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**Research on the Demand for International Reserves: Developments in Academia, the Contribution of IMF Researchers, and Influence on IMF Surveillance**

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**Abstract**

This paper reviews the academic literature on the demand for and adequacy of international reserves and assesses the contribution of research carried out by IMF staff to this literature. It also evaluates the impact of research on analytical approaches used by Fund staff to assess member countries' reserve holdings in the context of IMF surveillance activities.

The paper concludes that IMF economists were generally at the forefront of research during the 2000s, notably in empirical applications of theoretical models, in quantifying the effects of growing exposures to financial crises on reserve accumulation, and in developing new methodologies to infer optimal reserve levels.

Research influenced the policy frameworks for assessing reserves by drawing attention to sources of vulnerability resulting from sudden stops in capital flows and from currency and duration mismatches in balance sheets in the economy. A number of explicit indicators and models that were used in reserve assessments and advice to member countries had their origin in theoretical and empirical research.

Notwithstanding the success of research-based models in capturing stylized facts about the determinants of central banks' demand for reserves, an important lesson from empirical research has been that these models do not capture very well the idiosyncrasies of this demand across countries. These considerations imply that the search for a simple formula for reserves adequacy that would fit all countries is likely to be futile.

The views expressed in this Background Paper are those of the author(s) and do not necessarily represent those of the IEO, the IMF or IMF policy. Background Papers report analyses related to the work of the IEO and are published to elicit comments and to further debate.

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**ABBREVIATIONS**

FDI	foreign direct investment
FSAP	Financial Sector Assessment Program
IFS	<i>International Financial Statistics</i>
IR	international reserves
SIP	selected issues paper
SWF	sovereign wealth fund



## EXECUTIVE SUMMARY

This paper reviews the academic literature on the demand for and adequacy of international reserves and assesses the contribution of research carried out by IMF staff to this literature. The principal objective of the paper is to evaluate how IMF research during 2000–10 compares with the “state of the art” in academia during that period with respect to its theoretical underpinning, technical quality, and policy relevance. The paper also evaluates the impact of research on the analytical approaches used by staff to advise member countries in the context of IMF surveillance.

The paper concludes that IMF economists were generally at the forefront of research during the 2000s, notably in empirical applications of theoretical models, in quantifying the effects of growing exposures to financial crises on reserve accumulation, and in developing new methodologies to infer “optimal” reserve levels. We also find that there was a dynamic interaction between the researchers at the IMF and in academia. IMF research frequently identified key developments and puzzles, prompting with a short lag both “in house” and academic research. In the period since 2000, research at the IMF has contributed more than a third of the top-cited scholarly papers on international reserves.

Research influenced policy frameworks by drawing attention to sources of vulnerability resulting from sudden stops in capital flows and from exposures of balance sheets in different sectors of the economy to fluctuations in exchange rates and asset prices. This led to the elaboration of a number of explicit indicators and models that were used by IMF staff in reserve adequacy assessments and advice to member countries. While these indicators and models provided valuable frameworks for analysis, their usefulness in surveillance work was lessened by difficulties in calibrating them to account for country-specific circumstances.

Notwithstanding the success of research-based models in capturing stylized facts about the determinants of central banks’ demand for reserves, a central lesson from empirical research has been that these models do not capture very well the idiosyncrasies of this demand across countries. These considerations imply that the search for a simple formula for reserves adequacy that would fit all countries is likely to be futile. Instead, one may view the actual level of reserves as an indicator of the revealed preference of each central bank, operating subject to its constraints. The amount of reserves a country should hold is ultimately a function of the degree of risk aversion on the part of policymakers, the manner and extent to which they choose to adjust to external shocks, the availability of alternative sources of liquidity, and a number of other country-specific factors that are difficult to incorporate into indicators or models, no matter how sophisticated.





## I. INTRODUCTION

1. This paper reviews the academic literature on the demand for international reserves and assesses the contribution of research carried out by IMF staff to this literature. The principal objective of the paper is to evaluate how IMF research during 2000–10 compares with the “state of the art” in academia during that period with respect to its theoretical underpinnings, technical quality, and policy relevance. The paper also assesses how research on international reserves has influenced analytical approaches used by staff to advise member countries in the context of IMF surveillance.

2. Section II of the paper discusses the evolution of analytical and empirical approaches to modeling the demand for international reserves (IR) and assesses the contribution of IMF research to the literature by placing it in relation to the timeline of the major contributions originating in academia. It concludes that IMF researchers were generally at the forefront of research during the 2000s, notably in empirical applications of theoretical models, in quantifying the effects of growing exposures to financial crises on reserve accumulation, and in developing new methodologies to infer optimal reserve levels.<sup>1</sup> The section also points to issues that could usefully be the subject of further research.

3. Section III asks whether the Fund has incorporated these theoretical developments into its analysis of member countries’ reserves in the context of bilateral surveillance. From examining the methods that staff used to analyze the adequacy of member countries’ reserve holdings, and from reviewing the methodology used in all 2000–11 selected issues papers (SIPs) that dealt with reserve adequacy issues in the countries studied, we find that research shaped policy frameworks in particular by drawing attention to sources of vulnerability resulting from exposure of the economy to volatility of capital flows and fluctuations in exchange rates and asset prices. Specifically, a number of explicit indicators and models that were used in reserve assessments and advice to member countries had their origin in theoretical and empirical research. The section notes, however, that difficulties associated with the need to calibrate these indicators and models to country-specific circumstances imply that they need to be interpreted with care in the context of practical surveillance work.

4. The fourth and last section recalls a central message from empirical research, namely that models of the demand for reserves do not capture very well the idiosyncrasies of this demand across countries, even if they capture a number of stylized facts about its determinants. Similarly, it emphasizes that while indicators such as the simple ratio of reserves to short-term debt or recent more elaborate ones can provide useful information, they cannot substitute for more in-depth analysis based on the specific situation of the country they are applied to.

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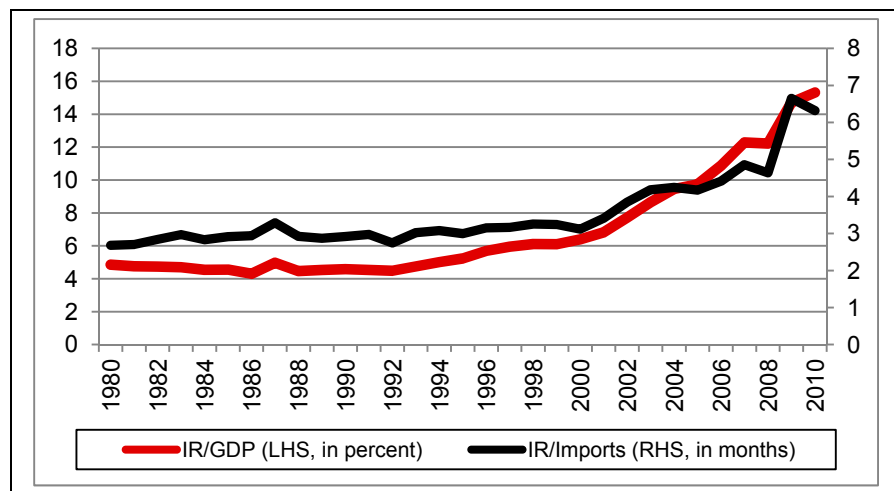
<sup>1</sup> An appendix summarizes the IMF working papers that provide the basis for this assessment.

## II. THE DEMAND FOR INTERNATIONAL RESERVES: RESEARCH IN ACADEMIA AND CONTRIBUTION OF IMF STAFF

5. The changing perspectives in the academic literature on IR adequacy reflect the evolving challenges facing emerging markets during the last two decades. A particularly pertinent development during the 1990s–2000s was the massive financial globalization which had a particularly large impact on emerging market countries. An unintended consequence of financial globalization was the growing exposure of the affected countries to financial turbulence associated with sudden stops of inflows of capital as well as with capital flight and deleveraging crises. The significant output and social costs associated with financial crises<sup>2</sup> added financial stability to the policy goals of national authorities. Accumulation of reserves was seen as a way, albeit not without costs, to build a defense against the increasing exposures to capital account shocks.

6. Thus, despite the proliferation of greater exchange rate flexibility, which was thought to reduce the need for reserves, international reserves/gross domestic product (IR/GDP) ratios increased substantially over the last two decades, and especially in the 2000s (Figure 1). At the end of 1999, global reserves were about 6 percent of global GDP, 3.5 times what they had been at the end of 1960, and 40 percent higher than in 1990. Reserve accumulation increased in the 2000s, more than doubling to about 14 percent of world GDP by the end of the decade. Measured in terms of the traditional import cover (IR/imports), global reserves, which had hovered around three months' imports during the 1980s and 1990s, increased to more than six months' imports by 2010.

Figure 1. The Evolution of Global International Reserves



Source: Own calculations based on IFS.

<sup>2</sup> Cecchetti, Kohler, and Upper (2009) estimated that the median output cost of 40 financial crises in a sample of 35 countries since 1980 was 8.6 percent if measured by the peak to trough change in GDP and 18.4 percent if measured by the cumulative loss of GDP.

7. The literature of the 2000s focused on the multidimensionality of the demand for international reserves, stemming from changing financial and commercial factors, and reflecting the growing exposure of emerging markets to financial turbulence. In the remainder of this section we review key developments in the research literature, emphasizing the evolution of analytical and empirical approaches and taking special note of the contribution of IMF researchers. Table 1 provides a selective chronological summary of influential papers, and Table 2 lists contributions by IMF staff, either individually or jointly with external researchers.<sup>3</sup>

Table 1. Selected Influential Publications Dealing with International Reserves  
(Ordered by Year of Publication)

Year	New development	Author(s)
1966	Specific cost benefit approach	Heller
1981	Explicit optimizing approach of IR as a buffer stock	Frenkel and Jovanovic
1992	Precautionary IR with costly sovereign defaults	Ben-Bassat and Gottlieb
2002	Buffer stock explains very little of IR holdings, exchange rate stability an important factor	Flood and Marion*
2003	Empirical evaluation, IR in emerging Asia seems excessive	Edison*
2003	IR accumulation as a by-product of export promotion, win-win for the U.S. and China	Dooley, Folkerts-Landau, and Garber
2003	Conditional access to global capital markets and higher crisis risk accounts for higher IR in East Asia	Aizenman and Marion
2004	IR/short-term external debt affects crises probabilities, IR levels consistent with optimal self-insurance	Garcia and Soto
2006	Explains the Guidotti-Greenspan rule, puzzled by the absence of steps to curb short-term external debt	Rodrik
2006 2007	Utility based welfare analysis with costly sudden stop indicates too much IR in East Asia	Jeanne and Rancière* Jeanne*
2007	Emerging markets financial integration and crises account for higher IR	Aizenman and Lee*
2008	Doubts the validity and the usefulness of monetary mercantilism	Aizenman and Lee*
2009	Interdependence of IR/GDP between neighboring countries	Cheung and Qian
2009	Greater importance for financial factors and lesser importance for trade factors over time	Cheung and Ito
2010	Deeper financial integration and domestic financial depth, and the fear of floating explain IR patterns	Obstfeld, Shambaugh, and Taylor

<sup>3</sup> To provide the reader an indication of the contributions of IMF researchers to the literature without having to mention it each time explicitly in the text, an asterisk attached to a reference indicates that the author or, in the case of multiple authors, at least one of the authors, was on the IMF staff at time the paper was written.

Table 2. Selected Influential IMF WPs Dealing with International Reserves  
(Ordered by Time of Issuance)

WP	Main finding	Author(s)
00/131	Stable relationship between reserves denominated in different currencies and its determinants: trade flows, financial flows, and currency pegs	Eichengreen and Mathieson
01/143	A new IR benchmark, dealing with external and internal drains, taking into account country risk and exchange rate regime	Wijnholds, de Beaufort, and Kapteyn
02/62	IR buffer stock works well statistically, but explains very little about countries' reserve holdings	Flood and Marion
WEO	Assesses the role of size, current and capital account vulnerabilities, exchange rate flexibility, and opportunity cost. IR of emerging Asia seems outlier	Edison
04/175	The insurance value of IR is quantified as an equivalent option value, calculating the cost of a regional insurance arrangement	Lee
04/189	Holding adequate reserves reduces exchange rate volatility	Hviding, Nowak, and Ricci
05/79	Mercantilist arguments accounting for China's IR are inconsistent—the IR surge since 2001 is mainly attributable to non-FDI capital inflows	Prasad and Wei
05/81	While most countries made money on their reserves during 1990–2001, most have been losing money during 2002–04	Hauner
05/198	IR during 1980s–90s are accounted by precautionary motives, a more liberal capital account regime increases international reserves	Aizenman and Lee
06/229	A tractable formula for the optimal IR; calibrations explain IR levels observed in many emerging market countries, but not emerging Asia	Jeanne and Rancière
06/280	Exporters in East Asia subsidized the cost of capital during decades of high growth, switched to hoarding large IR when growth faltered	Aizenman and Lee
07/146	Financial globalization and sudden stop risk are plausible explanations of IR surge in reserves but not of cyclical volatility	Durdu, Mendoza, and Terrones
07/293	IR diversifications in response to exchange rate changes stabilize exchange markets and the reserve currency shares	Lim
08/192	Much of the reserve increase in Asia can be explained by an optimal insurance model. Most of Asia can still benefit from higher IR	Ruiz-Arranz and Zavadjil
09/179	A roadmap to policymakers considering setting up a SWF	Das, Lu, Mulder, and Sy
09/229	For commodity- exporting countries the welfare gains of hedging commodity price risk amount to several percent of annual consumption	Borensztein, Jeanne, and Sandra
10/150	A potential conflict between IR management during the 2008–09 global crisis and the financial stability mandates of central banks	Pihlman and van der Hoorn
10/237	Pre-crisis reserve holdings helped to mitigate the initial growth collapse of emerging markets during the 2008–09 global crisis	Llaudes, Salman, and Chivakul

### **A. International Reserves as a Buffer Stock**

8. To recall, under the Bretton Woods system, adequate reserves were typically measured by months of import coverage: the prevailing rule of thumb considered three to four months of imports to be a reasonable coverage. This perspective fitted well in a world with limited financial integration, in which trade openness reflected a country's vulnerability to external shocks (Fischer, 2001\*). In the absence of reserves, balance of payment deficits would have to be corrected through a reduction in aggregate expenditures inducing recessionary pressures and imposing macroeconomic adjustment costs arising from sharp contractions of investment and consumption. As greater trade openness increased the exposure to trade shocks, reducing adjustment costs required higher reserve holdings.

9. The earlier literature focused on using international reserves as a buffer stock, as part of the management of an adjustable-peg or managed-floating exchange rate regime. Heller (1966) was the first to derive the optimal level of reserves using a cost-benefit approach.<sup>4</sup> Frenkel and Jovanovic (1981) reformulated Heller's approach in an optimal inventory management setting, where reserves serve as a buffer stock. In this framework, optimal reserves balance the macroeconomic adjustment costs incurred in the absence of reserves with the opportunity cost of holding reserves. Extensions of the buffer stock model predict that average reserves depend negatively on the opportunity cost of reserves, and exchange rate flexibility; and depend positively on GDP, adjustment costs, and reserve volatility, driven frequently by the underlying volatility of international trade.

10. Overall, the literature of the 1980s supported these predictions, but in a key contribution that had a significant influence on the direction of future research Flood and Marion (2002)\* pointed to the limited explanatory power of the buffer stock approach in accounting for the variations of reserve holdings across countries and time. The comprehensive empirical analysis in Edison (2003)\* raised further doubts about the ability of the existing frameworks to account for the rapid accumulation of reserves particularly in emerging Asia.

### **B. Self-Insurance Against Foreign and Domestic Exposures**

11. Empirical findings exemplified by the papers by Flood and Marion and Edison led to a search for new statistical and analytical frameworks that could rationalize the seemingly excessive reserve holdings. The subsequent literature focused on the observation that the deeper financial integration of developing countries had increased their exposure to volatile short-term inflows of capital (dubbed "hot money") that were subject to frequent sudden stops and reversals (Calvo, 1998; Edwards, 2004). Compared with the experiences during the

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<sup>4</sup> The benefit from holding reserves in Heller's model stems from the ability to avoid a reduction in output in case of a deficit in the balance of payments. The opportunity cost of holding reserves is the gap between the return on capital and on reserves.

1980s and 1990s, the magnitude and speed of the reversal of capital flows throughout the 1997–98 East Asian financial crisis surprised most observers (Aizenman and Marion, 2003). A common view was that East Asian countries were less vulnerable than Latin American countries to the perils associated with hot money. After all, East Asian countries were more open to international trade, had sounder fiscal policies, and showed much stronger growth performance. In retrospect, the 1997–98 crisis exposed the hidden vulnerabilities of East Asian countries, compelling market participants to update the probability of sudden stops affecting all countries.<sup>5</sup>

12. The increased risk of disruptive behavior of capital flows implied that hoarding international reserves could be viewed as a precautionary adjustment in countries with limited and conditional access to capital markets, reflecting the desire for self-insurance against exposure to future sudden stops. This argument led to the Guidotti-Greenspan rule of thumb—that countries should hold liquid reserves equal to their foreign liabilities coming due within a year.<sup>6</sup> This rule reflects the shifting focus of reserve adequacy assessments from flows of goods to flows of assets and hence to the sources of potential drains of foreign exchange reserves that are implicit in the balance sheet exposures of domestic economic agents.

13. Models of self-insurance took several forms in the literature. The first focused on international reserves as output stabilizers (Ben-Bassat and Gottlieb, 1992; Aizenman and Lee, 2007\*). Accordingly, international reserves can reduce the probability of an output drop induced by a sudden stop and/or the depth of the output collapse when the sudden stop materializes. Garcia and Soto (2004), Bank of Chile researchers, formalized these ideas in a useful framework quantifying the effect of reserves on the probability of a crisis and integrated it into a loss function analysis of the optimal precautionary levels of reserves. They concluded that the stocks of reserves for most countries in the early 2000s were consistent with an optimal self-insurance policy under reasonable assumptions regarding the cost of a crisis. Aizenman, Lee, and Rhee (2007) validated the precautionary approach for Korea, finding that the 1997–98 crisis had led to a structural change in Korea’s hoarding of international reserves, and that the Korean monetary authority had given much greater attention to a broader notion of hot money after the 1997–98 crisis, inclusive of short-term debt and foreigners’ shareholding.

14. Another version of self-insurance views the precautionary hoarding of international reserves as needed to stabilize fiscal expenditure in developing countries (see Aizenman and

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<sup>5</sup> The turmoil in financial markets following the failure of Lehman Brothers in 2008 showed that even advanced countries could be affected by the sudden-stop phenomenon.

<sup>6</sup> Rodrik (2006) explained the logic of the Guidotti-Greenspan rule, linking the desirable level of IR to the short-term foreign borrowing and the costs of sudden stops. He found it surprising that developing countries had not tried harder to reduce short-term foreign liabilities rather than building costly reserves.

Marion, 2004). Specifically, a country characterized by volatile output, inelastic demand for fiscal outlays, high tax collection costs, and sovereign risk may want to accumulate both IR and external debt, a combination that allows the country to smooth consumption when output is volatile. Their framework also suggests that greater political instability would reduce reserve accumulation, a result that is supported by the data. By implication, higher international reserves, other things being equal, may signal lower susceptibility to crisis, thereby reducing sovereign spreads.<sup>7</sup>

15. Jeanne and Rancière (2006)\* and Jeanne (2007)\* contributed a major extension of the earlier calibration-cum-regression methodology by providing a utility based estimation and calibration of the optimal levels of reserves. The framework provided strong predictions about optimal usable reserves in the context of self-insurance against sudden stops and currency crises. For the typical emerging market country, the model could plausibly explain a reserves-GDP ratio on the order of 10 percent, close to the long-run historical average, and it could justify even higher levels if one assumed that reserves have a significant role in terms of crisis prevention or if countries are very risk averse. Contrasting Latin America with Emerging Asia, however, they confirmed the earlier conjectures of Edison (2003)\* regarding the possible excess hoarding by Emerging Asia. However, Ruiz-Arranz and Zavadjil (2009)\* argued that, if account is taken of the effect of increased reserves on the interest rate on private external debt, the level of reserves, as of 2007, in Asia (excluding China) was consistent with the optimal insurance model of Jeanne and Rancière.

16. In a recent paper, Obstfeld, Shambaugh, and Taylor (2010) link trends in reserve hoarding to three key factors associated with the shifting positions in the Trilemma configuration since 1990.<sup>8</sup> The first factor is the “fear of floating,” manifested in the desire to tightly manage the exchange rate (or to keep it fixed). The desire to stabilize the exchange rate reflects a mix of goals—to boost trade, to mitigate destabilizing balance sheet shocks in the presence of dollarized liabilities, and to provide a transparent nominal anchor to stabilize inflationary expectations.<sup>9</sup> The second key factor is the adoption of active policies to develop and increase the depth of domestic financial intermediation through a larger domestic banking and financial system relative to GDP. The third factor is complementing the deepening of domestic financial intermediation with an increase in the financial integration of the developing country with international financial markets. The combination of these

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<sup>7</sup> This may reflect the deterrent effect of higher international reserves, signaling a deeper pocket of liquidity of the central bank, deterring capital flight and depreciation pressures. See Ruiz-Arranz and Zavadjil (2009)\*, Central Bank of Chile (2009) Box II.2, and De Gregorio (2011) for evidence on the role of international reserves in the determination of changes in emerging market bond indices.

<sup>8</sup> A fundamental contribution of the Mundell-Fleming framework is the economic Trilemma, stating that a country may simultaneously choose any two, but not all of the following three, policy goals: monetary independence, exchange rate stability, and financial integration.

<sup>9</sup> Calvo and Reinhart (2002).

three factors increases the exposure of the economy to financial storms, in the worst case leading to financial meltdowns, as was vividly illustrated by the Mexican 1994–95 crisis, the 1997–98 East Asian crisis, and the Argentinean 2001–02 financial collapses.

17. The recent history of emerging markets implies that the macroeconomic challenges facing them are probably more complex than navigating the Trilemma triangle. Lacking easy access to the institutional swap lines available to mature OECD countries, emerging markets self insure against financial instability associated with their growing financial integration with the global financial system. Recent studies validate the importance of financial factors as key determinants in addition to the traditional factors in accounting for increased international reserves/GDP ratios. Indeed, there is evidence that the role of financial factors has increased in tandem with growing financial integration. For example, Cheung and Ito (2009), and Obstfeld and others (2010) find that financial depth (measured by M2/GDP) is highly significant as an explanatory factor for reserve holdings, and that its importance has been growing over time.

18. These results are in line with a broader self-insurance view, where reserves provide a buffer both against deleveraging initiated by foreign parties, and against the sudden wish of domestic residents to acquire new external assets, i.e., “sudden capital flight.”<sup>10</sup> The high positive co-movement of international reserves and M2 is consistent with the view that the greatest capital flight risks are posed by the most liquid assets, i.e., by the liquid liabilities of the banking system as measured by M2. Indeed, early in the decade these considerations had led Wijnholds and Kapteyn (2001)\* to extend the Greenspan-Guidotti indicator by including also the ratio of reserves to M2 in a composite indicator of reserve adequacy.

19. While the self-insurance motive for holding reserves received substantial support in empirical studies, it remains true that it was not able to account for the rapid and sustained accumulation of reserves by a number of countries during the middle of the 2000s. For this reason, the literature explored other factors that could potentially explain the build-up of reserves. In the remainder of this section we review briefly three of these factors: mitigation of real exchange rate volatility, concerns about competitiveness, and “keeping up with the Joneses.”

### **C. Mitigation of Real Exchange Rate Volatility**

20. The mitigation of exchange rate volatility is of great importance to developing countries, because they are much more dependent on commodity trade.<sup>11</sup> Hviding, Nowak, and Ricci (2004)\* presented evidence that holding adequate reserves could lower exchange

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<sup>10</sup> Calvo (1998, 2006).

<sup>11</sup> Developing countries are three times more susceptible than OECD countries to income effects triggered by commodity terms of trade shocks. See Mendoza (1995) and Aizenman, Edwards, and Riera-Crichton (2011).



rate volatility, which in turn may allow a smoother output and potentially a higher growth rate. This finding was corroborated in Aizenman and Riera-Crichton (2008). To put this result in broader context, note that the literature of the 1990s identified large adverse effects of exogenous volatility on GDP and economic growth in developing countries. An important channel that may explain such negative levels and growth effects of volatility is capital market imperfection with low levels of financial development (Aghion and others, 2006).

#### **D. Mercantilism, Concerns About Relative Competitiveness and Relative International Reserve Positions**

21. The views linking the large increase in hoarding reserves to the growing exposure to sudden stops associated with financial integration face a well-known contender in a modern incarnation of mercantilism (Dooley, Folkerts-Landau, and Garber, 2003). According to this interpretation, reserves accumulation is a by-product of promoting exports, which are needed to create better jobs and thereby absorb abundant labor in traditional sectors.

22. Though intellectually intriguing, this interpretation remains debatable as a general proposition: the history of Japan and Korea suggests the near absence of mercantilist hoarding of international reserves during the phase of fast growth, and the prevalence of export promotion by preferential financing in targeted sectors. In both these countries, floundering economic growth led to the onset of large hoarding of reserves, probably from both mercantilist and self-insurance motives, in order to deal with growing fragility of the banking system (Aizenman and Lee, 2007)\*. This suggests that motives for reserve accumulation may change over time and may differ across countries—a hypothesis confirmed in a very recent IMF working paper (Ghosh, Ostry, and Tsangarides, 2012)\*.

23. These perspectives indicate that the substantial hoarding of reserves by some countries during the 2000s could reflect both mercantilist and self-insurance motives. Yet mercantilist hoarding by one country may induce competitive hoarding by other countries to preempt any competitive advantage gained by the first country—a reaction that would dissipate most competitiveness gains (Aizenman and Lee, 2008)\*. This view is consistent with the interdependence of the demand for international reserves among East Asian countries (Cheung and Qian, 2009). This interdependence effect could also be the result of a “keeping up with the Joneses” motive for reserve accumulation—according to which a country would add to reserves in order not to be seen to have lower reserves than a neighboring country and thereby be more susceptible to a loss of investor confidence.

#### **E. Contribution of IMF Research: An Overall Assessment**

24. From the previous narrative it should be evident that staff members of the IMF contributed a substantial share of the analysis of the demand for international reserves during the 2000s, either individually or in collaboration with external co-authors. Key papers have already been referred to and Table 2 and the Appendix contain references to additional IMF working papers that have made valuable contributions. Taken together these papers reflect

the leading role of IMF researchers in promoting influential research on international reserves. They indicate the willingness of IMF staff to challenge the pre-existing framework, and to adapt it to global developments.

25. A common approach to evaluating the quality of research relies on citation counts. While imperfect and subject to well-known biases, this approach provides a useful yardstick that relies on the revealed preferences of readers and contributors.<sup>12</sup> To gain further insight about the IMF's and academic research dealing with international reserves, we searched Google Researcher for the top-cited papers written since 2000 corresponding to "international reserves." The analysis focused on the top 100 papers dealing with developing and emerging markets, and found 18 papers with at least 50 citations during that time. The search was done on April 23, 2011. More than a third of these most cited papers were written by researchers associated with the IMF (see Table 3 for details). Practically all these papers aim at explaining recent trends, and are characterized by cross-fertilization and evolving dialogues between the IMF-affiliated researchers and academic researchers, with quite limited participation of other institutions.<sup>13</sup>

26. Taking stock of the timeline of these papers, and their citation trees, we find a dynamic interaction between the researchers at the IMF and in academia. IMF research frequently identified key developments and puzzles, prompting with a short lag further "in house" and academic research. The amalgamation of these works changed the assessment of reserves adequacy, reflecting the evolution of financial integration, exchange rate regimes, trade, and the patterns of global shocks and crises. As already noted, since 2000, IMF researchers have contributed more than one-third of the most cited papers.

27. Thematically, research at the IMF in the 2000s contributed (and frequently led) the following key developments: identifying and quantifying the diminishing explanatory power of empirical IR specifications used in the 1980s–90s; quantifying the effects of the growing exposure to financial crises on reserves accumulation by emerging market countries; and developing new methodologies using simulations-cum-regressions to infer the optimal precautionary, buffer stock reserves. These methodologies, especially the one inspired by Jeanne and Rancière (2006), rapidly became the new benchmark for supplementing the traditional rules of thumb for reserves adequacy.

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<sup>12</sup> An obvious limitation of citation counts is the truncation of the sample. Earlier papers have a longer citation horizon, giving them an automatic advantage over more recent contributions. See Aizenman and Kletzer, "The life cycle of researchers and papers in economics" (forthcoming, *Applied Economics*) for an overview and analysis of these issues.

<sup>13</sup> The fluidity of the interaction between IMF staff and academic researchers is reflected by the significant share of top papers written jointly by IMF staff members and visiting researchers. Furthermore, several of the key background contributions dealing with sudden stops and international reserves were written by academic researchers who joined the IMF, and by IMF staff who moved to academia.

Table 3. Top Google Researcher Cited Papers on “International Reserves” Since 2000<sup>1</sup>

Author/s	Title	Year <sup>2,3</sup>	Citations
Rodrik	The Social Cost of Foreign Exchange Reserves	2006	268
Dooley, Folkerts-Landau and Garber	The Revived Bretton Woods System: The Effects of Periphery Intervention and Reserve Management on Interest Rates and Exchange Rates in Center Countries	2004	220
Jeanne and Rancière*	The Optimal Level of International Reserves for Emerging Market Countries: Formulas and Applications	2006*	202
Aizenman and Marion	The High Demand For International Reserves in the Far East: What Is Going On?	2003	192
Aizenman and Lee*	International Reserves: Precautionary Versus Mercantilist Views, Theory and Evidence	2007*	173
Flood and Marion*	Holding International Reserves in an Era of High Capital Mobility	2003*	166
Aizenman and Marion	International Reserve Holdings with Sovereign Risk and Costly Tax Collection	2004	146
Garcia and Soto	Large Hoarding of International Reserves: Are They Worth It?	2004	96
Jeanne*	International Reserves in Emerging Market Countries: Too Much of a Good Thing?	2008*	94
Obstfeld, Shambaugh, and Taylor	Financial Stability, the Trilemma, and International Reserves	2008	91
Aizenman, Lee, and Rhee	International reserves management and capital mobility in a volatile world	2007	88
Aizenman and Lee*	Financial versus Monetary Mercantilism: Long-run View of Large International Reserves Hoarding	2008*	84
Bird and Rajan	Too Much of a Good Thing? The Adequacy of International Reserves in the Aftermath Of Crises	2003	70
Obstfeld, Shambaugh, and Taylor	Financial Instability, Reserves, and Central Bank Swap Lines in the Panic of 2008	2009	65
Cheung and Qian	Hoarding of International Reserves: Mrs. Machlup's Wardrobe and the Joneses	2009	65
Lee*	Insurance Value of International Reserves: An Option Pricing Approach	2004*	64
Hauner*	A Fiscal Price Tag for International Reserves	2005*	51
Aizenman	Large Hoarding of International Reserves and the Emerging Global Economic Architecture	2008	50

<sup>1</sup>Google Researcher platform was searched for “international reserves” since 2000 (the search was done on April 23, 2011). The table reports papers receiving at least 50 citations.

<sup>2</sup>Asterisks (\*) denote papers authored (or co-authored) by IMF staff.

<sup>3</sup>The year refers to the paper’s publication date. For most of these papers, the working paper version appeared well before the final publication.

## F. Open Issues Deserving Further Research

28. The global crisis of 2008–09 has exposed new imperfections of the global financial system, renewing old debates and pointing to issues that could usefully be the subject of further research. A list of such issues would include:

- (i) The tradeoffs between prudential regulations and reserve accumulation. Does the private sector view official reserve accumulation as an insurance, leading to moral hazard problems? Prudential regulations impact the entire balance sheet of a modern economy, affecting thereby the optimal level of international reserves. Arguably, the IMF sponsored research has been slower to pick up this direction, possibly because it remains a contentious issue dealing with the boundaries of economics and politics.<sup>14</sup>
- (ii) Can selective controls on capital movements substitute for accumulating reserves at times of large financial inflows to emerging markets? Are soft capital controls an effective way to deal with “yield chasing” capital inflows?
- (iii) (How) Does the use of international reserves to moderate exchange rate volatility impact the willingness of economic agents to hedge exchange risk, and thereby impact the costs and benefits from exchange rate flexibility? What role does the development of domestic financial markets play in this context?
- (iv) Local versus global optimality of hoarding international reserves. What is the appropriate balance between optimal reserve accumulation from the national perspective, versus the regional and the global perspective? (How) Can multilateral credit lines be structured so as to substitute for reserve hoarding at the national level?
- (v) What are the gains from supplementing reserve management with a sovereign wealth fund (SWF), especially for a commodity-exporting emerging market country? What is the optimal division of labor between the central bank and the SWF? What are the optimal accumulation rules?
- (vi) What accounts for the timidity in using reserves during the crisis—the fear of losing reserves or the gains from depreciations at times of collapsing demand?
- (vii) What are the optimal diversification patterns of reserves at times of a shift from a unipolar global currency system towards a multipolar system? How to ensure the stability of the adjustment process needed to accommodate deeper diversification? Is there a greater role for the SDR in accommodating this transition?

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<sup>14</sup> For an overview of some of these developments, see the *Geneva Report on the World Economy 11: The Fundamental Principles of Financial Regulation* (Brunnermeier, Crockett, Goodhart, Persaud, and Shin) and the references therein.

29. These factors suggest the need for a holistic approach, where the analysis of the demand for international reserves and reserve adequacy is put in the context of the broader set of policies that influence domestic financial stability, external vulnerability, the economy's ability to adjust to shocks, and the availability of international safety nets.

### **III. FROM THEORY TO APPLICATION IN IMF SURVEILLANCE**

30. Has research on international reserves affected IMF assessment and advice on reserves in member countries? In this section we address this question by examining the evolution of research-based analytical approaches that staff used in surveillance work and by reviewing the methodology used in all SIPs issued in 2000–11 that dealt with reserve adequacy issues in the countries studied.<sup>15,16</sup>

31. We find that research shaped policy frameworks by drawing attention to sources of vulnerability resulting from sudden stops in capital flows and from exposures of balance sheets in different sectors of the economy to fluctuations in exchange rates and asset prices. This led Fund staff to elaborate explicit indicators of reserve adequacy and models of optimal reserves that were applied in reserve adequacy assessments and advice to member countries. While the models of optimal reserves were highly innovative, we found that their practical implementation was hampered by difficulties in finding empirical counterparts to the theoretical concepts they were based on. Similarly, indicators of reserve adequacy would need to be adapted to country-specific circumstances in order to be useful, and in any event, could only serve as a first step in a more detailed analysis.

#### **A. Internalizing Lessons from the Asian Financial Crisis**

32. Financial crises in Mexico and East Asia the mid- and late 1990s marked a watershed in analysis of reserve adequacy. Until then the ratio of reserves to imports had been a widely used measure of the ability of the authorities to finance drains on reserves. The crises showed that capital outflows, or a sudden stop of capital inflows, could be a much more virulent source of foreign exchange drain. In addition, currency and maturity mismatches on official and private sector balance sheets could become sources of vulnerability. The assessment of reserve adequacy needed to change accordingly, and did.

33. The change in focus of assessments of reserves was part of a wider development to adjust the IMF's approach to surveillance and program design in emerging markets. This

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<sup>15</sup> We follow Banerji and Martinez (2012) Box 2 to identify papers that have been particularly influential in IMF surveillance: IMF (2000, 2001, 2004b), Wijnholds and Kapteyn (2001), Edison (2003), Jeanne and Rancière (2006), and IMF (2011).

<sup>16</sup> SIPs are documents attached to Article IV country reports in which staff have the opportunity to develop arguments more fully than in the country report itself. In addition to the 24 SIPs dealing with reserve adequacy, 5 SIPs covered topics related to SWFs but are not covered in this overview.

development came to be known as the balance sheet approach (see Allen and others, 2002). It was relevant not only for assessing reserve adequacy but also for strengthening the analytical tools for FSAPs and developing financial soundness indicators and early warning systems, as well as for application in research on topics such as the effects of liability dollarization on banks' balance sheets and the role of international lending in balance sheet crises (IMF, 2004a).

34. The balance sheet approach had its origin in the so-called third-generation models of currency crisis and in models that emphasized the joint occurrence of currency and banking crises. In essence, the approach focuses on shocks to stocks of assets and liabilities, rather than on flows, and seeks to identify mismatches in currency denomination, duration, and capital structure that can be the source of vulnerability when market prices change, or when sources of funding for a particular balance sheet structure cease to be available, as happens when capital inflows suddenly stop.<sup>17</sup>

35. An influential indicator of reserve adequacy based on balance sheet analysis was the Greenspan-Guidotti (GG) rule which, as already noted, implied that holding reserves equal to 100 percent of outstanding short-term debt would provide satisfactory protection against a sudden stop. Such a level provides the central bank with the needed liquidity to meet the demand for foreign currency if a sudden stop crisis prevents external refinancing of the short-term debt.

36. IMF policy papers that were issued during the period 2000–04 endorsed the use of the ratio of reserves to short-term debt as an indicator of reserve adequacy.<sup>18</sup> The justification for this approach was partly based on evidence showing that this ratio had predictive power as an early warning signal of exchange market pressure in emerging markets, and that it outperformed alternative indicators such as import cover and the ratio of reserves to broad money (Bussière and Mulder, 1999). Subsequent research generally confirmed that for emerging market economies larger international reserves reduce the probability of suffering a financial crisis.<sup>19</sup> As noted in Banerji and Martinez (2012), the ratio of reserves to short-term debt was the most frequently used single indicator of reserve adequacy in IMF Article IV country reports for emerging market economies during the 2000s.<sup>20</sup>

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<sup>17</sup> IEO (2003) had argued that “[t]he interaction of balance-sheet weaknesses and key macroeconomic variables is critical...” and had recommended that the Fund should review program design with this in mind.

<sup>18</sup> See IMF (2000, 2001, 2004b).

<sup>19</sup> See, for example, Frankel and Sarvelos (2010) and Gourinchas and Obstfeld (2011) and references therein. Rose and Spiegel (2011) offer a contrary view, however.

<sup>20</sup> An extension of the reserves to short-term debt ratio (IR/SD) was proposed by Wijnholds and Kapteyn (2001) who favored a composite indicator that combined IR/SD with the ratio of reserves to broad money, the latter being used as an indicator of possible capital flight. While not as frequently used as the simple IR/SD ratio, the composite indicator has been applied regularly in Article IV reports.

37. While the simple reserves/short-term debt indicator was viewed as a useful rule of thumb, the 2000–04 policy papers emphasized that using it would be only the first step in the analysis:

**There is some empirical support for a benchmark of one of such a ratio of reserves to short-term external debt across a range of emerging market economies. But such a benchmark only serves as a starting point for further analysis** based on a country's macroeconomic situation (including its “fundamentals” and its exchange rate regime) and on the microeconomic conditions that affect the functioning of the private sector (e.g., taxes, implicit and explicit guarantees, banking supervision, the bankruptcy regime). These microeconomic conditions can result in moral hazard, distort institutions' financing structure, and make sectors more vulnerable to external shocks. (IMF, 2000, pp. 2–3; emphasis in the original)

### **B. Attention to Reserve Build-up**

38. As reserve accumulation gathered pace in the early 2000s, the ratio of reserves to conventional measures such as imports, short-term debt, and broad money began to exceed what was considered adequate especially in emerging markets. As documented in the two previous sections of this paper, research at the Fund and elsewhere started to focus on whether the new higher levels of reserves could be explained by precautionary motives or whether foreign exchange reserves had become excessive, especially in Asia where the accumulation had been particularly rapid. The September 2003 issue of the IMF's *World Economic Outlook (WEO)* contained an essay written by Hali Edison of the Research Department entitled “Are Foreign Exchange Reserves in Asia Too High?”. The methodology employed in that paper was innovative and subsequently it was used in SIPs and surveillance contexts to assess reserve adequacy.

39. The empirical approach of the 2003 *WEO* essay was to relate the reserves of a country to a set of variables believed to determine the demand for reserves. These variables included scale variables (large countries typically hold more reserves than small countries), some measure of openness to trade or capital flows (the more open a country is the more vulnerable it is to external shocks and the more useful are reserves), and a measure of the cost of holding reserves.

40. Data constraints led to the use of gross reserves data in Edison's empirical analysis, but the essay went to some length to explain that it would have been preferable to utilize more refined concepts that net out the claims on reserves implicit in the derivative exposures of the central bank, as well as other commitments that reduce the availability of foreign exchange reserves. Central bank forward liabilities had, for instance, been a source of considerable drain on reserves during the Asian financial crisis.

41. Earlier, IMF policy papers (IMF, 2000; 2001) had also called attention to measurement. For example, it was suggested that contingent lines of credit could be added to gross reserves provided these lines were truly usable. More generally, these papers argued,

consideration should also be given to including the foreign assets held by the private sector in the definition of usable reserves. Conversely, claims on reserves resulting from derivative positions that could materialize immediately should be subtracted.

42. The IMF policy papers furthermore emphasized that the currency composition and interest rate structure of foreign debt should be monitored because exchange rate or interest rate changes could have important implications for balance sheets and therefore on reserves, and that domestic currency liabilities of the government to the domestic private sector as well as to non-residents could become a source of drain on reserves if capital controls were absent or porous enough for large scale outflows to be possible.

43. The new data template that the Fund introduced in 1999 substantially improved the ability to assess the size of usable reserves, and this should make it possible to conduct more reliable empirical analysis now than was feasible earlier. Nonetheless, most assessments of reserve adequacy by Fund staff, including those in IMF (2011), are still carried out using simple gross reserve measures.

### **C. A Formal Cost-Benefit Analysis**

44. The framework presented in IMF (2000, 2001, 2004b) did not contain an explicit cost-benefit analysis capable of indicating what the optimal level of international reserves should be for a country. Edison (2003) introduced the elements of such an analysis by means of illustrative calculations juxtaposing the sterilization costs of reserve holdings and the consumption-smoothing benefits. The paper “Country Insurance, The Role of Domestic Policies” (IMF, 2006) presented to the Executive Board in 2006 took the ideas a step further by presenting explicit formulae. The principal results pertaining to calculation of optimal reserves were based on Jeanne and Rancière (2006) which, as noted in the previous section and in Table 3, has become a leading reference on the topic of optimal reserve assessment.

45. The analytical basis of Jeanne and Rancière’s paper was a tradeoff between the consumption-smoothing benefits of reserves and their carry costs. By holding reserves, the authorities could stabilize domestic consumption in the event of a sudden stop of capital inflows. The costs were identified with the liquidity premium in the international capital market since reserves would need to be held in highly liquid assets if they were to be useful in crisis contexts.

46. The Jeanne and Rancière approach provided a relatively simple formula for the optimal level of reserves that made it easy to apply in country surveillance contexts. Its usefulness in providing advice turned out to be relatively limited, however, because the optimal reserve level indicated by the model was quite sensitive to the values of parameters, such as the degree of risk aversion and the probability of a sudden stop, that were difficult to estimate.



#### **D. Return to the Indicator Approach**

47. While IMF Management was expressing concerns about excessive reserve accumulation after the global financial crisis (as reported in Dhar, 2012), staff presented a new approach for assessing reserve adequacy to the Board in 2011 (IMF, 2011). The new approach returns to the idea of an indicator of reserve adequacy, and it represents a refinement in two dimensions of the analysis underlying the Greenspan-Guidotti metric.

48. First, it explicitly recognizes that drains of reserves can originate elsewhere than in the obligation to service short-term debt. Specifically, the new metric combines short-term debt, other (medium- and long-term debt and equity) portfolio liabilities, the stock of broad money, and exports in a composite gauge of potential foreign exchange pressure. The relative weights of each of the factors are determined by the size of the drains each one caused in past periods of stress in the market. This methodology harks back to a long-standing line of reasoning in the literature on capital flows according to which the volatility of capital flows differs depending on their type. For applications to reserve adequacy assessments see Kim and others (2005).

49. The second refinement consists of asking what proportion of the composite risk variable should be covered by international reserves. Earlier analysis had settled on 100 percent of short-term debt as the benchmark. The new metric retains the early warning properties of the indicator as one criterion for choosing the coverage ratio but adds two additional considerations: the relationship between the reserves-to-metric ratio and the fall in consumption during crisis episodes; and the correlation of the ratio with reserve losses, also during crisis episodes.

50. Although the new metric improves on the Greenspan-Guidotti rule of thumb, it suffers from the same potential drawbacks as any simple indicator. For example, while the weights attached to each component in the metric may be representative of the drain on reserves that that component has led to on average across a broad cross-section of countries, they may not fit very well with the circumstances of any particular country. In addition, the cost of holding reserves can vary substantially across countries, and the level of reserve coverage the authorities view as “comfortable” depends both on micro- and macro-economic factors such as the ability of the financial system to manage foreign exchange risk and the sensitivity of inflation, growth, and employment to exchange rate fluctuations.

51. Furthermore, the relatively sophisticated analysis that underlies the choice of weights in constructing the composite indicator may lead a casual user into the trap of misplaced concreteness. The balance sheet approach that was advocated early in the decade cannot be captured in a single indicator, so the injunction expressed then that calculating any such indicator should only be a first step in a more detailed analysis applies as strongly to the new metric as it did to the simpler reserves-to-short-term debt ratio.

### **E. Analysis of Reserve Adequacy in Selected Issues Papers**

52. In order to evaluate the impact of the evolving research on the practice of measuring IR adequacy in the context of Article IV consultations, we examined all 23 selected issues papers (SIPs) that dealt with international reserve adequacy in the countries and for the time period covered by the evaluation (2000–11). Table 4 provides a snapshot of the analysis in these SIPs. A large majority of the papers discussed reserves against the background of an analysis of the vulnerability of the economy to shocks. Most of the discussions were thoughtful, identifying the sources of vulnerability and the role of reserves as a buffer. In three cases the focus was on reserves in relation to other policy concerns, specifically monetary policy management and dealing with capital flows.

53. In most cases the analysis was based on conventional indicators—notably the ratio of reserves to short-term debt and import cover. Another indicator that had been identified in the literature on balance sheet risk—the ratio of reserves to the money supply—was also used in a large number of cases either individually or in combination with other variables. The adequacy of reserves was assessed both in relation to the customary cut-off values for each indicator and in relation to peers. Cross-country comparisons were carried out in many of the papers, and in a large majority of them the comparator countries were chosen based on economic similarities and geographical proximity.

54. The SIPs were also influenced by new ideas and approaches. Regression-based cross-country comparisons of reserve demand were used in two instances shortly after being introduced in the literature, and the explicit calculation of optimal reserves using the Jeanne-Rancière or a similar framework was carried out in two papers. In one case, original research was presented that was subsequently developed into an IMF working paper.

55. Overall the SIPs reviewed indicate that the authors were well acquainted with the relevant literature, although in some instances the analysis could have been better situated relative to this literature. A notable shortcoming was the dearth of references to work done by academics or officials in the country about which the SIP was written.

Table 4. Summary of the Analysis of Reserves in SIPs

Country	Year	Pages	Focus			Methodology								
						Model based			Indicators					Comparisons
			Vulnerabilities and reserve adequacy	Relationship with other economic policies	Other	Regression	Optimal reserves model	Others	Imports	Short-term debt	Money	GDP	Composite <sup>1</sup>	
Indonesia	2000	17	1						1	1	1			1
Romania	2000	24	1						1	1	1	1	1	1
Korea	2001	16			Money demand			Money demand	1					
South Africa	2001	20	1						1	1			1	1
Malaysia	2002	26	1					1	1	1	1			1
Philippines	2002	14			Reserve management					1				1
Mexico	2003	15	1						1	1	1		WK	1
Chile	2004	12	1			1			1	1	1			1
China	2004	10		Monetary management									1	
South Africa	2004	11	1							1				
South Africa	2006	14	1			1		1	1	1		1		1
Botswana	2007	22	1						1			1		
Brazil	2007	18	1				1		1	1	1			1
Indonesia	2007	18	1							1		1	1	1
South Africa	2007	21	1							1			SD, CA	1
Chile	2008	3			Optimal reserves		1					1		1
Indonesia	2008	22	1				1	1	1	1	1	1		1
Philippines	2008	18			Response to crisis				1	1	1			1
Peru	2009	10			Motives for interventions									
South Africa	2009	19	1		Response to GFC								SD, CA	1
Israel	2010	6	1		Dealing with global risk				1					
Poland	2010	19	1	Dealing with capital flows with IT							1		SD, CA	1
Algeria	2011	25	1						1	1	1		WK	1

<sup>1</sup>WK refers to Wijnhold and Kapteyn (2001), SD=Short-term Debt, CA=Current Account Balance.

#### IV. TAKING STOCK

56. The contribution of IMF research to the analysis of the demand for reserves and reserve adequacy has been substantial, and many lessons from this research have been incorporated in the policy frameworks used in the context of bilateral surveillance. Nonetheless a central message from empirical research has been that models of the demand for reserves do not capture very well the idiosyncrasies of this demand across countries, even if they capture a number of stylized facts about its determinants. Similarly, indicators such as the simple ratio of reserves to short-term debt or the composite indicator proposed in IMF (2011) can provide useful information but cannot be used as a substitute for more in-depth analysis based on the specific situation of the country they are applied to. The inherent challenges facing the quest for the optimal reserve adequacy formula suggest that applications of the frameworks in the field must take into account the multiple services provided by international reserves and that these can vary across countries:

- (i) Self-insurance against external instability suggests that the proper metrics for reserves adequacy include the country's short-term external debt, to deal with a short liquidity crisis; total external debt, to deal with prolonged liquidity crises inducing deleveraging of most external debt; and total external liabilities, to deal with prolonged liquidity crises in a country that wishes to minimize the exposure to balance sheet effects. However, accumulating international reserves to cover all the external liabilities is ill advised, because it may reduce the gains from financial openness. It would imply that the country accumulates low-yielding reserves against costly external liabilities, when paying most of the external liabilities with the accumulated reserves would be a better alternative. Instead, the central bank may wish to accumulate reserves in ways that reflect maturity exposure and structural exposures, with higher weights on shorter maturities, higher weight on debt versus equity, and lower weight on foreign direct investment, as suggested by the most recent indicator suggested in IMF (2011).
- (ii) For self-insurance against internal instability, a country may hoard reserves against domestic capital flight, to deal with exposure to a confidence crisis that induces agents to swap domestic assets for "safe haven" foreign reserves. This motive suggests that reserves may be scaled by M2, and by the exposure of the banking system to non-performing loans. But if internal instability leads to doubts about the safety of government debt, the entire outstanding stock of government securities could become a source of internal drain. Hoarding reserves to back up the liabilities of the government would not be feasible. Other remedies for the lack of trust in government debt would have to be sought.
- (iii) The weights attached to these considerations probably reflect structural factors, such as the risk aversion of the country/policymaker, the national saving rate (chances are that East Asian countries with high saving rates would opt to hoard more reserves

than countries in Latin America with lower saving rates), the income volatility induced by terms of trade shocks, the depth and quality of prudential supervision, and exposure to political instability.

57. These considerations imply that the search for a simple formula for reserves adequacy that would fit all countries is likely to be futile. Instead, one may view the actual level of reserves as an indicator of the revealed preference of each central bank, operating subject to its constraints.

## **Appendix. Abstracts of Selected IMF Working Papers Dealing with International Reserves, 2000–10**

**Eichengreen and Mathieson’s WP 00/131, “The Currency Composition of Foreign Exchange Reserves: Retrospect and Prospect”** finds that the relationship between the demand for reserves denominated in different currencies and trade flows, financial flows and currency pegs has been strikingly stable over time. The message: the international monetary system is in a mode of gradual continuous evolution, not of rapid discontinuous change.

**Wijnholds, Beaufort, and Kapteyn’s WP 01/143, “Reserve Adequacy in Emerging Market Economies”** recognizes the growing importance of capital flows. It proposes a new benchmark of reserves adequacy, consisting of the sum of short-term debt on a residual maturity basis (the external drain) and an allowance for possible capital flight (the internal drain), taking into account differences in country risk and exchange rate regime.

**Flood and Marion’s WP 02/62, “Holding International Reserves in an Era of High Capital Mobility”** provides a comprehensive analysis of the degree to which the buffer stock model, used during the Bretton Woods system to account international reserves, applies in the post Bretton Woods regime. The results are mixed: the buffer stock model of international reserve holding works about as well in the era of high capital mobility as it did when capital was less mobile. The model’s prediction that increased volatility significantly increases reserve holdings is very robust. But while the model works well statistically, it explains very little about countries’ reserve holdings. Most of the “explanation” in the regressions is due to country-specific fixed effects. Effective exchange-rate stability and a country’s financial and real-side openness, together with volatility and opportunity-cost elements, can explain about 40 percent of the variation in countries’ reserve holdings.

**Lee’s WP/04/175, “Insurance Value of International Reserves: An Option Pricing Approach”** develops a quantitative framework modeling the insurance motive for holding international reserves. The insurance value of reserves is quantified as the market price of an equivalent option that provides the same insurance coverage as the reserves. This quantitative framework is applied to calculating the cost of a regional insurance arrangement (e.g., an Asian Monetary Fund) and to analyzing one leg of an optimal reserve-holding decision.

**Hviding, Nowak, and Ricci’s WP/04/189, “Can Higher Reserves Help Reduce Exchange Rate Volatility?”** uses data from a panel of 28 countries over the period 1986–2002 to study the role of an increase in foreign exchange reserves in reducing currency volatility for emerging market countries. The results provide ample support for the proposition that holding adequate reserves reduces exchange rate volatility. The effect is strong and robust; moreover, it is nonlinear and appears to operate through a signaling effect.

**Prasad and Wei’s WP/05/79, “The Chinese Approach to Capital Inflows: Patterns and Possible Explanations”** uses a cross-country perspective to examine the evolution of capital flows into China, in terms of both volumes and composition. China’s inflows have generally

been dominated by foreign direct investment (FDI), a pattern that appears to be favorable in light of the recent literature on the experiences of developing countries with financial globalization. The authors argue that some popular mercantilist-type arguments are inconsistent with the facts. Contrary to some popular perceptions, the dramatic surge in foreign exchange reserves since 2001 is mainly attributable to non-FDI capital inflows, rather than to current account surpluses or FDI.

**Hauner’s WP/05/81, “A Fiscal Price Tag for International Reserves”** examines the quasi-fiscal impact of the opportunity cost of international reserves. It outlines a conceptual framework with particular emphasis on two key aspects: a more appropriate measure of gross opportunity cost, and potential savings from lower external debt spreads that countries “buy” by holding reserves. The framework is then applied to 100 countries over 1990–2004. The results suggest that a turning point was reached in the early 2000s: while most countries made money on their reserves during 1990–2001, most were losing money during 2002–04.

**Aizenman and Lee’s IMF WP 05/198, “International Reserves: Precautionary vs. Mercantilist Views, Theory and Evidence”** compares the importance of precautionary and mercantilist motives in the hoarding of international reserves by developing countries during the 1980s and 1990s. Overall, the empirical results support precautionary motives, showing in particular that a more liberal capital account regime is associated with larger international reserves. Theoretically, large precautionary demand for international reserves arises as self-insurance to avoid costly liquidation of long-term projects when the economy is susceptible to sudden stops. The welfare gain from the optimal management of international reserves is of a first-order magnitude, reducing the welfare cost of liquidity shocks from a first-order to a second-order magnitude.

**Jeanne and Rancière’s IMF WP 06/229, “The Optimal Level of International Reserves for Emerging Market Countries: Formulas and Applications”** presents a model of the optimal level of international reserves for a small open economy that is vulnerable to sudden stops in capital flows. Reserves allow the country to smooth domestic absorption in response to sudden stops, but yield a lower return than the interest rate on the country’s long-term debt. The authors derive a tractable formula for the optimal level of reserves, and show that plausible calibrations can explain reserves of the order of magnitude observed in many emerging market countries. However, the recent build-up of reserves in Asia seems greater than what would be implied by an insurance motive against sudden stops.

**Aizenman and Lee’s IMF WP 06/280, “Financial Versus Monetary Mercantilism: Long-Run View of Large International Reserves Hoarding”** points out that hoarding of international reserves by several East Asian countries has frequently been attributed to a modern version of monetary mercantilism: hoarding international reserves in order to improve competitiveness. From a long-run perspective, leading manufacturing exporters in East Asia (including Japan and Korea) adopted financial mercantilism—subsidizing the cost of capital—during decades of high growth. They switched to hoarding large international

reserves when growth faltered, making it harder to disentangle the monetary mercantilism from a precautionary response to the heritage of past financial mercantilism. Monetary mercantilism also lowers the cost of hoarding through its short-term boost to external competitiveness, but may be associated with negative externalities leading to competitive hoarding.

**Durdu, Mendoza, and Terrones's WP/07/146, "Precautionary Demand for Foreign Assets in Sudden Stop Economies: An Assessment of the New Mercantilism"** examines the view explaining the surge in foreign reserves as a new mercantilism in which reserves are a war-chest for defense against sudden stops. The authors conduct a quantitative assessment of this argument using a framework in which precautionary savings affect foreign assets via business cycle volatility, financial globalization, and endogenous sudden stops. Their results show that financial globalization and sudden-stop risk are plausible explanations of the surge in reserves but that cyclical volatility, which declined in the globalization period, is not.

**Lim's WP/07/293, "Do Reserve Portfolios Respond to Exchange Rate Changes Using a Portfolio Rebalancing Strategy? An Econometric Study Using COFER Data"** finds empirical support for a portfolio-rebalancing strategy: dollar depreciation/appreciation results in rebalancing switches vis-a-vis the other major reserve currency, the euro; valuation changes in the minor currencies tend to result in switches among themselves. Thus, currency diversifications in response to exchange rate changes appear to be stabilizing for exchange markets, and also stabilize the reserve currency shares.

**Ruiz-Arranz and Zavadjil's WP/08/192, "Are Emerging Asia's Reserves Really Too High?"** finds that reserves are not "too high" in the majority of Asian countries, though China may be a special case. Much of the reserve increase in Asia can be explained by an optimal insurance model under which reserves provide a steady source of liquidity to cushion the impact of a sudden stop in capital inflows on output and consumption. Moreover, the benefits of reserves in terms of reduced spreads on privately held external debt further explain the observed growth in reserves since 1997–98. Using threshold estimation techniques, the paper shows that most of Asia can still benefit from higher reserves because these reduce borrowing costs.

**Das, Lu, Mulder, and Sy's IMF WP/ 09/179, "Setting up a Sovereign Wealth Fund: Some Policy and Operational Considerations"** provides a roadmap to policymakers considering setting up a SWF, and reviews SWFs' existing policies and operations. It points out that policymakers should optimally consider both their sovereign assets and liabilities, together with their macroeconomic objectives, when setting up a SWF.

**Borensztein, Jeanne, and Sandri's IMF WP/09/229, "Macro-Hedging for Commodity Exporters"** applies a dynamic optimization model to estimate the welfare gains of hedging against commodity price risk for commodity exporting countries. The introduction of hedging instruments such as futures and options enhances domestic welfare through two



channels. First, by reducing export income volatility and allowing for a smoother consumption path. Second, by reducing the country's need to hold foreign assets as precautionary savings (or by improving the country's ability to borrow against future export income). Under plausibly calibrated parameters, the second channel may lead to much larger welfare gains, equivalent to several percentage points of annual consumption.

**Pihlman and van der Hoorn's WP/10/150 "Pro-cyclicality in Central Bank Reserve Management: Evidence from the Crisis"** analyzes reserve managers' actions during the crisis and draws some lessons for strategic asset allocation of reserves. A decade-long diversification of official reserves into riskier investments came to an abrupt end at the beginning of the global financial crisis, when many central bank reserve managers started to withdraw their deposits from the banking sector in an apparent flight to quality and safety. The paper estimates that reserve managers pulled around US\$500 billion of deposits and other investments from the banking sector. Although clearly not the main cause, this pro-cyclical investment behavior is likely to have contributed to the funding problems of the banking sector, which required offsetting measures by other central banks including the US Federal Reserve and Euro-system central banks. The behavior highlights a potential conflict between the reserve management and financial stability mandates of central banks.

**Llaudes, Salman, and Chivakul's WP/10/237, "The Impact of the Great Recession on Emerging Markets"** shows that the impact of the crisis was more pronounced in those emerging markets that initially had weaker fundamentals and greater financial and trade linkages. During the crisis, pre-crisis reserve holdings helped to mitigate the initial growth collapse. This finding contrasts with those of studies that find no significant relationship between reserves and the growth decline.

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