assumptions regarding both benefits of holding reserves—lowering the probability of a crisis and smoothing consumption during a crisis—and costs. Notable examples include Caballero and Panageas (2004), who focus on the real costs of a sudden stop of capital flows, and Garcia and Soto (2004), who assume that reserves affect both the probability of a crisis and its cost.

The framework most commonly used at the Fund was developed by Jeanne and Rancière (2006). The model assumes that risk-averse policymakers choose a level of reserves to maximize welfare in a small open economy vulnerable to sudden stops in capital flows. In the event of a sudden stop, when external debt cannot be rolled over, having a higher level of reserves is assumed to mitigate the fall in output and smooth consumption. The model also assumes a cost to holding reserves—with a yield lower than those on other assets in the economy. In this model, the optimal level of reserves is determined by the size and probability of the sudden stop, the potential loss in output and consumption, the opportunity cost of holding reserves, and the degree of risk aversion.

The optimal level of reserves in these models is based on various parameter assumptions. These include the size and probability of a sudden stop, potential loss in output and consumption, opportunity cost of holding reserves and the degree of risk aversion. Sudden stop (as measured by the stock of short-term debt at remaining maturity) is assumed to have a one-to-one relationship with the associated consumption loss. With zero liquidity premium, the model postulates an optimal level of reserves that smoothes domestic consumption in the event of a sudden stop. When there is no output loss, this optimal relationship is reduced to the Greenspan-Guidotti rule.

A limited number of highly stylized models have also been developed for LICs. Given the general inapplicability of most EM-based models, which focus on the role of reserves in preventing or mitigating capital account crises, in LICs' circumstances, papers have tried to focus on shocks relevant to this group of countries. For instance, Barnichon (2009) models insurance against natural disasters or terms-of-trade shocks while Drummond and Dhasmana (2008) extend the Jean-Rancière framework to examine the implications of aid and terms-of-trade shocks. However, as in the case of EM models, outcomes depend critically on parameters being assumed.

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23.   **Scenario analysis is another approach used to identify reserve needs**. Country-specific adverse scenario analysis—whereby shocks are applied to various components of the capital and current accounts over a period of time—has been used in many recent staff reports (and by reserve managers). The magnitudes of these shocks are usually determined by past experiences, projections, and country characteristics. Further assessment is also made on the extent of their transitory nature. The resulting financing gap, compared to the baseline projection, is then translated into potential drains on reserves, yielding information on adequacy of reserves. As such, scenario analyses can bring in rich country and time-specific

information and allow room for judgment that numerical metrics are unable to provide. Contingent financing vehicles—such as FCL arrangements and precautionary SBAs—have widely used this approach, with potential financing gaps fully or partially met by Fund resources. But there concerns remain over exclusive use of this approach, including the difficulty of determining the appropriate level of stress, the absence of an explicit accounting of costs of holding reserves, and difficulty in ensuring consistency across countries.

24.   **Country authorities report predominant use of traditional measures and peer comparisons**. Even though final reserve holdings do not appear to match the traditional metrics, the survey suggests that all three are taken into account by many countries. Peer comparison is also widely used, with additional methods used by a substantial minority. Examination of recent IMF staff reports for EMs shows that ratios to imports and short-term

debt are usually reported, with less use of broad money as an indicator, and about 10 percent of reports using optimality methods as part of a more in-depth examination of adequacy. Peer comparisons also appear to be used widely by market participants—raising the concern that in the absence of more fundamental analysis of potential reserves needs, a focus on relative reserve levels can contribute to a continuous upward spiral in their perception of needs.
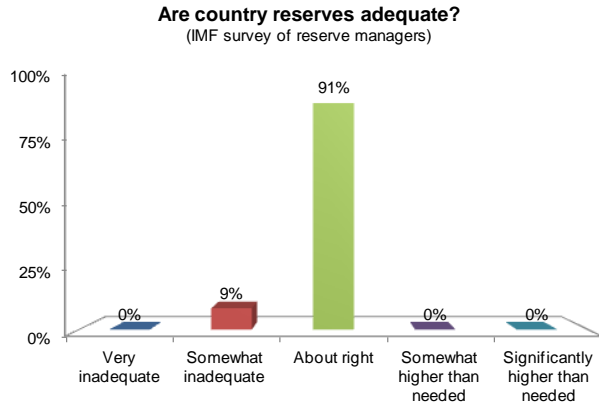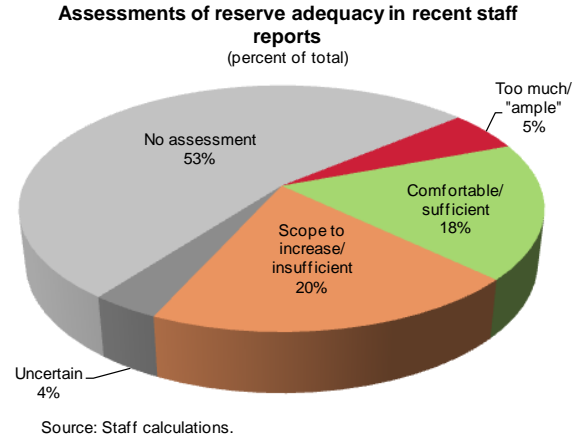

Approaches used by countries
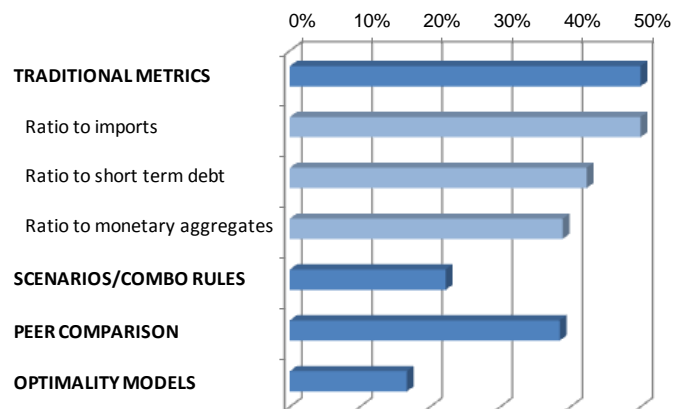
Source: IMF survey of reserve managers.

25.   **Despite the uncertainty over methodology, country teams and the authorities generally consider the level of reserves to be appropriate**. Almost all of the reserve managers who responded to the survey considered their level of reserves to be "about right," although this contrasts with other recent surveys in which an increasing number of central banks felt compelled and prepared to take on more investment risk due to rapidly rising reserve levels.[7] Similarly, in most of the recent EM staff reports surveyed, country teams either do not directly assess adequacy—which may point to it not being a central issue in surveillance in that country, in the context of a focused Article IV consultation—or consider the level to be sufficient. While inadequate reserve coverage is highlighted in some cases, over-accumulation is highlighted in only five percent of cases.

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[7] See e.g., Pringle, Robert and Nick Carver, 2007, "Trends in Reserve Management—2007 Survey Results," in RBS Reserve Management Trends 2007, ed. by Robert Pringle and Nick Carver (London: Central Banking Publications). Borio, Claudio, Gabriele Galati, and Alexandra Heath, 2008, "FX Reserve Management: Trends and Challenges," BIS Papers, No 40.

Are country reserves adequate?
(IMF survey of reserve managers)

Source: IMF survey of reserve managers.

Assessments of reserve adequacy in recent staff reports
(percent of total)

Source: Staff calculations.

C. Cost of Reserves

26. **Decisions on reserves levels need to be informed by an assessment of costs as well as of potential benefits.** The survey results suggest that two-thirds of countries use quantified measures of costs, often in the context of a cost-benefit framework, to inform their reserves strategy. But there is little consensus on appropriate measures of costs. Indicators identified in the literature include sterilization costs, actual or potential exchange rate valuation losses, the opportunity cost of foregone consumption or investment, and the cost from the maturity mismatch between reserves and sovereign liabilities. However, most of these measures reflect costs from exchange rate and monetary policy decisions—again, relating to NFA accumulation rather than holding gross reserves themselves—while others can be substantially reduced with an appropriate reserves management strategy without any need to affect reserves levels.
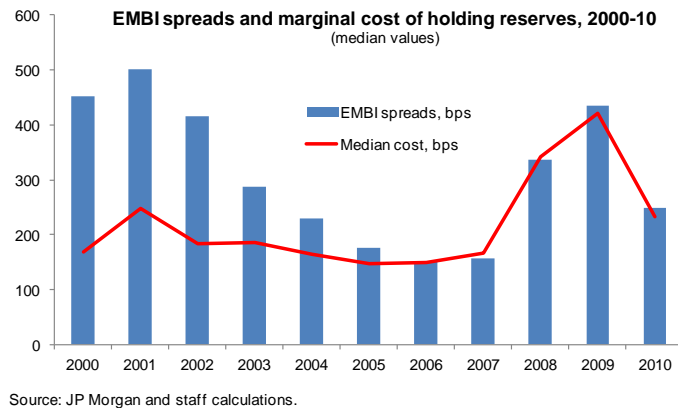
27. **Among alternative indicators, the net financial cost of holding reserves is probably the best proxy of their opportunity cost for emerging markets.**[8] This "cost of carry" is defined as the differential between the external funding cost of reserves and the return on the resulting liquid foreign assets—typically using measures of sovereign bond spreads such as the J.P. Morgan EMBI index. Use of this measure rests on two main assumptions: countries have market access and at the margin, reserves are effectively financed by external debt (since in principle the country could use reserves to redeem public external debt without affecting the domestic economy, subject only to coordination issues within the public sector); and there is not necessarily a maturity mismatch since reserves, while still consisting of liquid assets, could have matching maturities to corresponding debt liabilities.[9] In practice, of

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[8] See work by Rodrik (2006), Edwards (1985), Lee (2004), Garcia and Soto (2004), Wijnholds and Kapteyn (2001), Hauner (2005) and Jeanne and Rancière (2005) for use of alternative definitions of sovereign spreads as a measure of the cost of holding reserves.

[9] Jeanne and Rancière (2009) exclude the default risk premium from their costs analysis. However, the country's probability of default is separately included in the calibration of their cost-benefit framework.

course, coordination between central banks and governments may be lacking, and reserves are typically held at shorter maturity than government debt, adding to their carry cost.

28.   **However, endogeneity between sovereign spreads and reserve levels needs to be taken into account to avoid overstating costs.** Empirical studies find a negative relationship between reserves and spreads.[10] As a result, use of spreads can overstate the true opportunity cost of reserves. But this effect depends on the relative levels of reserves and debt: when reserves are low and debt is high, a given increase in reserves would lead to a much larger reduction in government funding costs than it would when reserves are high and debt is low. This is very relevant to the past decade, when EMs have seen reduced external debt and increased reserves. Estimates of this effect based on the methodology of Levy-Yeyati (2008) suggest it fell dramatically in scale in this period, so that although EMBI spreads fell sharply between 2001 and 2007, the median net financial cost of reserves remained relatively flat (at about 200 basis points), before rising in line with spreads in the crisis years (see chart). Nevertheless the endogeneity may still be highly relevant for a number of individual countries that still have high debt and low reserves; indeed the model would predict *negative* marginal cost of reserves for countries whose reserves are particularly low relative to external debt. But for the median EM country, reserves costs are estimated to have averaged around 0.5 percent of GDP over 2001−09.

EMBI spreads and marginal cost of holding reserves, 2000-10 (median values)

Source: JP Morgan and staff calculations.

29.   **For countries with very low external debt, the net financial cost of reserves is implied by foregone alternative investment opportunities rather than by debt financing costs.** For example, a country with already high reserves levels could decide to invest part of its resources in higher-yield—yet less liquid and riskier—assets. In this case, a measure such as the bond spread for investment grade corporates in advanced economies may offer a better alternative as an estimate of the cost of reserves.

D. Reserve Management and Institutional Arrangements

30.   **A complete assessment of adequacy would take into account the way reserves are managed**. Reserve management has traditionally been very conservative, with majority of reserves held in low-yielding but safe and liquid government bonds. However, in the years leading up to the recent crisis, a progressively larger share of reserves was shifted out of Treasuries into higher-yielding, less liquid assets. As the crisis unfolded, central banks reduced their exposure to these "nontraditional" asset classes (in many cases because of fear

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[10] See for example Eichengreen and Mody (1998), Rodrik and Velasco (2000), Lane and Phillips (2000), Dell'Ariccia, Schnabel and Zettelmeyer (2002), Kamin (2004), Hauner (2005), Levy Yeyati (2008).

of losses, rather than because they needed to liquidate the assets for balance of payments needs).

31.   **Inadequate reserve management can negatively impact the availability of reserves locally and globally.** Reserves that are held in less liquid or more risky assets can only be sold at a substantial discount or with considerable delay. Indeed, several asset classes that were assumed to be very liquid before the crisis turned out to be significantly less liquid during the crisis. This was especially true for central banks that needed to sell large amounts of a particular asset class. Further, when reserve managers globally decided to reduce their exposure towards non-government debt, they in turn exacerbated the foreign currency funding problems at commercial banks, which in turn prompted a policy response from the domestic authorities to provide foreign currency liquidity to their banks.[11] To the extent that these central banks had to use their reserves, the flight to quality in one central bank led to a reduction in reserve levels at another central bank.

32.   **Reserves should therefore be managed in a way that not only preserves their value, but also avoids procyclical behavior during a crisis.** This has implications for the strategic asset allocation (SAA) of reserves, as well as for incentives given to reserve managers. The SAA should attach more weight to countercyclical assets, i.e., those that rise in value during a downturn or recession (when they are likely to be needed the most). Active portfolio management, in combination with a mandate to outperform a benchmark, can create the wrong incentives for reserve managers if they invest in cyclical assets such as credits. Of course, to the extent that reserve holdings are more than adequate, the authorities may wish to manage these excess reserves part of sovereign wealth.

33.   **Just as reserve management can improves a country's ability to prevent and deal with a crisis, appropriate institutional arrangements and practices can reduce its vulnerabilities.** Key areas include public debt management and prudential regulation that addresses private sector imbalances. An appropriate debt management strategy can reduce the likelihood that servicing public debt could result in calls on foreign exchange reserves. Public debt in many emerging and developing economies typically has a large foreign currency component, leaving the country exposed to the risk of an appreciation of the foreign currency and—less prominently—to a rise in foreign interest rates. Short maturities of external debt compounds to these risks, and may lead to a drain on reserves if the debt cannot be rolled over.

34.   **Asset and liability management (ALM) techniques may be used to coordinate the risk profile of reserves and public debt** (Box 4)**.** Most countries already take ALM considerations into account for some assets and liabilities—for example, by matching the currency composition of reserves with that of short-term external debt—but few consider the complete sovereign balance sheet. Such an approach could reduce overall financial risks and therefore vulnerabilities to the country. An important first step for sovereign ALM would be

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[11] For a more comprehensive discussion, see Pihlman and van der Hoorn (2010): they estimate that reserve managers pulled out roughly US$500 billion of deposits from the banking sector between December 2007 and March 2009.

an exchange of information between the central bank and the debt management office on the composition of reserves and external debt.

Box 4. Managing External Vulnerability in Brazil, Korea, and Russia

Brazil
During the crisis, deteriorating external conditions led to significant pressures on the currency, but a comfortable foreign reserve level helped limit the adverse effects of the global financial turmoil. In particular, lending facilities in foreign currencies and intervention in the foreign exchange market through futures helped stabilize domestic financial conditions. With understanding of the important role of reserves to address risks from external liability during the crisis, the Brazilian central bank has continued to apply an asset and liability management (ALM) approach to reserve management by taking account of characteristics of the country's external debts.

Korea
In late 2008, Korea was hit by sudden capital outflows, experiencing rapid depreciation of the currency, and drew on reserves and Fed swap lines to reduce volatilities in forex markets and provide liquidity to the banking sector. Reserves fell from $260 billion to $200 billion from May to November 2008. In response, a risk factor-based approach in macro-prudential policies was adopted, especially to better manage vulnerabilities arising from external liabilities in the banking sector. Stronger foreign currency liquidity standards were introduced to reduce maturity mismatches and improve the quality of liquid assets for banks. In June 2010, the ceiling on FX derivatives position of domestic banks and branches of foreign banks was set. These measures have been effective in limiting the build-up of short-term external debt and therefore reducing balance sheet mismatches in the banking sector. Banks, especially branches of foreign banks, have raised more long-term debt and reduced their reliance on short-term funding.

Russia
During the crisis, the Russian economy was been hit hard by dual shocks—a collapse in oil prices and a reversal of capital flows. Significant liquidity provision to the banking sector and smoothing operation in the foreign exchange markets resulted in loss of foreign exchange reserves. A sizable part of the assets of Russia's SWFs were also used to cover a countercyclical fiscal expansion. This experience prompted the authorities to seek to establish a more sophisticated vehicle with adequate capacity and expertise for managing sovereign assets and liabilities. In this context, in April 2010, a draft law on the Russian Federation Agency (RFA) was proposed. The agency's key function is managing assets in the National Wealth Fund and public debts. This implies the introduction of an ALM approach focusing on managing risks rising from mismatches between assets and liabilities.

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35.   **Prudential regulation could help address private sector imbalances and reduce the need for foreign exchange reserves.** Strong private sector balance sheets with low exchange rate, credit, and liquidity risks could insulate the private sector from sudden reversals of capital flows or market freeze and therefore reduce the need for the central bank to build-up reserves to be the lender of last resort of foreign currency assets. In light of this and given the important role of financial institutions, strong supervision and regulation could minimize risks embedded in these institutions' balance sheets and reduce the likelihood of calls on foreign exchange reserves. During this crisis, some countries have adopted prudential measures to manage vulnerabilities arising from external liabilities in the financial sector.

III. ANALYTICAL APPROACHES FOR EMERGING MARKETS

First, cross-country experience on outflows during times of exchange market pressure is used to assess the relative risks posed by different elements of countries' liability structures, which are combined to form a single risk-weighted metric against which reserve needs may be assessed. Second, as a complement to this approach, regression analysis of observed reserve holdings against a range of precautionary variables is used to infer the degree to which countries' actual reserves levels are consistent with those of peers.

A. Sources of Balance of Payments Risk

36.   **Studies of individual crisis episodes show balance of payments pressure from a range of potential sources.** Accompanying figures depict these developments in the cases of Brazil and Russia. In each of these episodes, the pressure on the balance of payments arises from multiple sources—although mostly in the capital account—but with the combinations of pressures varying markedly across crises.

Source: WEO and staff calculations.
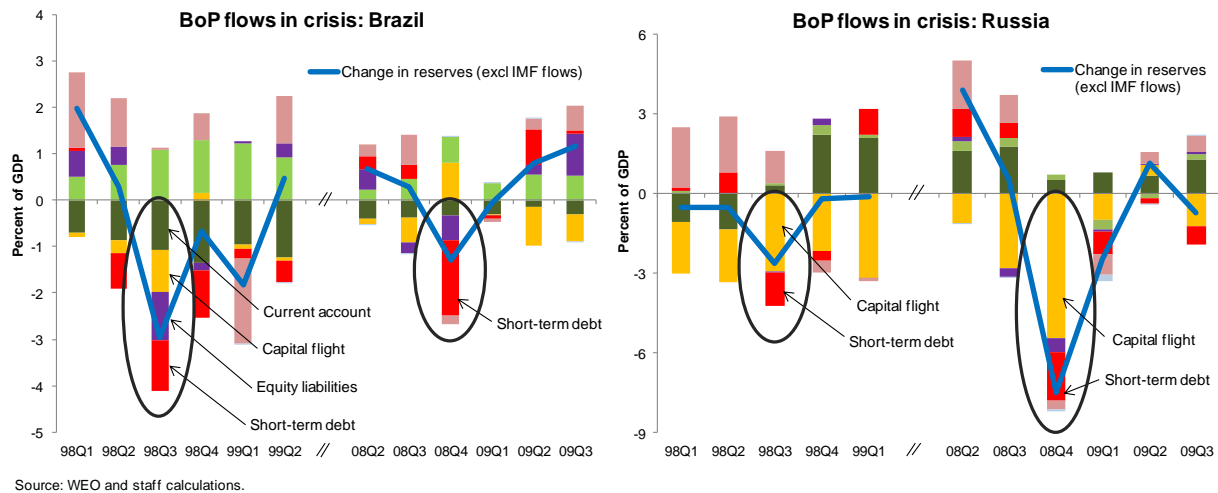
- In both the Russian episodes, capital flight (as indicated by *outflows into foreign assets*) and *short-term liabilities* were primary drains, while in the case of Indonesia the *sale of equities by nonresidents* was the major source of pressure.

- Both the Brazilian episodes demonstrate that drains from *lower export earnings* as well as multiple financial account sources can occur simultaneously.

- Comparing events in Brazil and Russia during both 1998 and 2008−09 also shows the important role reserves played—the outflow pressures were large in both periods, but these pressures only resulted in a full-blown crisis during the lower reserve period.

- Korea's experience suggests that despite much higher reserves during the recent crisis, contingent reserve substitutes such as foreign currency swap arrangements with other central banks can play an important supplementary role.

37.   **This experience suggests the need for a metric that encompasses a broad set of risks.** This accords also with the evidence from reserve demand regressions, the survey results, and indeed the range of metrics already in use. Sources of risk would include external liabilities as well as current account variables and some measure of potential capital flight. Trying to balance the need for both simplicity and completeness, the paper focuses on four specific sources of such drains that play separate—and essentially non-overlapping—roles:

- *Export earnings* reflect the potential loss that could arise from a drop in external demand or a terms of trade shock that, both of which remain relevant for many EMs. Imports would be the more familiar current account variable to use here, but would not capture risks of external demand collapse, and are also problematic to model, because they are endogenous to the amount of available financing, and so generally fall during crises, *improving* the balance of payments.[12] Of course in practical terms the choice between exports and imports would usually not make a major difference, as the two are usually of comparable size.

- The separate external liability stocks—*short-term debt* (at remaining maturity) and *medium- and long-term debt and equity liabilities*—account for additional different observed drains. The expectation would be that short-term debt would be the riskier, especially for floating rate regimes, where potential balance of payments needs from equity outflows should be reduced by depreciation of the local currency as well by falling equity prices.

- For capital flight risk, **broad money** is used to represent the stock of liquid domestic assets that could be sold and transferred into foreign assets during a crisis.[13]

The analysis does not include FDI liabilities as a source of drain, as there was no evidence in the dataset of EMs of the stock of FDI owned by foreigners being sold during times of stress. In principle, other risk sources such as derivatives exposures and exposure to speculative attack might be included too, but the former is subject to severe data limitations, and the latter is very hard to proxy.[14] However, the approach could be modified for a particular country if such risk sources are important and data are available.

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[12] Another way to look at this is that the original "three months of imports" rule is aimed at protecting against the *symptoms* of balance of payments problems, whereas subsequent metrics have all been aimed at the potential *sources* of the problems.

[13] While data on resident deposits would have been a preferable proxy, since non-resident deposits are included in the other liability measures, availability of such data only for a very limited set of countries and years necessitate the use of broad money instead. Nonetheless, available data suggest that the extent of such double counting is small, with broad money predominately domestic local currency deposits. The estimated loss is calculated removing valuation effects resulting from exchange rate changes during the crisis.

[14] This point is highlighted by the Russian experience summarized in the chart above, where heavy reserves losses in late 2008 appear to have been in large part associated with speculation against the ruble following the collapse in oil prices. A possible lesson from this and similar episodes is that rather than relying solely on reserves, countries highly dependent on volatile commodity prices should focus on ensuring strong policy frameworks and economic flexibility so as to be able to allow the nominal exchange rate to bear the brunt of the adjustment.

B. Derivation of the Proposed Reserve-Adequacy Metric

38. **Lack of crisis observations precludes direct estimation of how much reserves might be needed to meet each of these risks, and a two-stage approach is employed instead**. Regressions of overall balance of payments pressures against the four risk variables above are unable to separate out individual effects. Instead a two-stage approach is employed. In the *first stage*, the *relative* riskiness of different potential drains on reserves is estimated, primarily based on observed distributions of outflows from each source during periods of exchange market pressure, and a "risk-weighted liability stock" is constructed. In the *second stage*, the desired proportion of this liability stock that should be held as liquid reserves can then be gauged based on past crisis experience. The approach is thus similar to that used for regulatory requirements on bank capital, under which separate relative risk weights are assessed for each different asset classes, which are then added to create a risk-weighted asset stock against which capital needs are defined.[15]

39. **Estimates of relative risk weights for the first stage are based primarily on tail event outflows associated with periods of *exchange market pressure (EMP)*.**[16] Identified drains during such events—which represent potential loss in foreign exchange—are computed as (annual) percentage losses of the items discussed above: export income, STD, other portfolio liabilities, and liquid domestic assets (proxied by broad money). Distributions are estimated separately for fixed and floating exchange rate regimes. While most EMP events do not exhibit overall annual liability outflows or export losses, a significant left (negative) tail exists for each of these drains individually.

- *The proposed approach focuses on drains observed at the tenth percentile of each of the distributions*. Although essentially arbitrary, and obviously critical for the *absolute* magnitude of potential drains, the choice of threshold would be expected to have much less impact on estimates of the *relative* riskiness of different liabilities, the only aim at this stage. The tenth percentile is chosen as a reasonable balance between data limitations (since the further into the tails, the fewer observations and the less well-defined the distribution), and the need to test reasonably severe shocks. Table below shows the estimated risk weights derived from these observations.

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[15] As with bank risk capital weighting, potential correlations between risks are not taken into account, implying a more conservative approach than if it were assumed, say, that an export shock was unlikely to coincide with an episode of capital flight. Lack of data preclude estimating such correlations, but in any case it is not clear that correlations should affect the *relative* risk coefficients, rather than entering as part of the assessment of reserves need against the metric in the second stage. And the study of individual crisis episodes above certainly suggests a range of balance of payments drains can occur at the same time.

[16] Following Eichengreen and others (1997), the exchange market pressure index is a weighted average of reserves loss, exchange rate depreciation, and increases in the interest rate, with deviations from the average of more than 1.5 times its standard deviation considered a period of significant pressure.

10th percentile outflows during exchange market pressure events

| percent	Exports	Broad money	Short-term debt	Other portfolio liabilities
Fixed	8.9	12.4	24.4	27.6
Floating	2.3	7.1	24.4	9.2

Source: Staff calculations.

- *Some adjustments are made based on alternative estimation methodology, judgment, and to avoid giving a false sense of precision.* An alternative approach to estimating outflows from the two external liability variables (see the Supplement) points to a higher relative weight on STD and lower on other portfolio liabilities; this also accords with the observation that—for local currency-based liabilities in floating rate countries at least—past observed outflows may in part have reflected a choice to accommodate outflows rather than a strict necessity. And reflecting the very large uncertainty necessarily surrounding these estimates, "round-number" weights are proposed for the metrics for the two exchange regimes, as follows:

Fixed: 30% of STD + 15% of OPL + 10% of M2 + 10% of X

Floating: 30% of STD + 10% of OPL + 5% of M2 + 5% of X

Figure: Drains on the Balance of Payments
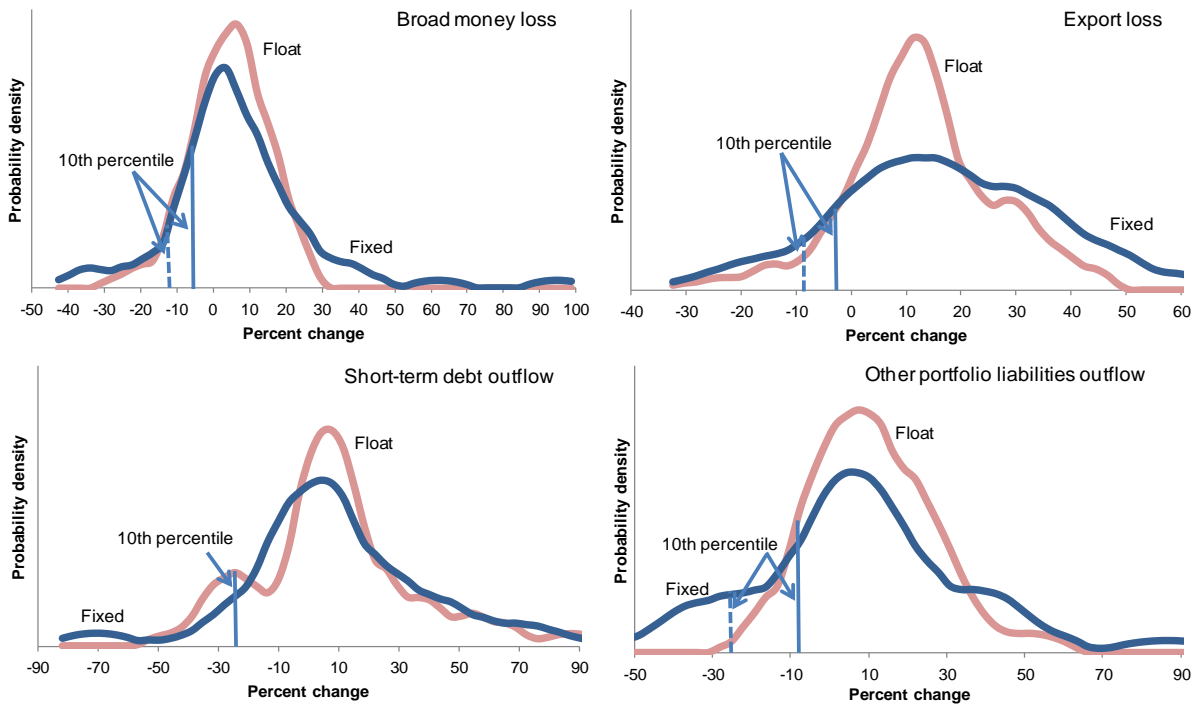


Source: WEO and staff calculations.

40.   **The *second stage*, then, is to consider the coverage against this metric a country should hold.** As with the traditional metrics, this is bound to be a controversial area, given the different factors at play, including assumed levels of risk aversion, estimated costs of reserves, and other individual country factors. However, evidence can be brought to bear on this question from past crisis episodes, which also provides a means of assessing the performance of the proposed metric relative to others. Three approaches are used to help inform this judgment, focusing on crisis prevention, crisis mitigation, and observed reserve losses:

(i)   *Effect of the reserves/metric ratio in reducing crisis probabilities*. The ratio of reserves to the metric is strongly positively associated with a reduction in the probability of an exchange market pressure event: Higher reserve holding relative to the metric significantly reduces the probability of an EMP event, with the reduction diminishing as the reserves ratio increases. The proposed metric performs markedly better in this estimation than any of the alternate traditional single or combined metrics—including import cover, short-term debt, broad money, the maximum of the traditional metrics, GDP and the Wijnholds and Kapteyn metric (see Supplement). As

a robustness check, a similar finding also holds in predicting the set of 11 extreme crisis events discussed in the recent review of crisis-related programs (SM/09/246). The regressions also suggest a strong crisis prevention role played by the overall policy framework, with a more prudent fiscal position (as measured by the cyclically adjusted primary balance) being associated with a lower crisis probability. Although the latter effect is not statistically significant enough to pin down its magnitude, the reserves/metric ratio remains highly significant (more so, in fact) with its inclusion.
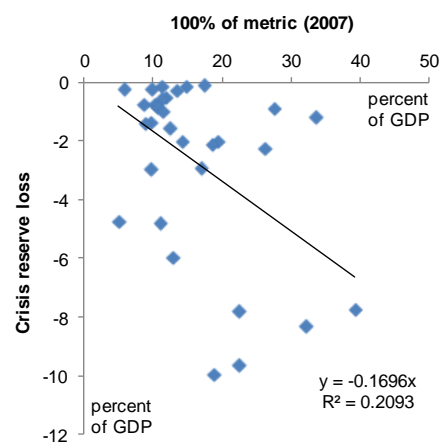

Source: Staff calculations.
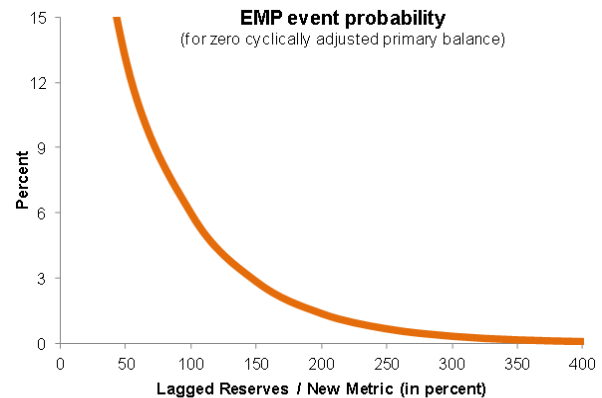
(ii)   *Impact of the reserves/metric ratio on the fall in consumption during a crisis.*
Following the methodology of the paper examining the effects on EMs of the global crisis (SM/10/116, 5/7/2010), consumption falls in crisis events, proxied by exchange market pressure, are regressed against the reserves ratio and other controlling variables. The reserves ratio is highly significant and again outperforms the other metrics. This approach also points to the importance of other fundamentals and policy variables, which are highly significant in the regression, but again without reducing the explanatory power of the reserves ratio.

Source: WEO and staff calculations.
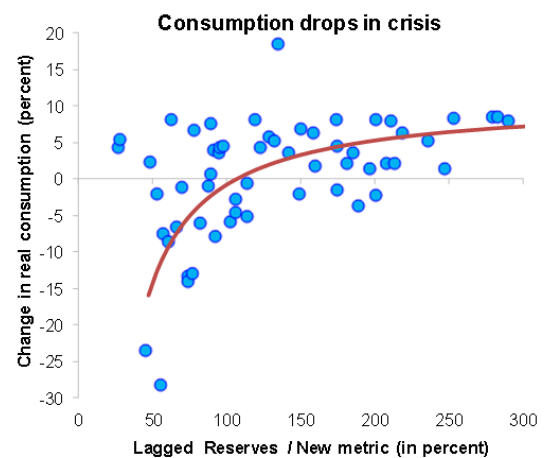
(iii) ***Correlations with reserves losses in the crisis***. As noted in Section II, STD was very weakly correlated with actual reserve losses in the recent crisis. The new measure performs much better, although unsurprisingly the relationship is still not tight. The median reserve loss as a share of the metric was 10 percent, the same as for STD, but the standard deviation was much lower, at 15 percentage points compared to 24 percentage points for STD, suggesting that the new metric is a more reliable guide to potential needs. Reserves losses of 50 percent of the metric are at the 95th percentile.

100% of metric (2007)

y = -0.1696x
R² = 0.2093

Source: WEO and staff calculations.

41. **These results highlight the degree of judgment needed, but taken together suggest coverage in the region of 100−150 percent of the metric might be regarded as adequate for a typical country.** Under the first method, crisis probabilities rapidly tail off as the coverage increases beyond this range; under the second, it is notable that large consumption drops were exclusively concentrated in countries with ratios below this level; while the third shows actual reserve losses in the crisis typically at 10 percent of the metric and hardly ever exceeding 50 percent. Of course, even if 100−150 percent were accepted as an adequacy range, it would not preclude countries from wanting to hold more (or less) than this, depending on their particular circumstances and degree of risk aversion. But given the costs of reserves, it should become increasingly important to focus relatively more on *other* means of defending against crisis, including (cheaper) contingent financing mechanisms, and improving overall policy and sovereign risk management frameworks.

C. Judgment in Application

42. **The proposal above reflects work in progress and should at best be regarded as a potential advance on existing metrics, and still providing guidance only at the most general level.** Additional experience and analysis can yet be brought to bear both on what weights should be put on different sources of risk and also on how much of the resulting metric is reasonable to hold. And considerable judgment would be required in application to individual countries. To take a few examples:

- The weight on STD might be reduced where these liabilities are predominantly owed to foreign parents, or increased when predominantly from the wholesale market. Similarly a large share of trade credits within STD might imply less need for reserve cover.

- The weight on exports might need to be much higher where reliant on particularly volatile commodities.

- The weight on M2 could be reduced (or even eliminated) where effective capital controls are in place that would prevent capital flight.

- Reserves needs of dollarized economies—or rather, their foreign currency needs—may differ from other countries. On the one hand they might be lower given the absence of currency risk; on the other foreign currency liquidity needs of the banking sector could in principle be very high in the absence of local currency issuance-to the extent that it may not be practical to try to meet this risk with availability of foreign currency, but to rely on a strong supervisory regime instead.

- A country that relies on remittances could supplement the proposed metric by including an estimated weight on this source of risk.

- Within the floating rate classification, a country that is willing or able to tolerate large swings in the exchange rate might be comfortable holding a lower reserve coverage of the metric, whereas a country determined to avoid significant depreciation might want to hold more—although allowing more exchange rate flexibility would usually be a better option than seeking defense with very high reserves in cases where the exchange rate is overvalued and at risk of speculative attack.

- Countries with generally weak fundamentals might want to hold higher coverage of the metric (while seeking to address the underlying vulnerabilities).

Adjusting the metric in this way can be seen as a first step towards the full scenario analysis approach that is needed for a complete assessment of potential liquidity buffers. Empirically it is difficult to isolate exactly how such country-specific factors might affect potential balance of payments needs, although this might be a fruitful area for future work. And given a strong premium on simplicity and ease of use, it is probably better to maintain a highly simplified metric against which judgment can be transparently applied according to a country's particular circumstances. Trying to calibrate these effects within the metric could result in a "black box" with outputs that are hard to interpret. A further extension of the approach, to provide estimates of optimal reserves in a standardized cost-benefit framework, is discussed in the Supplement, with country results presented in Section E below.

D. A Cross-Country Regression Approach to Reserve Adequacy

43. **Another, complementary, approach to understand countries' motivations and to compare reserves levels across countries is to model actual reserve holdings**. To the extent that these holdings reflect precautionary considerations, a model of reserve demand can shed light on the relative importance of different variables, and provide a means of distinguishing between countries based on these revealed preferences. The first question is whether the overall trends identified in Section A—particularly the growth of reserves in recent years—can be explained by a model of precautionary demand for reserves. The answer is a partial *yes*. The estimated model for EMs fits the data for average reserve growth reasonably well, with precautionary variables explaining most of the growth of reserves over the past decade. Unsurprisingly, just as with any of the metrics, the regression model does not track individual country holdings very closely, suggesting that some countries are holding reserves for different purposes than identified, or are more or less risk averse than their peers. But, as discussed further below, the relative position of countries compared to the

predicted values from the estimation accords quite well with the message from the metric calculations.

44.   **Use of the reserve demand model for assessing the level of reserve adequacy is predicated on the assumption that, averaged across countries and over the regression sample period, countries are neither systematically over- or under-insured from a precautionary perspective.** Given this premise, the reserves demand model informs about how individual EMs' holdings of reserves may be expected to vary from the sample average depending upon their specific vulnerabilities, and reserves holding costs. That the model can explain much of the increase in the *average* reserve holdings by EMs since 2000 suggests that—if EMs as a group were considered appropriately (or somewhat under-) insured during the 1990s, then much of this increase is consistent with precautionary demand against rising risks, for the average country. To the extent that individual countries' reserve holdings substantially exceed the model prediction (which takes account of various factors that might be expected to affect precautionary demand), it suggests that other motivations (precautionary or nonprecautionary) are at play.

Contributions to cumulative reserves increase
(percent of GDP)
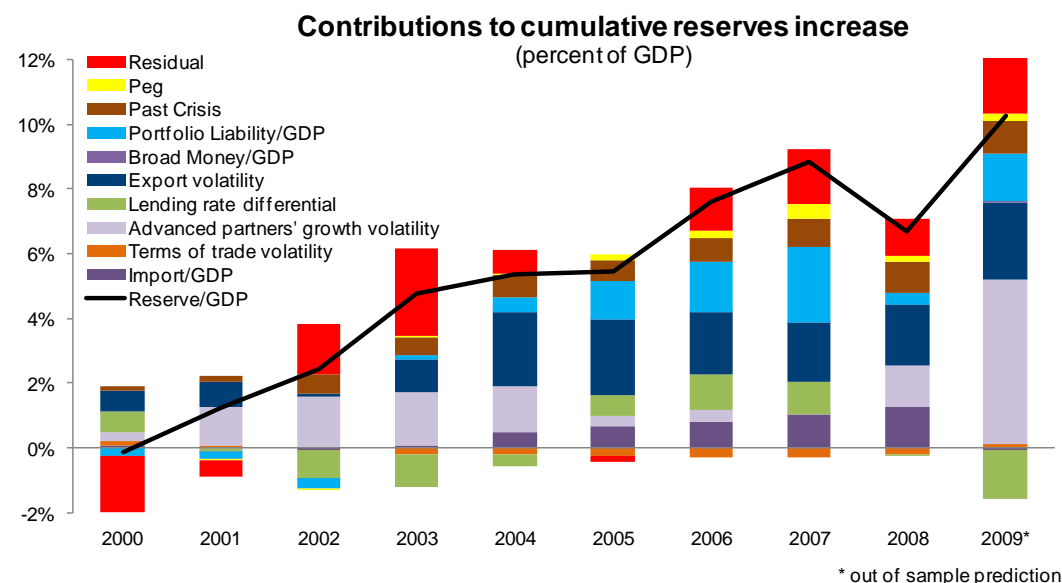
Source: WEO, IFS and staff calculations.

45.   **The model provides important insights on the issues that appear to be important in determining countries' reserve holdings.** The model, which has a reasonably good fit, identifies the following areas:

- *External environment.* While there are potentially many such variables (such as the VIX, which is not significant in the regressions) that capture the external uncertainty facing EMs, the volatility of real GDP growth in (advanced economy)

EM Estimated Reserve Demand

Dependent variable: EM reserves/GDP, 1990-2008

Imports/GDP	0.155	**
M2/GDP	0.00002	
Portfolio liabilities/GDP	0.363	***
Terms of trade volatility	0.106	***
Export volatility	0.267	**
Partner growth volatility	0.024	**
Interest rate differential with the US	-0.018	
Peg Dummy	0.017	
Crisis Dummy	0.039	**
Constant	0.003	
Observations	800	
R-squared	0.39	

*** and ** = significance at 1 and 5 percent levels.

trading partners, and the volatility of the terms of trade appear to have explanatory power with expected sign.

- *Current account risks*. The import ratio continues to be a significant (and the most robust) determinant of reserve holdings, as does the volatility of export receipts. In fact, current account variables are particularly significant in explaining the increase in reserves over the past decade.

- *Capital account risks.* The third group of variables is intended to capture the potential need for reserves arising from capital account risks. Perhaps surprisingly, short-term debt is not a good explanatory variable for reserve holdings, and is strongly dominated by overall portfolio liabilities—the coefficient on which is, at 0.36, is very comparable to the weights used in the metric approach discussed above. Broad money has the expected sign, but the coefficient is very low and is not statistically significant.

- *Cost of holding reserves*. As discussed in Section II, determining the opportunity cost of holding reserves is not straightforward. Perhaps reflecting this, the interest rate differential between the country's government treasury bill rate (or other available short-term interest rate) and the corresponding U.S. asset, a crude proxy for this cost, is not statistically significant though it enters the regression with the expected negative sign.

- *Other*. The regression includes dummy variables for whether the country has experienced a financial crisis, and for whether the country has a de facto pegged exchange rate regime. The prior crisis dummy is significant, suggesting that countries that have experienced significant crises are more risk averse and have correspondingly greater precautionary demand for reserves than their peers. The pegged exchange rate regime dummy is insignificant.

46.   **The analysis points to three main conclusions.** First, precautionary motives appear important in explaining both the time series and cross-sectional variation in reserve holdings. Second, both at the average level and for some individual countries there may be additional reasons to hold reserves, which are not well captured by the purely precautionary elements of the model. These may reflect non-precautionary motivations, or they may reflect precautionary motives that have not been possible to identify econometrically (for example, a generalized but unobservable increase in risk aversion). Third, while traditional variables (such as imports) continue to help explain countries' precautionary demand for reserves, other liabilities and other potential calls on reserves are clearly important.

## E. Application of the EM Frameworks

47.   **As with previous metrics, countries mostly hold reserves that would be adequate by the proposed measure.** The figure below shows individual countries' reserve coverage against the metric. Based on end-2009 data (since when reserves have risen in most EM countries), about 35 percent of the sample was within the proposed adequacy range, with roughly 40 percent with reserves above the range and about 25 percent below the range. But

the caveats discussed above should be borne in mind in trying to draw conclusions on individual countries without taking their specific circumstances into account. For example, of the 11 countries with cover below 100 percent, one is dollarized, two have currency boards, and another has extensive capital controls—all factors which could significantly affect assessment of reserve adequacy (and some of the others have seen large rises in reserves in the past year, which would probably put them inside the range as of end-2010). Similarly, some countries with reserves above the suggested range may have important country-specific vulnerabilities—such as high exposure to commodity price volatility, for example—which could significantly raise their precautionary needs. And an assessment that a country has more reserves than might be needed as liquidity buffers is not to say that reserves are necessarily "excessive" from a broader perspective; for example if a nonrenewable resource exporter with limited institutional capacity chose to hold its precautionary *savings* in reserves rather than in alternative investment vehicles.

Reserves against risk-weighted metric
(reserves as percent of metric, 2009)
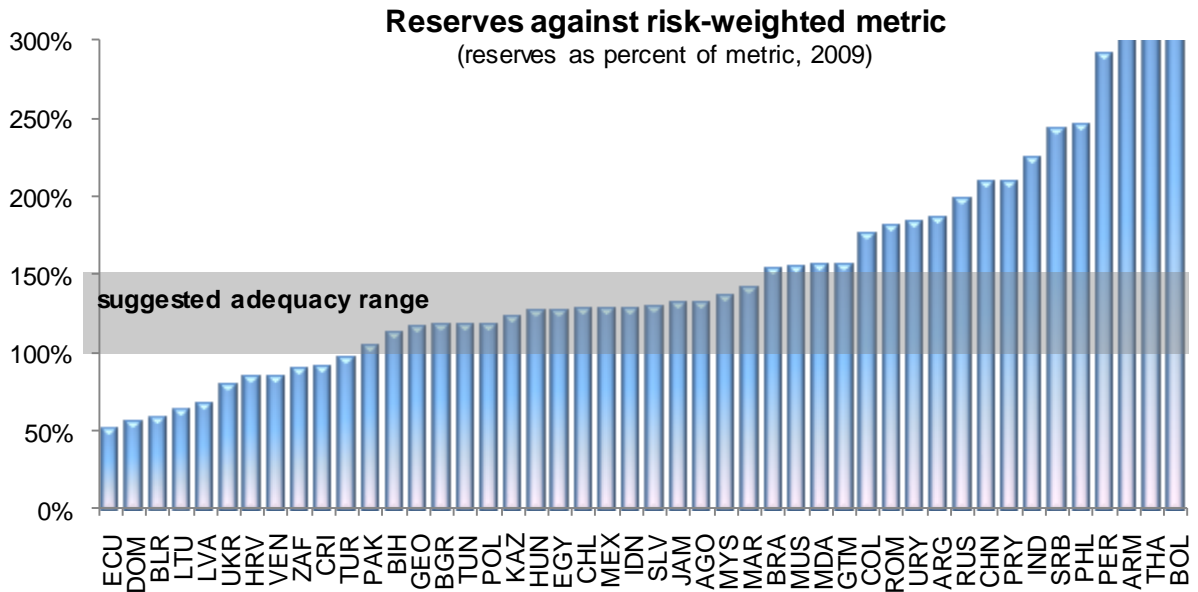
Source: WEO and staff calculations.

48.   **Assessments against the new metric are broadly consistent with a "combined" approach to traditional metrics.** The figure below shows 100 percent coverage of the new metric against the maximum of the three "traditional" metrics. This maximum lies within the 100−150 percent range of the new metric in more than half the cases, although there are a number of countries for which the "maximum of traditional" approach would point much higher reserves than either the new measure or the country's actual holdings. This highlights that the proposed metric is an extension of existing practices rather than a radical departure, although as noted in Section III.B above there is evidence that it may be a better yardstick against which to measure reserves from a precautionary perspective than the traditional metrics—whether the latter are examined in isolation or together.

New metric vs. maximum of traditional metrics
(percent of GDP)
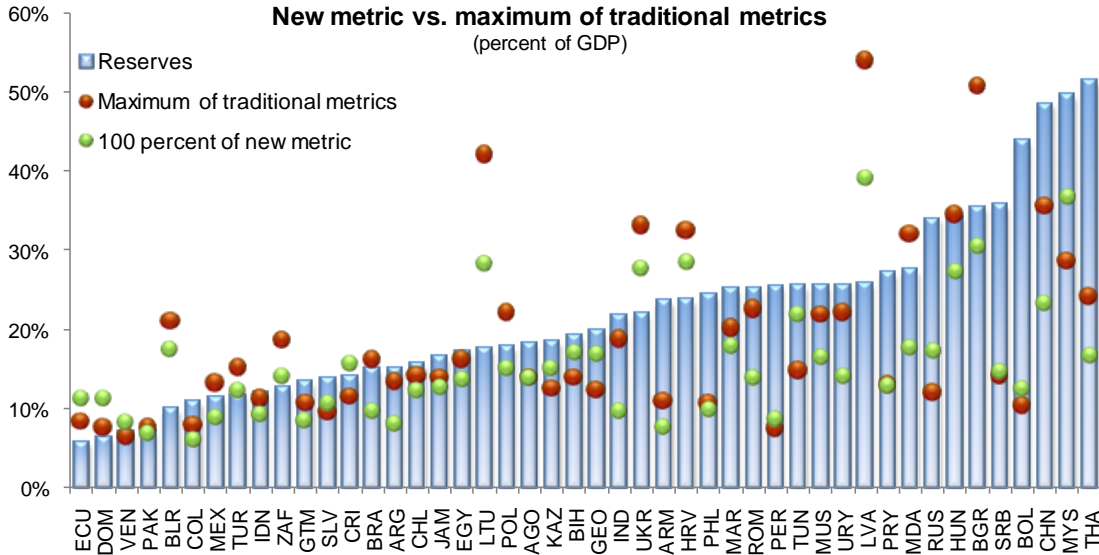
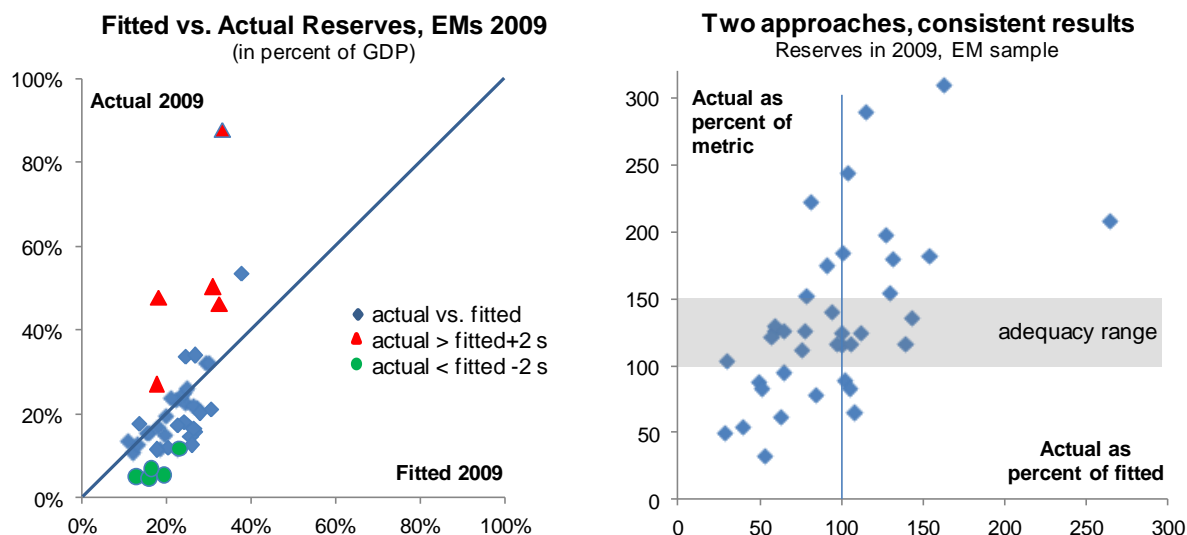Source: WEO and staff calculations.

49.   **Using this metric within a standardized cost-benefit framework can provide some evidence on possible "optimal" reserves levels, but also highlights model dependence.** The figure below shows the results of the model—further described in the Supplement—calibrated using reserve holdings relative to the metric as the defense against a balance of payments shock associated with a certain (exogenous) output loss. The benefit in avoiding this output loss is balanced against the cost of reserves, as represented by EMBI spreads. The two dots shown on the chart illustrate the resulting optimal reserves levels for two different assumptions about output loss. For most countries, the resulting optimal levels are within a margin of error of the "adequacy" level provided by the metric—highlighting clearly the effect that varying model parameters, or indeed the structure of the model, can have.

Reserves: Actual vs. Model-based Optimal Level
(reserves as a percent of metric, 2009)
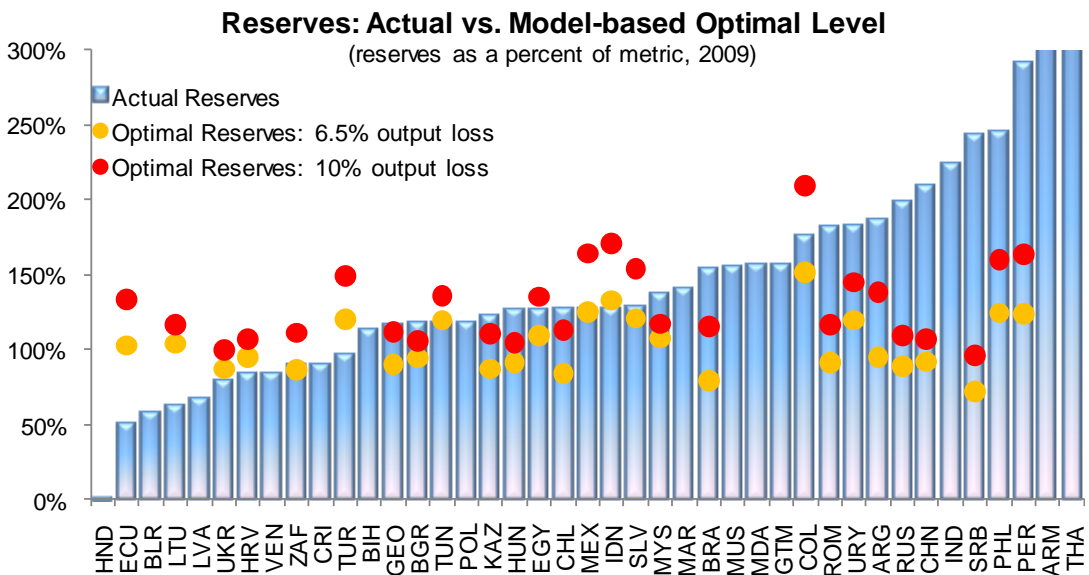
Source: WEO and staff calculations.

50.   **Comparison of actual reserves holdings with fitted values from the regression provides a further means of assessing relative reserve holdings across countries**. The left chart shows countries' relative positions from the regression for 2009, with a few countries showing very high levels of reserves compared to peers, with a number showing smaller negative deviations. The right chart shows the information from the regressions compared to their position against the proposed metric. Notwithstanding the very different approaches employed, the information is reasonably consistent. Most countries appear as either relatively high on both measures or relatively low on both, with divergent messages in only a few cases.

Source: Staff calculations.

## IV.   RESERVES IN LICS: COMBATING CURRENT ACCOUNT SHOCKS

A.   Trends Before and During the Crisis

51.   **As with EMs, accumulation has generally outpaced traditional reserve adequacy metrics across LICs**. While the build-up has been slower than in EMs, most countries have accumulated more reserves since 2002 than suggested by standard rules of thumb, with the median coverage ratios among LICs being around 4.7 months of imports, and 55 percent of broad money in 2009 (see Figure below).[17] Recent accumulation has outpaced these measures for both fixed and floating exchange regimes, with larger increases for oil exporters, but these trends mask significant differences across individual countries. As of 2009, over a quarter of all countries had reserve levels below three months of imports, while only a handful were below the range for both rules of thumb, reflecting low levels of financial

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[17] . The short-term debt metric is not reported because of the poor quality of short-term external debt data in a large number of LICs. For LICs with reliable short-term debt data, reserve holdings were found to be significantly above the rule of thumb, reflecting their limited market access and reliance on concessional longer-term financing from official sources.

development in LICs. The accelerating build-up of reserves across LICs reflects low initial reserve holdings, increasing openness of economies, a favorable global environment, and as indicated by the survey of reserve managers, policy choice among countries to build precautionary reserves to insure against balance of payment risks.

Recent Trends in Reserve Accumulation in LIC

Reserves in Months of Imports


Reserves to Broad Money (in percent)
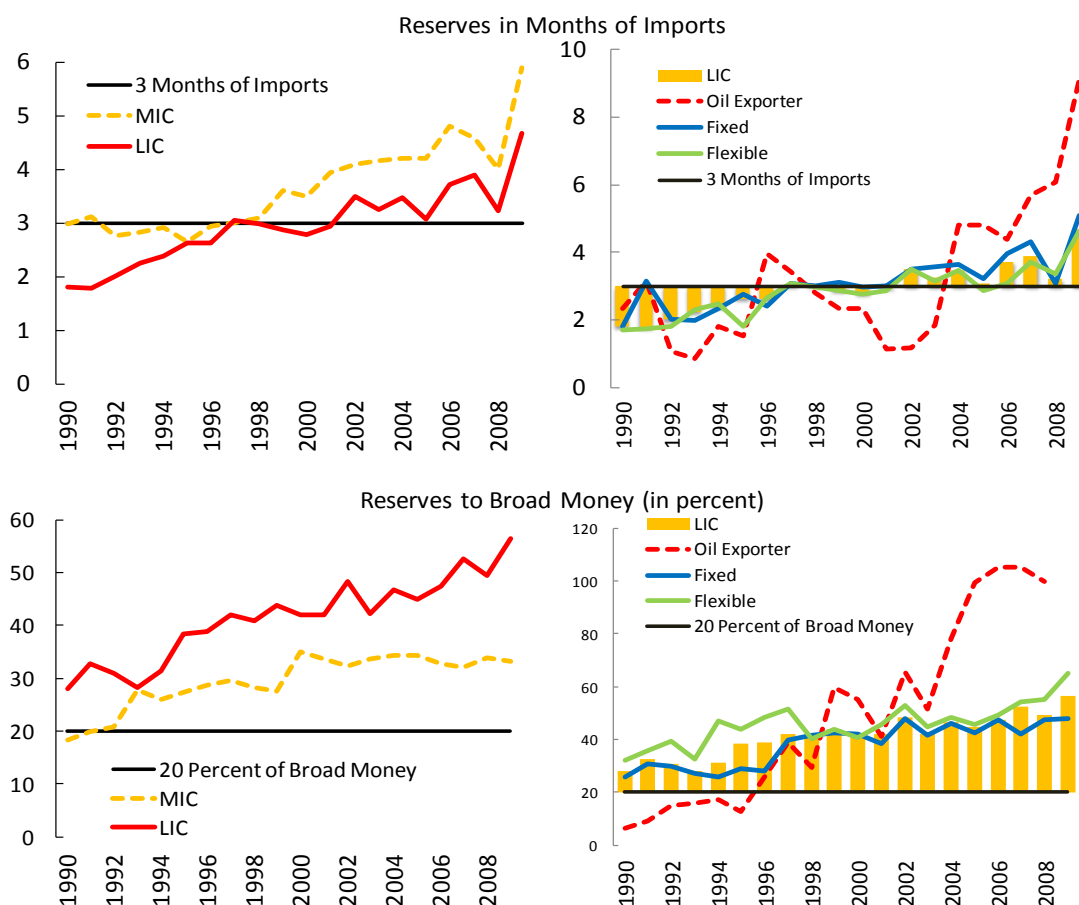
Source: WEO and staff calculations.

52.   **Evidence suggests that reserves have provided an effective cushion against external shocks.** Event study analysis of past large external shocks suggests that countries with reserves covering more than three months of imports appear to have been better able to smooth consumption and absorption relative to those with lower coverage.[18] For instance, in the event of large external demand and terms-of-trade shocks, cumulative consumption losses over a five-year period— measured as yearly loss relative to the pre-shock three-year trend growth—were quite substantial at about 6−17 percentage points for countries with reserve

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[18] This is based on an event study analysis of external shocks over 1980-2007. A shock event was identified when the annual percentage change in the shock variable (terms of trade, external demand, FDI/GDP, aid/GDP) fell below the bottom 10th percentile of the country-specific distribution.

coverage of less than three months of imports, whereas the impact was limited among those with higher coverage (Crispolti and Tsibouris, 2011). These findings are borne out for other types of shocks routinely faced by LICs. The analysis also points to the importance of country characteristics and vulnerabilities in assessing reserve adequacy: the shock-mitigation effect of reserves was found to be particularly pronounced, for instance, in highly indebted economies, small islands, commodity exporters, and countries with fixed exchange rate regimes.

Consumption Drops and Exogenous Shocks in LICs
(losses respect to pre-shock trend, median values)
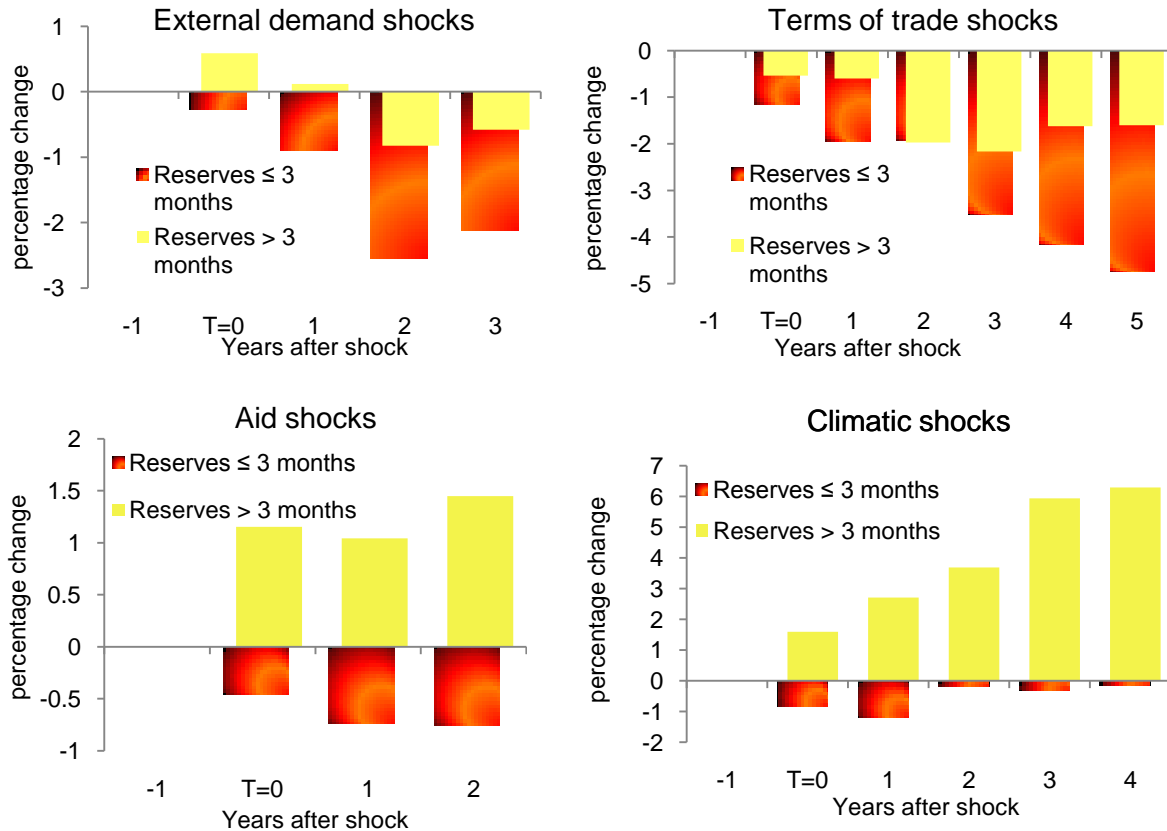
Source: WEO and staff calculations.

53.   **Reserves also proved useful in cushioning the impact of the current global financial crisis**. Among most LICs, while financial channels were largely muted given their limited market access, those that entered the crisis with higher reserve coverage were better able to buffer domestic absorption against spillovers from advanced economies—reflected in external demand shocks and drops in external financing flows. They were also more able to protect investment to help offset the effects of the crisis, whereas low levels of reserves were associated with a sharper contraction in real-per-capita investment.

Impact of Crisis: Absorption Growth
(median percent change)
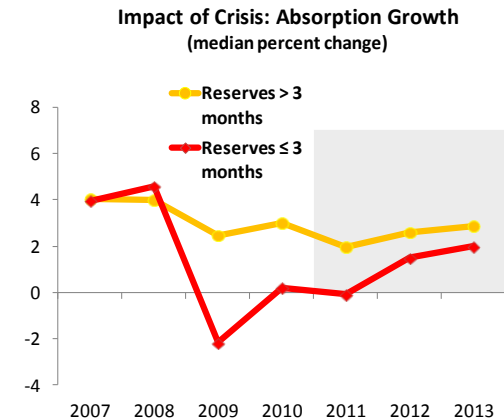
Source: WEO and staff calculations.

54.   **The recent growth of reserves in LICs is in line with precautionary motives for holding reserves.** A regression model of precautionary demand for reserves in LICs for the 1992−2001 period finds that reserve holdings are positively and significantly related to indicators of current account vulnerability (import ratio and export volatility) and indicators of capital account vulnerability, such as broad money. Volatility of the exchange rate and de facto fixed exchange rate regimes are also significantly associated with higher reserve holdings. The proxy for the cost of holdings reserves is of the expected sign but lacks statistical significance. The empirical model accounts for over 60 percent of the variation in reserves (excluding country fixed effects), suggesting that precautionary motivations are important in explaining the average reserve growth across LICs. A comparison of out-of-sample forecasts derived from the model with actual reserve buildups for the 2003−08 period (excluding the 2009 SDR allocation, which could have distorted LIC reserve holdings), indicates that the growth in LICs' reserve holdings has been broadly in line with evolving fundamentals.

LIC Estimated Reserve Demand

Dependent variable: LIC reserves/GDP, 1992-2001

VARIABLES	1992-2001 All (1)
Income	-0.0045***
Log(Population)	-2.2280***
Imports/GDP	0.2611***
Exchange rate volatility	-0.0351**
Export volatility	0.0482**
M2/GDP	0.3374***
Peg Dummy	1.2851*
Interest rate differential	-0.2178
Observations	414
R-squared	0.639

Note: Regression includes a constant term.
*, **, and *** = significance at 10, 5, and 1 percent levels.

Source: WEO and staff calculations.

LICs: Actual and Predicted Reserves, 2002-2008
(mean, in percent of GDP)
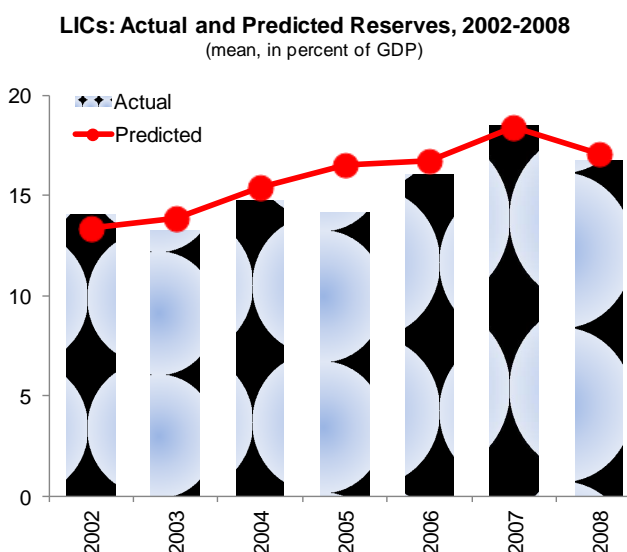
55.   **The analysis suggests that precautionary motivations for holding reserves can vary across different country groups.** Running separate regressions for commodity and noncommodity exporting LICs indicates that while export volatility is a more important determinant of reserve holdings among commodity exporters, the import ratio is particularly significant in explaining the increase in reserves for noncommodity exporters. This points to the need to tailor methodologies for assessing adequacy according to country structural characteristics and the types of risk they face.

B. A New Approach for LICs

56.   **Assessing reserve adequacy in LICs requires an understanding of the role of reserves in smoothing domestic consumption/absorption in response to external shocks.** It is well documented that weakly diversified economic structures and reliance on

international trade to import large quantities of essential goods render LICs vulnerable to significant fluctuations in consumption and absorption—imposing large welfare losses—in the event of external shocks.[19] As the event study has shown, reserves can provide an important buffer against such shocks. These observations suggest the need for a framework for assessing reserve adequacy in LICs in terms of insurance against the types of risks they face. A number of key differences between EMs and LICs are highlighted that underpin the focus of the proposed approach:

- *Limited access to international markets*: While EM crises are generally characterized by pressures on the capital account, reflecting access to market financing, most LICs still have limited market access and so the external drains are primarily on the current account. Thus, current account-based measures (such as reserve coverage in month of imports) remain a useful indicator for a vast majority of LICs.

- *Exogenous nature of shocks*: LICs are routinely faced with substantially different external shocks than EM, including sharp swings in foreign aid, remittances, and FDI, as well as natural disasters. While both sets of countries may be affected by shocks to the terms of trade, the frequency and incidence of such shocks—and consequently the welfare costs—tend to be higher in LICs. Capital account crises faced by EMEs are often endogenous to reserve holdings—i.e., low reserve holdings can play a role in precipitating crises— whereas shocks faced by LIC tend to be exogenous in nature. This suggests that a direct estimation of how much reserves might be needed to combat external shocks in LICs is much less statistically problematic.

57.   **The proposed approach aims to provide a tractable optimal reserves framework for assessing reserve adequacy in LICs.** The crisis prevention and mitigation benefits of reserves in the event of adverse external shocks—where a crisis is defined as a sharp drop in absorption—are empirically estimated using data on past severe shock episodes. Calibrated optimal reserves are then derived using the estimated regression coefficients, reference values for the opportunity cost of holding reserves, and simplified assumptions about the extent of risk aversion.

58.   **As a first step, large exogenous shocks and associated crisis events are identified from the data.** Large external *shocks events* for the period 1990−2009— comprising external demand, terms of trade, FDI, foreign aid, remittances and large natural disasters— are identified if the annual percentage change of the relevant variable falls below the 10th percentile in the left-tail of the country-specific distribution. The choice of the 10th percentile reflects the focus on reasonably severe events, while defining shocks over country-specific distributions captures cross-country heterogeneity among LICs with respect to their economic structure and vulnerability to external shocks. Within these shock episodes, a *crisis* is defined as a sharp drop in absorption when the following two conditions hold: (i) the post-shock two-year average of real absorption falls below the pre-shock three-year average; and (ii) absorption growth is negative in the shock year. The probability of a crisis within these

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[19] See Loayza, Rancière, Servén, and Ventura (2007) and Perry (2009)

episodes is around 30 percent, suggesting that not all shock events are associated with a drop in absorption.[20]

59.   The absorption smoothing benefits of reserves in the event of shocks are calculated in two steps:

- First, to capture the impact of reserves on the *likelihood* of a crisis, the probability of a drop in absorption in the event of external shocks is estimated as a function of reserves (in months of import) and other pertinent pre-shock country-specific fundamentals (see Table below).[21] The regression results point to a statistically significant crisis prevention role for reserves and sound fundamentals (such as a stronger fiscal position and better institutional quality as proxied by the World Bank's Country Policy and Institutional Assessment (CPIA)). Exchange rate flexibility and access to Fund financing following a large shock are also associated with a significantly lower crisis probability. The regressions also show that the marginal impact of reserves on crisis probabilities depends on country characteristics: increasing reserve coverage from three to four months of imports reduces the probability of a crisis by about 3.5 percentage points for fixed exchange rate regimes, while a smaller reduction is achieved under flexible regimes.

Crisis Probability and Reserves
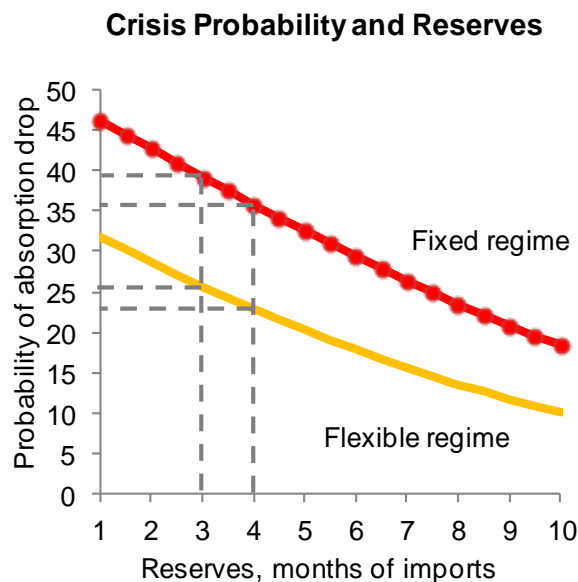
Probability of Absorption Drop
(Panel Probit regression, 1990-2007)

VARIABLES	
Reserve, months of imports (t-1)	-0.0896***
	(0.0339)
Flexible exchange rate regime (t-1)	-0.3801***
	(0.1366)
Government balance, % of GDP (t-1)	-0.0323***
	(0.0125)
CPIA (t-1)	-0.3090***
	(0.1056)
IMF program (t)	-0.3021**
	(0.1409)
Constant	0.8648**
	(0.3614)
No. of observations	445
R^2	0.11

Note: Standard errors are in parentheses. *, **, and *** indicate statistical significance at 10 percent, 5 percent, and 1 percent.

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[20] There is a marked difference in real absorption growth between the crisis and non-crisis samples (of over 8 percentage points).

[21] A large number of candidate variables were considered, including the degree of financial development, inflation, and trade openness, but were found to be statistically insignificant.

- Second, to assess the impact of reserves in mitigating the *severity* of a crisis, the magnitude of absorption drop (measured in percent of GDP) is regressed against the reserves ratio, exchange rate regime, and the size of shocks. The regressions also include fixed effects to control for cross-country heterogeneity.[22] The results suggest that international reserves do indeed reduce the size of absorption losses in the event of external shocks. The results also point to the importance of exchange rate flexibility in facilitating adjustment to real shocks. As reported in the Supplement, the regressions results are largely robust to alternative estimation approaches and country samples.

Magnitude of Absorption Drop
(Panel OLS Regression, 1990-2007)

VARIABLES	
Reserves, months of imports (t-1)	-2.2403***
	(0.6677)
Flexible exchange rate regime (t-1)	-8.6983***
	(2.1689)
External demand growth	-0.9320**
	(0.4356)
Terms of trade growth	-0.0841*
	(0.0484)
Change in FDI to GDP	-0.0159
	(0.3391)
Change in aid to GDP	0.0527
	(0.0839)
No. of observations	418
R^2	0.34
Country fixed effects	Yes

Note: Standard errors are in parentheses. *, **, and *** indicate statistical significance at 10 percent, 5 percent, and 1 percent. Reserves are measured in logs.

60.   **Decisions on how much reserves to hold against external shocks require an assessment of their benefits and costs, and the degree of country risk-aversion.** While the above regressions provide estimates of the benefits of holding reserves, as noted in Section II, the appropriate measure of the costs of holding reserves is not clear cut. For this reason, several reference values are considered for the opportunity cost of holding reserves.[23] The optimization framework underpinning the calibration assumes risk-neutrality, which is arguably simplistic, but avoids arbitrary assumptions about the degree of risk aversion that plague existing optimal reserve models.[24] This also implies that the calibrated reserves should be considered as a *lower bound* of the optimal reserves that would obtain under greater risk-aversion (see the Supplement for details on the calibration).

61.   **Calibrated optimal reserves vary depending on country characteristics and the cost of holding reserves.** Optimal reserve levels are generally higher for fixed exchange rate regimes, commodity exporters, and for fragile states, reflecting their greater vulnerability to

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[22] Lack of sufficient observations on remittances preclude inclusion in the regression. Other explanatory variables, including a dummy for access to Fund support were also considered, but were found to be statistically insignificant.

[23] These are based on existing estimates of the marginal product of capital, which is an important measure for LICs given their large investment needs, as well as the differential between domestic and foreign real interest rates. Caselli and Freyer (2007) calculate a range of 3 to 8 percent for the marginal product of capital in LICs.

[24] Assuming risk-neutral utility may appear at odds with the precautionary motive for holding reserves. But precautionary reserves holdings are not equivalent to precautionary savings which would not arise under risk-neutral utility. In the analysis, the precautionary motive for holding reserves refers to an incentive to guard against the inability to finance tail shocks due to limited and uncertain market access.

exogenous shocks.[25] While the range of computed optimal reserves encompasses the standard measure of three months of imports, the results suggest that this metric could be inadequate for countries with fixed exchange rate regimes. Sensitivity analysis using a range of plausible cost estimates corroborates this finding (see Figure). For the representative LIC in the sample, and assuming the unit cost of holding reserves is set at 4 percent, the "insurance" value of a flexible exchange rate regime—measured in terms of annual savings in the cost of holding optimal reserves—is about 0.6 percent of GDP per year (or over three months of imports on average). A similar calculation suggests that the availability of (contingent) Fund support can results in annual savings in holding optimal reserves of about 0.3 percent of GDP per year (two months of imports), and could possibly be higher.

**Illustrative Calibration of Optimal Reserves for LICs**
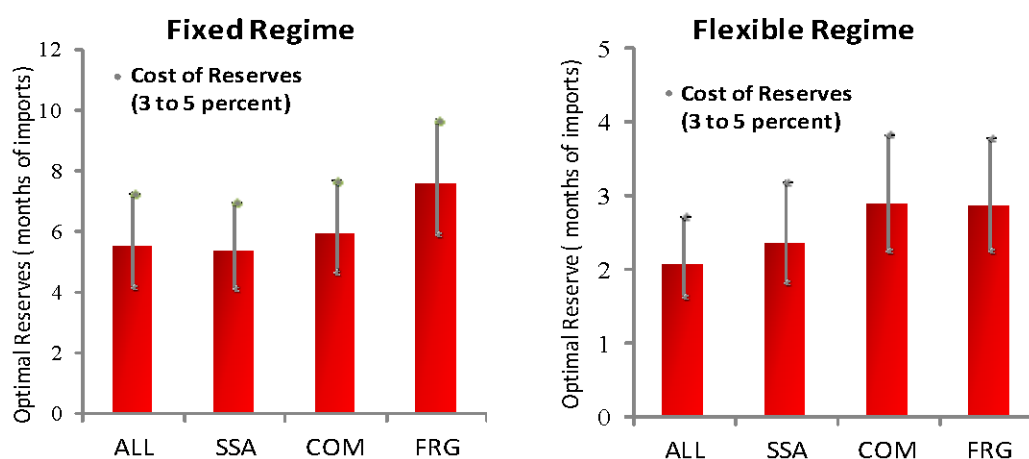
1/ The calculation assumes access to Fund-support following a shock.
2/ Country groups are as follows: SSA = Africa, COM = commodity exporters, FRG = fragile states.
Source: Staff calculations.

62. **These results also highlight the role played by the overall policy framework in the determination of optimal reserve levels.** As is evident from the chart, assuming the unit cost of holding reserves is set at 4 percent, a stronger fiscal position is associated with lower optimal reserves. The analysis further suggests that the trade-off between optimal reserves and strength of policy fundamentals differs across exchange rate regimes, with a higher sensitivity for fixed-rate regimes. These results illustrate why it would not be appropriate to apply a uniform metric for reserve adequacy—including the traditional rules of thumb—across all LICs.
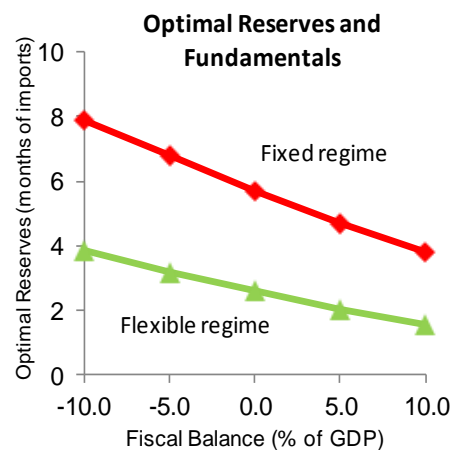
Source: Staff calculations.

[25] The categorization of fragile states relies on definitions of "fragility" adopted by the World Bank.

C. Application of the Metric to LICs

63.   **While the proposal outlined above represents an advance over existing methods for assessing reserve adequacy in LICs, its application to country specific circumstances requires judgment**. The approach provides an empirically grounded framework to determine the appropriate size of the reserve to import ratio that is needed against exogenous shocks. As with other approaches, however, it cannot fully capture the range of factors that bear on the country's resilience to shocks and the appropriate level of reserve buffers to hold. Judgment would then be required in applying the framework, particularly given the large heterogeneity within LICs.

- Capital flight risks in some LICs suggest that the proposed approach could be supplemented with the EM-type metric. This accords also with the evidence from the LIC reserve demand regressions, which show that broad money is a significant determinant of precautionary reserve holdings.

- Calibrating the model using past history of shocks runs the risk of failing to fully capture structural changes in countries and new potential risk sources. A forward-looking assessment of reserve adequacy would then be particularly important for LICs given rapid structural transformation and growing global integration through trade and financial linkages. Supplementing the proposed approach with the EM-type metric could be relevant in these circumstances as well.

- While the calibration results for fixed rate regimes can provide rough guidance, an assessment of reserve adequacy in currency unions would need to take into account the institutional features and requirements of the currency union arrangement.

64.   **An assessment of actual reserve holdings against the derived optimal reserves suggests that, on average, LIC holdings are broadly adequate.** The Figure below shows a comparison of actual reserve holdings for countries against the computed optimal reserve levels. Based on end-2008 data, LICs with fixed exchange regimes, particularly commodity exporters and fragile states, were, on average, below the computed adequacy range. Countries with flexible regimes were well above the range, although this masks significant differences across individual countries. A comparison of optimal reserves with end-2009 data shows a slightly different picture as the 2009 SDR allocation likely distorted reserve holdings for many LICs. A number of caveats should be borne in mind while drawing inferences from this comparison: countries with flexible regimes are relatively more open and integrated with international financial markets as compared to other LICs, suggesting that EM-like considerations may be playing a role (see above); other nonprecautionary motives for holding reserves, including monetary policy and exchange rate decisions by the central bank, could also be pertinent for managed float regimes.

Actual versus Computed Reserves, 2008−09
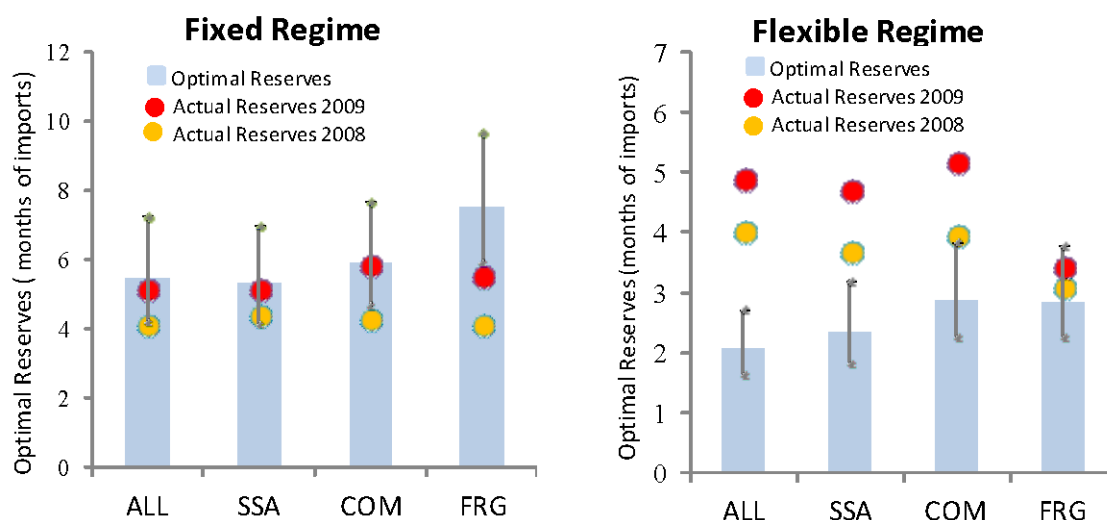
Source: Staff calculations.

Notes: The calculation assumes access to Fund-support following a shock.
Country groups are as follows: SSA = Africa, COM = commodity exporters, FRG = fragile states.
Optimal reserves is calculated assuming the cost of holding reserves is 4 percent. A range
of optimal reserves is also shown assuming the cost of reserves varies from 3 to 5 percent.

V. ADVANCED ECONOMIES: DO RESERVES MATTER?

65. **Relatively little attention has been paid to reserve adequacy in AMs until very recently**. As noted in Box 2, unlike EMs, most AMs were assumed to have little precautionary reason to hold reserves, given their strong access to markets even under adverse conditions. Sudden-stop crises were also discounted for this group of countries, as AMs were generally thought to have strong institutions and policy frameworks, deep financial markets, flexible exchange rates and ample policy space to respond to adverse shocks. Furthermore, given that many AMs were either reserve currency issuers or could borrow in their own currencies, reserve accumulation concerns were seemingly redundant. While some AMs do hold very high levels of reserves, these were usually understood to have arisen either primarily from nonprecautionary motivations, or because of other particular country circumstances.

66. **However, the recent global crisis and ensuing stress in some European countries has generated considerable interest in revisiting reserve adequacy issues in AMs**. Currency mismatch and dollar shortage severely affected many European financial institutions at the onset of the crisis, and the ability of central banks in Europe to serve as lenders of last resort was greatly constrained by their lack of dollar reserves. In many AMs, domestic banks with significant international operations relied on access to funding in euros and dollars, a need that was typically satisfied by issuing commercial paper and transacting in the FX swap market. As the crisis evolved, liquidity in these wholesale markets evaporated and funding and hedging became very expensive or dried altogether. AMs that issue debt in a currency that they cannot directly control—which include several European countries

currently under stress—can arguably face additional capital account risks akin to those faced by EMs. These developments suggest that some AMs may also need adequate reserves to protect financial stability and insure against external financing shortfalls (Box 5).

67.   **Full insurance against financial stress in AMs could imply impractically high levels of reserves.** AMs typically have very large, globally integrated financial markets, often involving gross assets and liabilities in multiples of GDP. To fully cover potential liquidity needs from, say, a sudden withdrawal of external bank wholesale funding, or to hold a large ratio of broad money, would likely imply extremely high reserves—probably so high as to make them impractical, both from the point of view of the individual country (which would have to resort to correspondingly high gross debt issuance to finance the reserves) and especially globally, if AMs were to pursue such a course en masse. And although reserves are currently much cheaper for AMs than others, this could change under such a scenario.

68.   **AMs may rely on central bank swaps instead of reserves, especially for systemic events.** If funding markets in a particular reserve currency were to dry up (as occurred in the recent crisis), it will typically be in the interest of that country's central bank to ensure global market liquidity remains. Thus foreign AMs relying on such funding can probably have confidence that swaps will be available in such systemic crises, even if they are not arranged in advance. The concern instead might be more for nonsystemic events, when the AM in question is shut out from funding markets for idiosyncratic reasons. Here there may be less expectation that central bank lines will be extended to the country. But again, holding very high reserves against such a risk is probably neither practical nor the most effective insurance: instead countries should focus on macro-prudential policies to reduce the risk of such liquidity shocks.

69.   **While some eurozone countries need larger fiscal buffers, it is far from clear that much higher reserve levels would have made a significant difference for the countries that are currently facing financing problems.** The eurozone crisis has highlighted the excessively low liquidity buffers held by some sovereigns. But holding very much larger reserves would have meant adding commensurately to their debt levels; the additional liquidity would not have helped where the need instead is to ensure that solvency is maintained, through policy adjustment and long-term financing.

Box 5. Lessons From the Crisis: Experiences of Denmark and Sweden

Denmark

The Danmarks Nationalbank (DNB) holds reserves mainly to maintain the peg of the krone to the euro, and intervenes in the foreign exchange markets fairly regularly. When the krone came under pressure during the crisis, the DNB first sold foreign exchange and later also raised interest rates to support the currency. Since Denmark has an AAA rating, in previous crises it had been possible to immediately to replenish the international reserves by issuing short-term commercial paper loans and later replacing them by longer-term loans if possible. However, during the crisis, the commercial paper market froze after the failure of Lehman Brothers. This meant that the central bank, on the behalf of the government, could not issue commercial paper on some days at the peak of the crisis. Furthermore, it took some time before the government was able to raise longer-term foreign loans at an acceptable price. Since the crisis, the DNB has more than doubled its foreign exchange reserves, mainly by buying currency on the market, but also by some government borrowing in foreign currency. Reserves now stand at around US$80 billion (about 25 percent of GDP).

Sweden

At the peak of the crisis, the Riksbank tapped the Federal Reserve and ECB currency swap arrangements, and borrowed about $15 billion externally (via the national debt office) to boost international reserves. In part, this was to increase the availability of foreign currency liquidity, given Swedish banks' substantial reliance on foreign currency wholesale funding as well as their subsidiaries' large non-krona denominated lending commitments in the Baltics. This experience has prompted the suggestion that the level of international reserves (currently about US$50 billion, around 9½ percent of GDP) needs to be reassessed. At the same time, to avoid the build-up of potential vulnerabilities, the Riksbank is also investigating use of existing or potential instruments to improve the resilience of banks, for example by changing bank reserve requirements in domestic or foreign currency. [1]

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1/ Governor Stefan Ingves, "Challenges for the Design and Conduct of Macroprudential Policy", the BOK-BIS Conference, Seoul, Korea, January 2011.

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70.   **Thus the metrics developed for EMs might—in modified form—have relevance for some AMs, but for most, reserves needs depend on detailed country-specific factors**. Lack of observations precludes empirical study of crisis factors such as that carried out for EMs and LICs. The proposed metric above—derived from a rich sample of EM crises—might have relevance for some AMs in assessing tail events against which to hold reserves, but appropriate weights would need to be carefully considered, and may well be smaller. In the end, there may be no alternative to scenario analysis based on detailed attention to country circumstances for most AMs. In general, this highlights how the increasing complexity of countries with increasing levels of development makes "one-size-fits-all" approaches more difficult to apply: simpler current-account based metrics may suffice for LICs; while for EMs metrics need to be broader based; and finally for AMs the complexities and disparities among countries may be such as to make a standardized approach very hard to identify.

VI. CONCLUSIONS AND ISSUES FOR DISCUSSION

71. **The analysis presented in the paper suggests a multi-pronged approach.** Analyses of reserve adequacy should rely on country characteristics, directly exploring pressures against which reserves are held. For most EMs, which have tended to experience drains in the capital account during periods of exchange market pressure, simple rules of thumb should be complemented by a more comprehensive analysis. To this end, the paper suggests a new metric that builds on existing approaches to encompass various possible drains on reserves, and which appears to perform well as a more broad-based measure against which to assess reserves levels. A similar tractable model that relies on country-specific shocks is developed for LICs. Estimated models of reserve demand can complement these approaches as a means of comparing countries' reserve levels against their peers from a precautionary perspective.

72. **In addition to the approaches presented in the paper, country-specific factors should be taken into account by considering additional measures or analyses.** As relevant, country authorities and teams may wish to supplement adequacy assessments with alternative metrics and scenarios reflecting the relevant risk profiles. The latter is likely to be especially relevant for countries that face different vulnerabilities than the ones on which the proposed metrics focus. Reserves considerations could also take into account availability of contingent financing from the IMF—especially lines of credit with ex ante conditionality that emphasize the role of good policy fundamentals and institutions as the first line of defense. A direct examination of the authorities' motives for reserve accumulation and their estimates of costs and other alternatives should also be considered. Scenario analysis is also particularly useful if the perceived risk environment has changed or if new vulnerabilities have emerge. Several complementary approaches may thus be necessary to guide decisions on reserve adequacy.

Issues for discussion

73. In light of the paper's findings and recommendations, Directors may wish to consider the following issues in particular:

- Is a move beyond traditional metrics warranted?

- For EMs, is the risk-weighted approach to develop a broader yardstick against which to measure reserves appropriate? Does the suggested adequacy range against this measure seem reasonable?

- Does the proposed framework for LICs adequately capture factors bearing on reserves needs?

- Should advanced countries change significantly their approach to reserves? If so, how should it be calibrated?

- Do peer comparisons (cross-country reserve demand regressions) provide another satisfactory means of assessing adequacy?

- In evaluating adequacy of reserves how should issues relating to the management of reserves, and broader sovereign balance sheet risks, be factored into the analysis?

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