INTERNATIONAL MONETARY FUND

Assessing Reserve Adequacy—Supplementary Information

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I. CONSTRUCTION OF A NEW METRIC FOR EMS[1]

A. Construction of the Metric

1. **The metric proposed in the main paper is based on outflows**—principally in relation the relevant stock of underlying foreign liabilities or domestic assets—during periods of exchange market pressure (EMP). Especially as it remains the primary reason countries accumulate reserves for insurance purposes, the metric is based on balance of payments drains experienced during EMP episodes—i.e., a measure of sufficient reserves periods of pressure and ahead of a full-blown crisis. Specifically, we consider potential foreign exchange pressures resulting from shocks to the following parts of the balance of payments:

- Earning from the **export of goods and services**. Although not a stock, the sudden loss of export earnings—resulting from a fall in foreign demand or falling prices—can put pressure on particular countries, as evidenced by the case of Brazil during its 1998 crisis (as described in the main document). We use the nominal U.S. dollar value of goods and service exports from the WEO database.

- The ability of foreigners to liquidate their positions during periods of market stress makes **external liabilities** a common source of loss. We treat the change in *short-term debt* (at remaining maturity) and *other (debt and equity) liabilities* separately, reflecting the likely differential behavior of each during periods of EMP. Short-term debt at remaining maturity is defined as outstanding short-term debt plus amortization due in the following year, and comes from the WEO database. Other liabilities are defined as the difference between sum of total portfolio investment and other investment liabilities less the measure of short-term debt described above. The flow (stock) measures of non-short-term debt liabilities are based on BOP (IIP) data available from the IMF's IFS database.

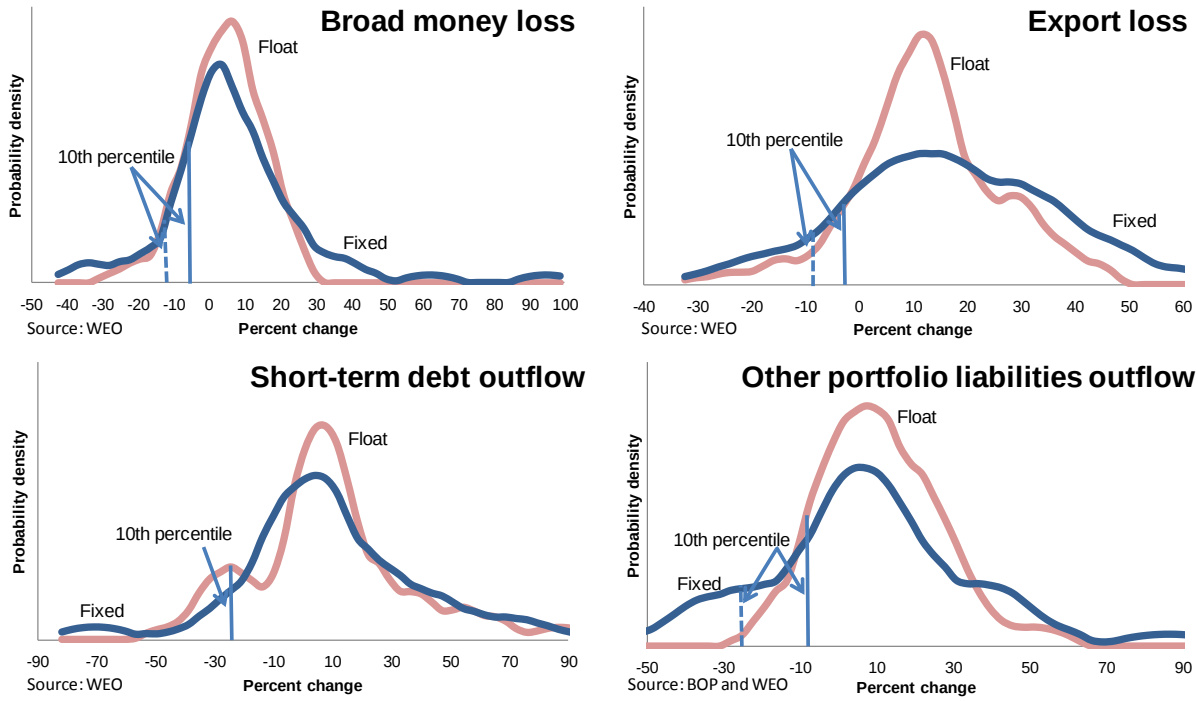
- **Domestic Assets.** To capture the impact of capital flight, we consider broad money as a measure of liquid domestic assets that could leave (and be exchanged for foreign exchange) due to capital flight ahead of, or during, a crisis. Although the possible inclusion of nonresident deposits suggests some potential double counting, the extent of seems very limited in our sample. Despite the very limited data available on the extent of nonresident deposit, based on that collected for Vulnerability Exercise, the share of broad money accounted for by nonresident deposits is small for all but very few countries. We used the measure of broad money in the WEO database.

2. **The metric is constructed as the simple sum of the potential drains**—based on past exchange market pressure episodes—and each countries vulnerability based on their current export earnings, stocks of external liabilities, and broad money. Experiences of

[1] Section prepared by Nathan Porter (SPR).

countries with fixed and flexible exchange rate regimes are assessed separately in terms of their past EMP episodes.[2]

3. **To calculate the drain based on past EMP events, we pool all events where, following Eichengreen and others (1997), the value of an exchange market pressure (EMP) index for a country exceeds its mean by more than 1.5 times its standard deviation**. Also following Eichengreen and others (1997), the EMP index used is based on upward movements in interest rates, exchange rate depreciation, or reserves loss, each weighted by its country specific standard deviation. Based on these events, the drains are calculated as the percentage loss during the event year. For instance, in the case of export earnings, this would be the percent change in exports relative to the average level of earnings in the three years before the event. Similarly, for the liability stocks, the drain is measured as the relevant liability outflow, using balance of payments data, in percent of the average stock of liabilities in the three years before the event year. With BoP data excluding valuation effects, the measure drain should reflect the actual pressure on the currency or central bank reserves. The drain from domestic capital flight is similarly defined as the percentage change of broad money during event year relative to the average three years ahead (correcting for the valuation impact of exchange rate). From the resulting distributions—conditional on the exchange rate regime—of these drains during EMP events, we take the 10th percentile drain—percentage loss of liability stock, exports, or broad money—as the basis for our metric measure. The metric is then constructed by multiplying the 10th percentile loss by the *previous year's* export earnings, liabilities stocks, or stock of broad money.



[2] The exchange rate regime classification is based on the Fund's AREAER, with the top two categories described as "flexible."

4. **The choice to sum the components can be argued to be both conservative and pragmatic**. The conservatism reflects the fact that possible correlations between BoP drains are likely to be at least to some extent offsetting. This development of a metric for EMs does not explicitly account for these correlations because correlations can change abruptly, particularly during times of crisis. As a robustness check, a metric based on the maximum of the 10^{th} percent drain (as described above) and the largest of the individual components based on the 5^{th} percentile drain were also computed, but were found to be dominated by the 10^{th} percentile combination metric. Nonetheless, the conservative nature of this metric seems appropriate given the ultimate focus on the question of adequacy.

B. Reserves Coverage and the Likelihood of EMP Events

5. **The proposed metric seems predict EMP and other crisis events better than traditional metrics**. To compare the relative performance of various metrics in accounting for vulnerability to EMP events, a series of logit regressions relating the probability of such an event with each of the metrics were estimated (Table 1). Given that the general policy environment is likely at least as important as reserves in explaining these events, the regressions also accounted for the cyclically adjusted primary balance as an additional explanatory variable. The proposed metric outperforms all the traditional metrics, including that proposed by Wijnholds and Kapteyn (2001), with higher reserves coverage against this metric significantly reducing the probability of EMP event. The only other metric that is significant with the correct sign is broad money, and then it is less significant than the metric proposed in the paper and insignificant when included alone. As a robustness test, a logit regression was also run against a sample of 11 extreme crisis-related events studied in SM/09/246: low reserves coverage against the metric also significantly explains these events.

Table 1. Comparison of Various Reserve Adequacy Metrics: Logit Regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Independent variable	EMP events										Crisis Events	
Reserves/Metric	-1.431 ***	-1.447 ***	-1.453 ***	-1.779 ***	-2.058 ***	-0.784 **					-1.221 ***	-1.504 ***
	(0.43)	(0.50)	(0.44)	(0.50)	(0.51)	(0.38)					(0.24)	(0.45)
Cyc. Adj. Primary Balance/GDP	-0.108	-0.108	-0.111	-0.103	-0.08							-0.082
	(0.08)	(0.08)	(0.09)	(0.08)	(0.08)							(0.09)
Reserves/STD(RM)		0.000137					-0.00265					
		(0.00219)					(0.00252)					
Reserves/Broad Money			-0.00029 **					-0.01				
			(0.00012)					(0.01)				
Resrves in months of imports				0.14					0.029			
				(0.09)					(0.09)			
Reserves/Wijnholds-Kapteyn Metric					75.7 *					-2.985		
					(40.95)					(20.19)		
Constant	-1.448 ***	-1.449 ***	-1.457 ***	-1.754 ***	-1.57 ***	-2.025 ***	-2.516 ***	-2.554 ***	-2.931 ***	-2.748 ***	-3.366 ***	-3.305 ***
	(0.42)	(0.42)	(0.44)	(0.45)	(0.45)	(0.40)	(0.31)	(0.32)	(0.46)	(0.28)	(0.50)	(0.69)
Number of observations	337	337	325	337	335	452	452	440	452	444	452	337

Source: Staff estimates.

Notes: All independent variables are calculated using the previous year's data. "Crisis events" are the 11 extreme events studied in SM/09/246. Standard errors are reported in paretheses under coefficient estimates; with ***, **, and *, respectively denoting significance at 1, 5, and 10 percent levels.

II. AN ALTERNATIVE APPROACH TO RESERVE METRIC WEIGHTS[3]

6. **An alternative to the computation of drains as described in Section I would be to estimate the size of *potential* net outflows from non-FDI liabilities during a crisis as a parametric function of the pre-crisis levels of liabilities**. The estimated equation is a flow-stock equation that relates net liability flows to the (lagged) stock of liabilities. The equation can then produce an empirical model of *net* capital flows—i.e., a weighting formula to be applied to liabilities. An estimate of potential net outflow, thus the need for reserves, would then be obtained by using the weighting formula.

7. **Estimation is undertaken for a sample of 48 countries covered in the IMF's Vulnerability Exercise for emerging-market economies** (VEE) over the period of 1990−2009, allowing for different coefficients between crisis and non-crisis periods. Crisis is identified as an event where net capital flow is below the 10th percentile net outflow observed in the sample.[4] Given the focus on potential *outflows*, the sample is restricted to observations with negative net liability flows (i.e., net liability outflows). The estimation results suggest that liability outflows are typically debt flows, and that short-term debt is particularly vulnerable to market pressure (Table 2, column 1). However, equity flows also turn out to be an important component of net outflows among countries with fixed exchange rate regimes, although their behavior during a crisis is quite the opposite of what is observed during non-crisis periods (column 3).

8. **A metric could then be constructed by applying these weights to their associated liability stocks**. However, given large unexplained variation in capital flow regressions using the average predicted values as a reserve metric would be considered not conservative enough for insurance purposes. A more conservative metric could be developed by augmenting the average predicted values with a measure of unexplained uncertainty in capital flows such as the root mean squared error (RMSE) of capital flow regressions.

[3] Section prepared by Jun Il Kim (RES).

[4] Other crisis indicators are also explored including those identified in the VEE or based on the exchange market pressure, but tend to yield often insensible results for the crisis period perhaps for reasons relates to the use of annual data. Specifically, net capital flows in annual frequency are only weakly correlated with those crisis indicators which are constructed based on the data in quarterly or higher frequency.

Table 2. Non-FDI Capital Flows and Liabilities: Estimation Results

Independent variable : Net Liability Flow (NLF)			
	All	Float	Fixed
Lagged STD	-0.05 **	-0.04	-0.08 **
	(0.03)	(0.05)	(0.03)
Lagged LTD	-0.04 ***	-0.05 ***	0.00
	(0.01)	(0.01)	(0.02)
Lagged Equity	-0.03	0.00	-0.09 *
	(0.03)	(0.05)	(0.05)
Lagged STD * Crisis	-0.11 ***	-0.15 ***	-0.01
	(0.03)	(0.05)	(0.05)
Lagged LTD * Crisis	0.01	0.01	-0.06 *
	(0.02)	(0.03)	(0.03)
Lagged Equity * Crisis	-0.04	-0.08	0.3 *
	(0.09)	(0.11)	(0.17)
Constant	-0.42	-0.57	-0.47
	(0.49)	(0.71)	(0.74)
RMSE	2.27	2.11	2.22
R-squared	0.38	0.54	0.37
Observations	109	62	47

Source: Staff estimates.

Notes: The regression sample is restricted to the observations with negative net liability flows. All variables are in percent of GDP, except for the crisis dummy. STD and LTD refer to short-term debt (at remaining maturity) and other debt liability (= portfolio debt liability + other investment liability - STD), respectively. The Crisis dummy takes 1 if net capital flow is below the 10th percentile of the sample distribution (and 0 otherwise). Standard errors are reported below the coefficient estimates in parentheses; ***, **, and * denote significance at 1, 5, and 10 percent levels.

III. A Model-based Approach to Reserve Adequacy[5]

9. **The cost-benefit analysis presented in the main paper builds on the model of Jeanne and Rancière (2007)**. The model considers both benefits—of by reducing the probability of crisis and the resulting output loss—and costs of reserves, in the context of a welfare-maximization framework for a small open economy that is vulnerable to sudden stops in capital flows, with risk-adverse policy makers choosing a level of reserves to maximize the utility of consumers. The model assumes that, in the event of a sudden stop, external debt cannot be rolled over and output falls below its long-run growth path. In such circumstances, availability of reserves mitigate the fall in output and smooth consumption. However, there is a cost to holding reserves, since they yield a lower return than other assets in the economy.

10. **Baseline parameters for calibration are taken from the paper estimates for emerging markets as well as standard assumptions in the literature**. Specifically, in this model-based approach, the optimal level of reserves is determined by the size and probability of the sudden stop, the potential loss in output, the opportunity cost of holding reserves, and the degree of risk aversion:

- The size of the sudden stop, proxied in Jeanne-Rancière framework by the stock of short-term debt, is assumed to be equal to the metric proposed in the paper—that is, to the potential outflows to be experienced by the country during periods of exchange market pressure based on the composition of its external assets and liabilities;

- The probability of a sudden stop (at 10 percent) and the coefficient of risk aversion (at 4) are set at prudent levels, in line with the literature;

- The cumulative loss in output (at 6.5 percent) is taken from the Jeanne-Rancière work, based on their analysis for an average middle-income economy;

- Potential growth rates for each country are based on estimates of potential GDP growth over the past 10 years;

- The opportunity cost of reserves is taken from the paper's estimates of the average cost of reserves for each country, based on the methodology in Levy-Yeyati (2006) to account for the impact of reserves in reducing sovereign spreads. The cost of reserves for countries with public debt lower than 5 percent of GDP is set equal to the missed return from investing in investment grade corporate bonds.

11. **The optimal level of reserves is sensitive to the choice of parameters, notably for the size of the output loss**. To this purpose, the summary chart in the main paper presents two different optimal reserve estimates depending on size of the output loss (6.5 and 10 percent).

[5] Section prepared by Manuela Goretti and Ferhan Salman (SPR).

IV. Optimal Reserves for LICs: Calibration and Robustness Results[6]

12. **This section provides details on the methodology employed for the calibration of optimal reserves in LICs** and reports the findings of the sensitivity analysis undertaken for the empirical analysis reported in Section IV of the main paper.

A. Calibration of Optimal Reserves

Analytical Framework: Cost-Benefit Approach

13. **Determination of optimal reserves requires an objective function that weighs the benefits of holding reserves against its costs**. Albeit simplistic, LICs are assumed to maximize the net benefit of holding reserves (NBR), characterized as follows:

$$\underset{R}{\text{Max}} \quad NBR = -q \cdot P(R,Z) \cdot C(R,Z) - r \cdot R$$

where *P* and *C* represent the conditional probability of a crisis given a large shock event and the cost of a crisis, respectively,—both of which depend on reserves (*R)* and other control variables (Z); *q* and *r* refer to the unconditional probability of a large shock event and the unit cost of holding reserves, respectively. The first term on the right hand side reflects the benefit of holding reserves (in terms of reducing the expected cost of a crisis) while the second captures the cost of holding reserves. Given the dependence of the probability and cost of a crisis on Z, the maximization of NBR would yield optimal reserves as a function of Z and *r* (and the estimated parameters of *P* and *C*).

14. **While the specification of NBR reflects the precautionary motive for holding reserves, it assumes risk-neutral utility to model the cost of a crisis** in the event of external shocks—as proxied by real absorption loss in percent of GDP. It is well known that existing optimal reserve models are plagued by arbitrary assumptions on the degree of risk-aversion, and that the resulting optimal reserves are very sensitive to such assumptions. For this reason, the calibration exercise aims to simulate a *lower bound* of the optimal reserves that would obtain under more general risk-aversion. Several more realistic options are explored to account for a more conservative risk attitude of LICs than implied by the assumption of linear utility.

Calibration Strategy

15. **In the calibration, the probit and OLS equations for absorption loss in the event of shocks for 49 countries reported in the paper are used as baseline specifications** for *P*(*R, Z*) and *C*(*R, Z*). These regressions include pre-shock reserve levels as an independent variable, controlling for fundamentals, shock size, and other pertinent country characteristics such as exchange rate regimes. While updated data for economic fundamentals are readily

[6] Section prepared by Era Dabla-Norris (SPR), Jun Il Kim (RES), and Kazuko Shirono (SPR).

available, shock variables are unknown if the calibration were to be undertaken for out-of-sample periods. Two options are available to address this issue. First, specific shock values could be taken from the sample used for the estimation, which is the approach used for the illustrative calibration results reported in the paper. Alternatively, shock values could be simulated by assuming a multivariate normal distribution for shocks, with the variance-covariance estimated from the sample. Optimal reserves could then be calibrated for each set of simulated shock values, and then averaged to yield final results. Despite considerable computational burden, this option has the important advantage that it explicitly accounts for the correlation among shocks.[7]

16. **Other parameter values used in the calibration are taken directly from the data**. Specifically, the unconditional probability of a large shock event (q) is estimated from the data to be 0.5 (the sample average). For the unit cost of holding reserves (r), several reference values are considered, ranging between 2 percent and 6 percent. These values are based on various existing estimates of the marginal product of capital and the differential between domestic and foreign real interest rates (adjusted for real financial return on reserves of about 1 percent a year). Economic fundamentals, such as fiscal balance and the CPIA index are set to their respective five-year average over the period of 2003−07 for each country group.

17. **Shock values in the calibration are taken from the sample median for different country groups**, including all LICs, Sub-Saharan Africa (SSA), commodity exporters, and fragile states. The estimated real absorption loss (for chosen values of shocks and country fundamentals) is augmented by one standard deviation of the residuals from the OLS absorption loss regression; assuming normality, the augmented value corresponds roughly to the upper 85th percentile of the distribution of absorption losses. Given that there remains large unexplained variation in the OLS absorption loss regression (the regression accounts for 35 percent of the variation in absorption loss across countries), this adjustment is intended as an attempt to capture possible risk aversion in LICs. In fact, in view of large uncertainty surrounding estimates of risk-aversion parameters, experimenting with more extreme shock values or larger adjustments, while assuming risk-neutral utility, could be a practical approach to address differences in the risk attitude across countries.

Calibration Results

18. **The calibration assumes the availability of access to (contingent) Fund support in the event of large shocks**, which affects the conditional probability of a crisis. Calibrated

[7] Ignoring possible correlation among shocks could lead to an under- or over-estimation of optimal reserves depending on the sign of correlation: if shocks were positively (negatively) correlated, calibration exercise that assumes uncorrelated shocks would yield lower (higher) optimal reserves. Assuming a specific set of shock values is even more restrictive as shocks tend to be non-stochastic in nature.

optimal reserves are reported in Table 3 for different country groups.[8] As can be seen from the table, these vary from less than 2 month of imports to over 12 months of imports depending on country characteristics, fundamentals, and the cost of holding reserves. Sensitivity analysis undertaken for the calibration results (not reported here) suggests that optimal reserves are higher if more extreme shock values are considered (taken for the bottom 10th or 25th percentile of the group-specific distribution instead of the median).[9] In all instances, optimal reserves are generally higher for the fixed exchange rate regime, and for fragile states and commodity exporters. For example, assuming that the unit cost of holding reserves is 4 percent, optimal reserves for commodity exporters are 3.4 months of import even under the flexible regime if shock values were set to the 25th percentile.

Table 3. Calibrated Optimal Reserves: An Illustrative Example
(In months of imports)

Exchange Rate Regime	Unit Cost of Reserves (%)	Country Group			
		ALL	AFR	COM	FRG
Fixed	2	9.9	9.4	10.2	12.6
	3	7.3	7.0	7.7	9.7
	4	5.5	5.3	5.9	7.6
	5	4.2	4.1	4.7	5.9
	6	3.3	3.3	3.8	4.7
Flexible	2	3.9	4.7	5.4	5.3
	3	2.7	3.2	3.8	3.8
	4	2.1	2.4	2.9	2.9
	5	1.6	1.8	2.3	2.3
	6	1.4	1.5	1.8	1.9

Note: Reported optimal reserves are for the case where access to Fund support is available; ALL=all countries, AFR=Sub-Saharan African countries, COM=commodity exporters; FRG=fragile states.

B. Robustness Checks for Regressions

19. **Various robustness checks are undertaken to test the sensitivity of the regression results for the probability and magnitude of a crisis**. In the crisis probability regressions, all coefficients are highly statistically significant and of the expected sign, and broadly

[8] Further disaggregation of country groups, albeit desirable in light of significant heterogeneity across LICs, is not considered since the number of countries is highly uneven across country groups, often with too few countries in a certain group to yield statistically meaningful results.

[9] Since a large shock event is defined as a *union* of six individual shock events (defined as the event at or below the 10th percentile of the country-specific sample distribution), the unconditional probability q should be close 0.6 if individual shocks are uncorrelated. The sample estimate of 0.5 thus suggests that individual shocks are positively (albeit weakly) correlated in the sample. However, it should be noted that since the benefit of holding reserves is increasing in q, optimal reserves are also increasing in q.

similar across specifications and estimation methods (Table 4). Robustness across subsamples is confirmed for the coefficient of the reserve variable in the probability regressions (Table 5), and also in the OLS regressions for absorption loss (Table 6). Moreover, in all regressions, the coefficients on other controls are broadly similar, and are largely significant and of the expected sign. The regression result for the magnitude of absorption loss is also robust to alternative specifications of the reserve variable (not reported here). For example, if R*=R/(1+R) replaces log(R), which was assumed to capture non-linearity in the crisis mitigation role of reserves, the coefficient on reserves is still highly statistically significant. Moreover, calibrated optimal reserves are also very similar to those obtained under the log specification.

Table 4: Probit and Logit Models for Absorption and Consumption Drops

	Absorption		Consumption	
	(1)	(2)	(3)	(4)
	PROBIT	LOGIT	PROBIT	LOGIT
Reserve, months of imports	-0.0896***	-0.1556***	-0.0866***	-0.1443**
(t-1)	(0.0339)	(0.0595)	(0.0329)	(0.0567)
Government balance, % of GDP	-0.0323***	-0.0537**	-0.0243**	-0.0400**
(t-1)	(0.0125)	(0.0220)	(0.0120)	(0.0203)
CPIA	-0.3090***	-0.5129***	-0.2538**	-0.4251**
(t-1)	(0.1056)	(0.1766)	(0.1027)	(0.1709)
Flexible exchange rate regime	-0.3801***	-0.6568***	-0.3402**	-0.5805***
(t-1)	(0.1366)	(0.2340)	(0.1333)	(0.2245)
IMF program	-0.3021**	-0.5223**	-0.2550*	-0.4204*
(t)	(0.1409)	(0.2374)	(0.1376)	(0.2296)
Constant	0.8648**	1.4790**	0.7406**	1.2589**
	(0.3614)	(0.6039)	(0.3525)	(0.5840)
No. of observation	445	445	445	445
Pseudo R2	0.1099	0.1103	0.0814	0.0812

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

Table 5: Absorption Drop Probit Regression Robustness Check

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Longer sample period (1980-2009)	Drop fragile	Drop commodity exporters	Drop oil exporters	Drop island economies	Drop AFR	Drop MCD	Drop EUR	Drop APD	Drop WHD
Reserve, months of imports (t-1)	-0.0944***	-0.1018**	-0.1333***	-0.0949***	-0.0734**	-0.1196	-0.0902***	-0.0906***	-0.1028***	-0.0902**
	(0.0285)	(0.0490)	(0.0446)	(0.0357)	(0.0354)	(0.0872)	(0.0344)	(0.0339)	(0.0350)	(0.0358)
Government balance, % of GDP (t-1)	-0.0267***	-0.0175	-0.0312**	-0.0343***	-0.0363***	-0.1279***	-0.0276**	-0.0316**	-0.0224*	-0.0295**
	(0.0097)	(0.0169)	(0.0149)	(0.0132)	(0.0138)	(0.0363)	(0.0126)	(0.0125)	(0.0126)	(0.0126)
CPIA (t-1)	-0.2801***	-0.3805*	-0.4028***	-0.3245***	-0.2560**	-0.3386**	-0.2715**	-0.3065***	-0.3834***	-0.2403**
	(0.0876)	(0.2080)	(0.1209)	(0.1083)	(0.1256)	(0.1698)	(0.1092)	(0.1055)	(0.1215)	(0.1139)
Flexible exchange rate regime (t-1)	-0.4304***	-0.1392	-0.5043***	-0.4106***	-0.3884***	-0.8172***	-0.3549**	-0.3610***	-0.2530*	-0.4219***
	(0.1207)	(0.1779)	(0.1700)	(0.1400)	(0.1492)	(0.2649)	(0.1413)	(0.1372)	(0.1491)	(0.1461)
IMF program (t)	-0.2083*	0.1042	-0.1440	-0.2820*	-0.3642**	0.2073	-0.3532**	-0.3078**	-0.4710***	-0.3206**
	(0.1189)	(0.2016)	(0.1741)	(0.1453)	(0.1561)	(0.2620)	(0.1464)	(0.1414)	(0.1578)	(0.1483)
Constant	0.8224***	0.7844	1.2357***	0.9175**	0.6974*	0.4044	0.7584**	0.8663**	1.3446***	0.6598*
	(0.2830)	(0.7989)	(0.4296)	(0.3803)	(0.4130)	(0.5948)	(0.3758)	(0.3614)	(0.4022)	(0.3951)
N	590	282	311	427	385	163	414	439	368	396
Pseudo R2	0.1022	0.0457	0.1431	0.1105	0.1080	0.2057	0.1042	0.1081	0.1279	0.1016

Note: Standard errors are in parentheses. *, **, and *** indicate statistical significance at 10 percent, 5 percent, and 1 percent, respectively.
Regional country groups are defined as follows: AFR = Africa, MCD = Middle East and Central Asia, EUR = Europe, APD = Asia Pacific, WHD = Western Hemisphere.

Table 6: Absorption Loss OLS Regression Robustness Check

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Baseline	Drop fragile	Drop commodity exporters	Drop oil exporters	Drop island economies	Drop AFR	Drop MCD	Drop EUR	Drop APD	Drop WHD
Log of reserves, months of imports (t-1)	-2.2403***	-2.0268*	-1.5548**	-2.0425***	-2.5021***	-0.0673	-2.2679***	-2.2753***	-2.3968***	-2.6317***
	(0.6677)	(1.1416)	(0.6324)	(0.6634)	(0.7306)	(1.3657)	(0.6556)	(0.6682)	(0.7075)	(0.7173)
Flexible exchange rate regime (t-1)	-8.6983***	-8.4203**	-5.6632**	-8.6269***	-7.8198***	-10.3606***	-9.2590***	-8.6741***	-7.4263***	-9.0198***
	(2.1689)	(3.3245)	(2.2809)	(2.2192)	(2.5429)	(2.9899)	(2.2666)	(2.1678)	(2.3578)	(2.4843)
External demand growth	-0.9320**	-1.1587*	-0.8478**	-0.8066*	-0.5799	-1.4003**	-0.7156	-0.9371**	-0.7284	-1.0432**
	(0.4356)	(0.6734)	(0.4294)	(0.4242)	(0.4415)	(0.6759)	(0.4788)	(0.4343)	(0.4471)	(0.4752)
Terms of trade growth	-0.0841*	-0.0704	0.0072	-0.0732	-0.1193**	-0.0898*	0.0007	-0.0854*	-0.0834	-0.1091**
	(0.0484)	(0.0431)	(0.0226)	(0.0478)	(0.0561)	(0.0523)	(0.0257)	(0.0488)	(0.0522)	(0.0505)
Change in FDI to GDP	-0.0159	0.6605**	-0.7468	0.1236	-0.1136	0.5123*	-0.4515	-0.0397	-0.0145	-0.0450
	(0.3391)	(0.2762)	(0.4908)	(0.4551)	(0.3237)	(0.3088)	(0.3085)	(0.3432)	(0.3825)	(0.3270)
Change in aid to GDP	0.0527	0.2125	0.0941	0.0615	0.0427	0.1883***	0.0661	0.0503	0.0537	-0.0503
	(0.0839)	(0.2199)	(0.1081)	(0.0855)	(0.0904)	(0.0633)	(0.0848)	(0.0841)	(0.0875)	(0.1373)
N	418	264	287	401	360	143	394	414	349	372
Adjusted R2	0.34	0.37	0.47	0.34	0.33	0.59	0.34	0.32	0.27	0.35
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Robust standard errors are in parentheses. *, **, and *** indicate statistical significance at 10 percent, 5 percent, and 1 percent, respectively.
All specifications include country fixed effects, but they are not reported in the table.
Regional country groups are defined as follows: AFR = Africa, MCD = Middle East and Central Asia, EUR = Europe, APD = Asia Pacific,

V. MANAGING VULNERABILITIES IN KOREA[10]

20. **After the recent crisis, Korean government's measures to reduce vulnerabilities arising from a reversal in capital flows and to further develop its bond market have been expanded.** Since the Asian crisis, ensuring that the level of reserves is adequate and maintaining sound economic fundamentals have been the corner stone of Korea's policy to prevent future crisis. However, during this crisis, Korea was again hit by sudden capital outflows, experienced rapid depreciation of the Korean Won, and had to deploy its reserves and draw Fed currency swap lines to reduce volatilities in FX markets and provide liquidity to Korean banks. In light of this, Korea adopted additional measures to reduce related vulnerabilities. The key ones include adopting macro prudential regulation policies to reduce volatility of capital inflows and improve the resilience of bond markets.

21. **A risk factor-based approach in macro-prudential policies was adopted.** In November 2009, stronger foreign currency liquidity standards to reduce maturity mismatches and improve quality of liquid assets for banks were introduced. For example, Korean banks were required to raise their long-term foreign currency borrowing to 90 percent of their long-term lending from the earlier 80 percent. A 125 percent cap on forward foreign exchange contracts (relative to underlying export revenues) was imposed between banks and exporters.[11] In June 2010, the limits on FX derivatives contracts of domestic banks and branches of foreign banks were set, mainly targeted to limiting banks' short-term overseas borrowing,[12] [13] and regulations on banks' foreign currency liquidity and monitoring on capital flows were strengthened. In December 2010, a plan to impose levy on non-deposit foreign currency liabilities of banks was announced. Under this plan, short-term debt would be subject to a higher levy rate compared to long-term debt.

22. **The measures were phased-in gradually to reduce distortional effects.** The principle of "grandfathering" was considered and the ceiling on FX derivative positions came into effect with three-month grace period and Levy on the banks is envisaged to take effect in the second half of 2011 to allow time to collect views from market experts and academia. Nonetheless, the uncertainty about possible revisions to the FX derivative limits was cited as a cause for concern by market participants.

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[10] Section prepared by Joonkyu Park (MCM).

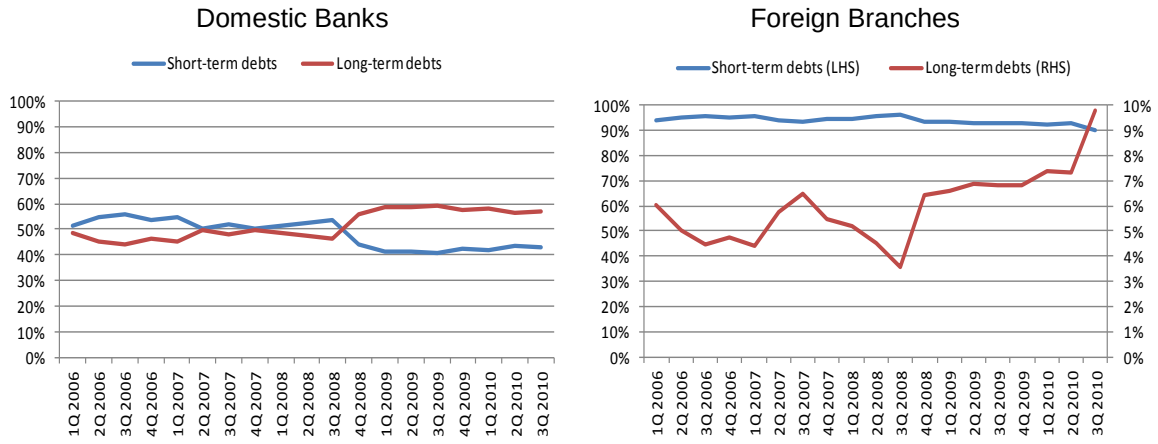
[11] In August 2010, the long-term borrowing requirement ratio was further revised up to 100 percent and the cap on forward foreign exchange contracts was further reduced to 100 percent.

[12] The limit for domestic banks was set at 50 percent of capital in the previous month; while the limit for foreign bank branches was set at 250 percent of capital in the previous month.

[13] FX derivatives trading between banks and enterprises, shipbuilders or asset management companies, led to the increase in short-term overseas borrowing, which was one of the main factors behind the surge in short-term external debt in 2006~2007. About half of the increase in total external debt of US$172 billion in the same period is credited to the increase in FX forward purchases by banks from exporters, especially shipbuilders.

23. **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, in particular, branches of foreign banks, have raised more long-term debt and reduced their reliance on short-term funding (Figure 1).

Figure 1. Portion of Short-term and Long-term Debts among Total External Debts



Source: Ministry of Strategy and Finance.

24. **The Korean government has put emphasis on developing bond markets over the past decade.** This came from the lesson the dependence on short-term external debts was one of key causes of the financial crisis. The authorities took a number of measures to develop Treasury bond markets, which could, in principle, act as a backbone for developing corporate bond markets. Thanks to much increased volume and liquidity, during the recent crisis, Korea's local bond market played an important role in providing financing to the government and corporations when international capital market and overseas liquidity conditions were under stress from late 2008 to early 2009.

25. **After the crisis, the government faced another challenges—absorbing rapid debt inflows.** Foreign investors' bond holdings more than doubled from January 2009 to October 2010. Fixed-income flows bring complications to monetary policy and sudden reversal can trigger significant volatility, although central bank's reserves can provide a buffer. To manage the pace of short-term inflows, in January 2011, the authorities reintroduced the withholding tax on nonresident purchases of treasury and monetary stabilization bonds.[14] The government has also issued a higher portion of longer-term Treasury bonds (10 and 20 years)

[14] Some investors raised issue of inconsistency of policy measures, pointing out the fact that the government abolished withholding tax in May 2009.

to attract investors with longer-term investment horizon.[15] As a result, the average maturity of Treasury bonds continued to lengthen—5.33 years in 2010 compared with 4.85 years in 2008 and foreign investors hold more position in long-term bonds than in the past.

26. **The government has been also active in introducing measures to further deepen its bond markets and diversify investor base to increase the absorptive capacity, which could help better accommodate capital inflows.** Key measures include starting to issue Treasury repo bonds, reintroduction of inflation-linked Treasury bonds, and announcement of the plan to activate futures markets on Treasury bonds.

[15] Foreign investors can dispose their positions in longer-term bonds in the secondary market. However, long-term investors, especially those with long-term liability such as pension funds and insurance companies tend to have less incentive to dispose their long-term asset positions, mainly due to more concerns on price risks and mismatch in asset-liability management (ALM).

Table. Data for Selected Emerging Market Countries (In billions in U.S. dollars, 2009) 1/

Country name	Country code	GDP	Reserves (eop)	Imports	Exports	M2 (eop)	Short-term debt (eop)	Other portfolio liabilities (eop)	Exchange rate regime 2/
Albania	ALB	12.1	2.3	6.5	3.4	9.1	1.1		float
Algeria	DZA	139.8	149.3	49.1	48.2	98.6	1.0		other
Angola	AGO	75.5	13.7	41.8	41.5	28.4	2.4	18.3	other
Antigua and Barbuda	ATG	1.1	0.1	0.8	0.5	1.1	0.0		other
Argentina	ARG	310.2	46.2	49.2	66.6	93.5	41.4	45.4	float
Armenia	ARM	8.5	2.0	3.7	1.3	2.2	0.0	4.6	float
Azerbaijan	AZE	43.1	5.4	9.9	22.8	10.5			other
Belarus	BLR	49.2	4.9	30.4	24.8	13.3	10.3	11.0	other
Belize	BLZ	1.4	0.2	0.8	0.7	0.8	0.1		other
Bolivia	BOL	17.5	7.6	5.1	5.4	9.0	1.0	2.9	other
Bosnia and Herzegovina	BIH	17.0	3.2	9.4	5.5	9.6	1.3	6.7	other
Brazil	BRA	1600.8	237.4	174.7	180.7	1292.6	70.5	605.2	float
Bulgaria	BGR	48.7	17.2	27.1	23.1	35.0	24.7	10.4	other
Chile	CHL	163.5	25.3	49.3	62.2	78.0	23.1	61.0	float
China	CHN	4990.5	2417.9	1113.2	1333.3	8878.1	287.0	353.7	other
Colombia	COL	231.8	24.8	38.4	38.2	90.6	10.6	45.2	float
Costa Rica	CRI	29.3	4.1	12.3	12.4	16.8	3.2	4.5	other
Croatia	HRV	63.0	14.9	24.8	22.4	43.8	20.5	34.4	other
Czech Republic	CZE	190.3	41.2	122.1	132.9	147.6			float
Dominican Republic	DOM	46.7	2.9	14.1	10.4	16.8	3.1	10.6	other
Ecuador	ECU	52.0	2.9	17.2	15.5	13.6	3.4	12.9	other
Egypt	EGY	188.6	32.4	59.9	47.0	151.8	4.0	31.8	other
El Salvador	SLV	21.1	2.9	8.0	4.7	1.1	1.5	8.2	other
Estonia	EST	19.3	4.0	12.4	13.5		11.9	9.5	other
Gabon	GAB	11.0	1.9	4.2	6.3	2.6	0.3		other
Georgia	GEO	10.8	2.1	5.3	3.2	2.7	1.3	5.7	other
Guatemala	GTM	37.7	5.0	12.7	9.2	15.7	4.0	7.5	float
Honduras	HND	14.1	2.1	8.6	6.0	7.3			other
Hungary	HUN	129.3	44.1	93.2	99.8	84.9	44.5	126.0	float
India	IND	1228.9	266.2	359.2	279.6	1150.8	69.1	270.7	float
Indonesia	IDN	539.4	63.7	112.2	133.2	216.2	59.8	148.4	float
Iraq	IRQ	65.2	46.3	54.4	40.6	39.9			other
Israel	ISR	195.4	60.6	63.1	67.9	142.4			float
Jamaica	JAM	12.6	2.1	7.0	4.3	4.1	0.4	10.4	float
Jordan	JOR	25.1	11.7	16.5	10.9	28.2	0.5		other
Kazakhstan	KAZ	113.6	20.8	38.9	48.3	0.0	14.1	53.5	other
Korea	KOR	832.5	270.0	400.5	431.8	1733.6			float
Latvia	LVA	25.9	6.6	11.5	11.2	11.9	14.0	23.8	other

Source: WEO, IFS and staff calculations

1/ Country sample chosen for relevance to reserve adequacy discussion and does not necessarily correspond to any formal definition of emerging market countries.
2/ "float" corresponds to the categories "floating" and "free floating" in the IMF AREAER de facto exchange rate classification for end-2009.
Definitions:

Nominal GDP in US$ (WEO database)

Nominal exports and imports of goods and services (WEO database)

Nominal Broad Money stock in US$ at end of period exchange rates (WEO database)

STD is the stock at residual maturity. That is, the stock at original maturity plus the amortization of MLT debt in the year ahead (both from WEO, US$)

Other portfolio liabilities is portfolio liability stock *plus* other investment liability stock *minus* STD at residual maturity. Portfolio and other investment liabilities

Table. Data for Selected Emerging Market Countries (In billions in U.S. dollars, 2009) 1/ (Concl.)

Country name	Country code	GDP	Reserves (eop)	Imports	Exports	M2 (eop)	Short-term debt (eop)	Other portfolio liabilities (eop)	Exchange rate regime 2/
Lebanon	LBN	34.9	29.6	28.4	22.8	98.7	51.9		other
Libya	LBY	60.2	104.3	27.1	37.4	35.8	1.4		
Lithuania	LTU	37.1	6.5	20.6	20.1	17.5	15.6	13.5	other
Macedonia	MKD	9.7	2.1	5.7	3.5	4.6	2.1		other
Malaysia	MYS	193.0	95.5	144.5	186.0	275.3	26.6	108.3	other
Maldives	MDV	1.3	0.3	1.1	0.8	1.1	0.3		other
Mauritius	MUS	8.6	2.2	5.1	4.2	9.4	0.2	6.9	float
Mexico	MEX	882.3	99.6	257.6	244.6	579.1	46.7	236.7	float
Moldova	MDA	5.4	1.5	4.0	2.0	2.7	1.7	2.0	float
Mongolia	MNG	4.2	1.3	2.6	2.3	2.0			float
Montenegro	MNE	4.2	0.6	2.7	1.3				other
Morocco	MAR	91.4	22.8	37.2	26.3	91.6	1.4	27.2	other
Pakistan	PAK	162.0	11.4	39.2	23.2	61.0	3.6	58.1	float
Panama	PAN	24.9	3.0	7.5	8.7	22.8			other
Paraguay	PRY	14.2	3.8	7.4	7.2	5.6	0.2	3.2	other
Peru	PER	126.8	32.1	25.8	30.5	41.2	9.3	46.9	float
Philippines	PHL	161.2	39.1	55.2	47.9	85.7	12.2	56.4	float
Poland	POL	430.6	76.1	170.6	171.1	252.7	95.3	151.8	float
Romania	ROM	163.7	40.9	61.6	51.1	64.6	36.8	58.6	float
Russia	RUS	1231.9	417.8	253.5	345.0	645.4	147.4	454.2	other
Serbia	SRB	41.6	14.8	18.9	11.8	17.7	5.8	29.0	float
Seychelles	SYC	0.8	0.2	1.1	0.8	0.4	0.0		float
South Africa	ZAF	284.0	35.5	80.4	77.9	264.0	31.7	133.9	float
Sri Lanka	LKA	42.0	4.7	11.7	9.0	15.8			float
St. Kitts-Nevis	KNA	0.6	0.1	0.3	0.2	0.6	0.0		other
Syrian Arab Republic	SYR	52.3	17.4	19.3	16.7	161.3	5.6		other
Thailand	THA	264.0	135.6	156.0	180.9	318.4	38.4	72.5	float
Tunisia	TUN	43.5	11.1	20.9	19.9	29.3	6.4	17.8	other
Turkey	TUR	614.5	71.1	151.3	142.8	348.1	93.0	222.1	float
Turkmenistan	TKM	18.5	18.9	11.3	9.5	4.1	0.4		other
Ukraine	UKR	117.4	25.6	56.2	54.3	61.0	38.8	61.9	other
United Arab Emirates	ARE	223.9	36.1	187.5	202.3	201.7	63.8		other
Uruguay	URY	31.5	8.0	7.8	8.5	14.2	7.0	11.8	float
Venezuela	VEN	325.7	22.3	48.1	59.6	98.2	20.8	32.5	other
Vietnam	VNM	93.2	16.8	72.3	62.8	116.6	7.2		other

Source: WEO, IFS and staff calculations

1/ Country sample chosen for relevance to reserve adequacy discussion and does not necessarily correspond to any formal definition of emerging market countries.
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Other portfolio liabilities is portfolio liability stock *plus* other investment liability stock *minus* STD at residual maturity. Portfolio and other investment liabilities are taken from the IFS IIP database, and are in US$.