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Are Emerging Asia's Reserves Really Too High?

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Abstract

Empirical analysis does not suggest that reserves are “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 explains 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 in terms of reduced borrowing costs.

This Working Paper should not be reported as representing the views of the IMF.

The views expressed in this Working Paper are those of the authors and do not necessarily represent those of the IMF or IMF policy. Working Papers describe research in progress by the authors and are published to elicit comments and to further debate. The authors would like to thank Olivier Jeanne, Jaewoo Lee, Paul Gruenwald, Gian Maria Milesi-Ferretti, and Perry Warjiyo for very helpful comments.

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I. INTRODUCTION

This paper looks at whether foreign exchange reserves in emerging Asia have grown to beyond what is needed to support financial stability. In assessing global foreign exchange reserve levels in September 2003, the World Economic Outlook concluded that reserves in some Asian emerging market economies were approaching a point where a slowdown in the rate of accumulation was desirable. Since then, however, reserves in these economies have continued to surge in nominal terms. The rapid accumulation of reserves is often seen as the by-product of a development strategy based on boosting exports and growth through maintaining undervalued exchange rates, and thus a reflection of growing global imbalances. Green and Torgerson (2007) state that the largest reserve holders among emerging markets far exceed needed precautionary levels and that the marginal precautionary return to additional reserve accumulation is now low; they see most reserve accumulation as an attempt to limit exchange rate flexibility. Summers (2006) see excessive reserves as wasteful given the large infrastructure and social needs in emerging markets.

Why have reserve holdings in Asia increased so sharply over the past decade? Fundamentally, reserves are held to provide liquidity in case of temporary shortfalls in exports or capital inflows, and thus avoid disruptive changes in the exchange rate, or investment and consumption. In addition, reserves can protect the domestic banking system—and more broadly domestic credit markets—from outflows of domestic or external resources (Obstfeld, Shambaugh, Taylor (2007)).

Based on such motivation, there appears to have been plenty of cause for Asian economies to increase their reserves over the past decade. Much of the recent increase in reserves can be explained by the precautionary motive, and has paralleled the sharp expansion of trade and capital flows, as well as the increase in the volatility of gross capital flows to Asian economies. These factors have increased the disruptive potential of sudden stops. In addition, accelerated financial intermediation, including the development of local bond and equity markets, have raised the stakes in case of outflows from the domestic financial system. Finally, the build-up of reserves in Asia was a natural response to the disruptions and the disastrous impact of the 1997–99 crises on the economic, political, and social fabric, which has understandably increased risk aversion. Thus, despite moves towards more flexible exchange rates and better capital market access, many emerging market central banks have used the opportunities provided by large current account surpluses and capital inflows since the 1997–99 crises to build reserves. Indeed, the high level of reserves could be a major help in maintaining financial stability in Asian economies during the current global credit crunch when the possibility of a sudden stop and/or capital outflows from these economies has risen significantly.

Of course, it could be claimed that with the shift to inflation targeting and floating exchange rates, Asian economies need less reserves than before. In our view, this is wishful thinking. Sudden stops in a financially increasingly integrated world can cause even greater volatility in nominal and real exchange rates, especially in relatively thin and institutionally less developed financial markets. Thus, in addition to less political tolerance for volatility, the

level of financial development may explain why Asian economies have had a tendency to hold increased reserves compared with small open industrial economies such as Australia and New Zealand.

Empirical analysis does not suggest that reserves are “too high” in the majority of Asian economies, though China may be a special case. After recovering following the crisis, reserve adequacy indicators have leveled off in Asia (excluding China). In fact, in Asian economies with very high indicators of reserve adequacy, these indicators have begun to decline, as some of these economies have moved further toward exchange rate flexibility and have accumulated reserves at a slower pace in the past few years. On the other hand, economies with relatively lower reserves continue to increase reserve holdings, resulting in some convergence. Reserve adequacy indicators for emerging Asia (outside of China), at least in the aggregate, can no longer be considered as significantly out of line with other emerging economies. Moreover, much, though not all, 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. While there is an opportunity cost to holding reserves, which is considered in the insurance model, it does not incorporate the impact of reserves in lowering spreads on an economy’s privately held external debt. Using threshold estimation techniques, we show that most of Asia can still benefit from higher reserves in terms of reducing borrowing costs.

This paper first looks at reserve developments in Asia using traditional adequacy indicators, including the ratios of reserves to imports and short-term debt. However, we argue that the latter is no longer an adequate indicator of vulnerability because of the strong expansion of non-debt cross border flows, and prefer the ratio of reserves to gross external liabilities for this purpose. We also compare reserves with some broad domestic financial aggregates to assess whether reserves are adequate to protect the financial systems against domestic and internal drains. Subsequently, we assess whether reserves in emerging Asia exceed the optimum level using an existing model (Jeanne, 2007), making changes in parameters to take into account conditions in Asia. Finally, we use a threshold model and assess the benefits of reserves in terms of reduced borrowing spreads.

II. DEVELOPMENTS IN RESERVE ADEQUACY INDICATORS

The foreign exchange reserves of Asian economies have quadrupled since the end of the 1997–99 financial crisis. Even after excluding China, reserves more than doubled **in nominal terms** during 2000–07 (Figure 1). Relative to GDP, there has also been a significant increase in reserves, by about 10 percentage points over 2000–07, to 36 percent of GDP, excluding China (Figure 2). Emerging Asia’s reserves also reached the equivalent of about 5 percent of global GDP (in nominal terms) at end 2007.

Traditional reserve adequacy indicators in emerging Asia remain high, but have begun to moderate in recent years because of the acceleration in global trade and capital flows over the past few years. Excluding China, the **ratio of reserves to imports** has declined modestly since 2003, though it is still significantly higher than the traditional benchmark of three months of imports (for which there is little theoretical substantiation) and higher than in the

1990s (Figure 3). China's reserve to import ratio, however, continues to rise. There has been some convergence between the economies of the region in terms of the reserves to imports ratio, with the economies with the highest ratios showing declines in recent years, and the opposite trend evident in economies with lower ratios. Similar trends are evident for many of the other reserve adequacy indicators. Only in Singapore could the decline in reserve ratios have possibly been caused to a significant extent by transfers to sovereign wealth funds. While there is little insistence in economic literature that the equivalent of three months of imports (or of one year of short-term debt) is an appropriate level of reserves, these indicators remain important in operationally assessing the level of reserves; for example, they are still used in most IMF staff reports.

The **ratio of reserves to external debt coming due within the next year** has become the standard indicator of vulnerability to capital account crisis, and has found the most empirical support (Bussière and Mulder, 1999). This ratio remains very high in emerging Asia, exceeding the recommended 100 percent under the Greenspan-Guidotti rule by a wide margin in all economies (Figure 4). Nevertheless, it has started to moderate in the past few years, reflecting some increase in short-term debts in some economies, notably India and Korea. In our view, however, the very high levels of these ratios overstate the extent to which Asian economies are insured against sudden stops, especially in view of the sharp increase in portfolio and direct investment flows to emerging Asia (see Box 1).

Reserves currently cover less than one-third of external liabilities in emerging Asia (excluding China) (Figure 5).¹ Reflecting greater real and financial integration with the global economy, cross cross-border capital flows in emerging Asia—both in and out—have grown sharply over the past decade, resulting in a build-up in external assets and liabilities in all the economies of the region (Figure 6). The ratio of reserves to external liabilities increased through 2002 as emerging Asia rebuilt its reserves following the crisis, but has since eased. It has been declining—albeit very gradually—or stable in all economies, except China and Malaysia. In addition to the increase in size, the volatility of gross capital flows has risen (Asia and Pacific Regional Economic Outlook, IMF, 2007). According to this work (Table 1), the increase in volatilities for gross flows can be explained by their growing size and the increasing share of portfolio and other investments in total flows. On the other hand, the volatility of net inflows has decreased, indicating that gross inflows and outflows are better synchronized. As the reasons for the better synchronization are not fully understood, there is no guarantee that this trend will continue. In all, while it is not possible to calculate a benchmark for an adequate level of reserves compared with external liabilities, current reserve levels in most Asia economies do not appear excessive against historical levels given the size of gross liabilities and the increased volatility of gross flows.

Reserves on average cover about one-third of **broad money** in emerging Asia. This ratio can be interpreted to measure resilience to outflows from an economy's banking system. All emerging Asian economies are above the Wijnholds and Kapteyn (2001) recommended holdings of 5–20 percent, though there is little theoretical substantiation for this threshold

¹ Data from Lane and Milesi-Feretti (2007).

Table 1. Volatilities of Capital Flows in Asia-Pacific Economies 1/

	Inflows		Outflows		Balance (net inflows)	
	1987-1996	2001-2006	1987-1996	2001-2006	1987-1996	2001-2006
Emerging Asia (excluding Hong Kong and Singapore) 2/						
Total Capital Flows	2.76	3.48 * ³	1.29	2.62 **	2.95	2.65
Direct Investment Flows	0.55	1.03 **	0.28	0.47 *	0.68	0.82
Portfolio Investment Flows	0.79	2.01 **	0.19	1.01 **	0.87	2.04 **
Other Investment Flows	2.45	1.88	1.08	2.26 **	2.52	2.15
ASEAN						
Total Capital Flows	3.31	4.54 *	1.17	2.79 **	3.20	3.35
Direct Investment Flows	0.78	1.53 **	0.12	0.68 **	0.78	1.24 *
Portfolio Investment Flows	1.12	2.23 **	0.23	0.66 *	1.23	2.30 **
Other Investment Flows	2.91	2.33	1.11	2.64 **	2.77	2.10
Korea and Taiwan						
Total Capital Flows	3.16	3.70	2.36	3.23	4.06	2.46
Direct Investment Flows	0.16	0.71 **	0.75	0.34	0.70	0.53
Portfolio Investment Flows	0.48	3.11 **	0.27	2.10 **	0.59	2.59 **
Other Investment Flows	3.14	1.87	1.74	1.97	3.67	2.67
Singapore						
Total Capital Flows	10.80	14.57	12.14	15.74	5.95	4.08
Direct Investment Flows	4.29	5.74	2.06	12.10 **	4.19	9.94 *
Portfolio Investment Flows	2.26	4.15	5.52	4.09	5.43	5.49
Other Investment Flows	12.14	10.84	11.27	13.99	5.46	6.21
China						
Total Capital Flows	1.29	1.24	0.49	2.53 **	1.51	1.87
Direct Investment Flows	0.84	0.46	0.26	0.30	0.84	0.37
Portfolio Investment Flows	0.26	0.33	0.04	1.29 **	0.24	1.30 **
Other Investment Flows	0.81	0.90	0.25	2.85 **	0.98	2.29 *
Australia and New Zealand						
Total Capital Flows	3.18	5.29	2.52	6.34 **	2.92	1.84
Direct Investment Flows	1.09	5.33 **	1.78	3.17 *	2.22	2.86
Portfolio Investment Flows	1.88	3.93 **	0.61	1.59 **	1.73	4.34 **
Other Investment Flows	2.54	2.98	0.99	3.73 **	2.36	2.80

Sources: APD Regional Economic Outlook, April 2007.

1/ Volatility is defined as standard deviations of changes in capital flows relative to nominal GDP.

2/ Numbers for the group of countries are simple averages of the standard deviations calculated for individual countries.

3/ ** and * indicate the standard deviation increased with statistical significance at 1 and 5 % (based on F-statistics), respectively.

(Figure 7). The overall number is somewhat distorted by Singapore where the ratio is over 80 percent. There has been little change in the ratio since 2004, as broad money growth has kept pace with reserves.

Financial deepening has outpaced reserve growth in emerging Asia (excluding China) since 2002. To measure the potential for outflows from the domestic financial system in the broadest sense, we tap a World Bank database to derive a series that includes all financials sector deposits (not just the banking system), as well as domestically issued government and corporate bonds and equity market capitalization (Figure 8). In 2005 (the latest data available), reserves covered about 15 percent of financial sector deposits, bonds and equities, according to a World Bank database. The ratio for most economies was around 10 percent, with only Singapore and Taiwan Province of China, in the 30–40 percent range. The ratio has declined for all economies in 2002–05.

Box 1: Why Scale Reserves by Gross External Liabilities?

Over time the nature of balance of payments shocks has evolved. The ratio of reserves to imports was developed to measure resilience to trade shocks that tended to predominate before the liberalization of financial systems and capital accounts. Subsequently, with the increase in cross-border capital flows and the rising possibility of sudden stops and capital outflows, the ratio of reserves to external debt maturing within a year became a key indicator of reserve adequacy. This reflected in part the nature of the crisis in Asia and elsewhere in the 1990s when banks and corporations built-up large short-term foreign exchange liabilities with which they financed long-term investments that did not generate foreign exchange. Foreign exchange reserves were not sufficient to finance outflows of short-term capital when they occurred. The ratio of reserves to short-term debt was thus highly suitable for assessing vulnerability to these type of currency and maturity mismatches and was indeed a good predictor of crisis.

Capital flows to non-emerging Asia have evolved considerably since the crisis of the 1990s. The share of debt, including short-term debt, has decreased (Figure 6). Moreover, portfolio flows have proved to be the most volatile form of capital flow, and the volatility of both gross inflows and outflows has risen sharply since 2000. Indeed recent episodes of global risk aversion such as May–June 2006 or August 2007 have been most felt in domestic bond and equity markets which have been volatile in many economies. While somewhat more stable, the volatility of direct investment flows has also increased (Table 1). Moreover, long-term liability holders rarely remain passive when balance of payments problems arise. As noted by Wyplosz (2007), speculation mostly takes the form of short-term liabilities, but long-term holders can quickly build up hedges, and the potential for such a build-up is captured by looking at the overall liability position.

Of course, it is not suggested that reserves need to cover external liabilities entirely, as in the case of the Greenspan-Guidotti rule. The appropriate coverage adequacy ratio should clearly be lower for some components (FDI, portfolio equity) than for others (short-term debt). It would make little sense to argue that the Greenspan-Guidotti rule of 100% coverage should apply to total gross liabilities (if each dollar of gross capital inflow should be saved in reserves, rather than being invested domestically, why have capital inflows?). So there probably should be different reserve coverage depending on the nature of the liabilities. The appropriate coverage of policies could also depend on the volatility of the particular flow/liability.

In sum, the ratio of reserves to gross external liabilities appears to best capture the vulnerability to sudden stops and capital account reversals, especially in light of the growing complexity of capital market instruments.

Excluding China, emerging Asia's reserve adequacy are not out of line compared with other emerging markets. After their moderation over the past few years, emerging Asia's reserve adequacy, excluding China, are only modestly higher than South America's, but lower than the average for other emerging markets, given the sharp increase in oil producers' reserves. China's reserves, however, have continued to grow rapidly and reserve adequacy indicators are considerably higher than in most other emerging markets.

III. AN INSURANCE MODEL OF OPTIMAL RESERVES

This section attempts to explain the recent buildup in international reserves in emerging Asia using an insurance model of optimal reserves based on the work of Jeanne (2007).² In the model, reserves enable an economy to cushion the impact of a sudden stop in capital flows on domestic consumption and output by providing a ready source of liquidity. However, holding liquid reserve assets entails an opportunity cost equal to the difference between the return on capital and on reserves. The optimal level of reserves is derived from this cost-benefit analysis and depends on: the probability and size of a sudden stop (or crisis), the output loss in the event of a sudden stop, the opportunity cost of holding reserves, and the degree of risk-aversion. The model is calibrated on economy-specific data for 11 emerging market economies in Asia and results compared with actual levels of reserves at the end of 2007.

The Model

Jeanne (2007) derives the optimal level of reserves by minimizing a loss function that equals the opportunity cost of reserves plus the expected welfare cost of a crisis:

$$Loss = \delta R + \pi f(R)$$

where δ is the opportunity cost of reserves; R is the reserve holdings; π is the probability of a crisis or sudden stop; and $f(.)$ is the welfare cost of a crisis, which is increasing in the size of the sudden stop and the output loss (L and ΔY). Assuming constant risk aversion (σ) and an exogenous probability of crisis, the optimal level of reserves is given by:

$$R = L + \Delta Y - \left[1 - \left(1 + \frac{\delta}{\pi} \right)^{-1/\sigma} \right]$$

² In an earlier paper, Ranci ere and Jeanne (2006) present a similar model of optimal reserves. We calibrate both models and obtain similar results. This paper presents calibration results of the 2007 model; results using the 2006 model are available upon request.

That is, the optimal level of reserves is larger the greater the size and output cost of a crisis, the higher the probability of a sudden stop, the lower the cost of holding reserves, and the higher the degree of risk aversion.³

Estimating Output Loss

The Asian crisis provides a useful benchmark to assess the size of the output loss in the event of a sudden stop in capital flows, a key parameter in the model. Given its massive impact on the region, it is reasonable to assume that this episode has, to a large extent, motivated the rapid accumulation of international reserves across Asia and that many economies may have accumulated reserves to cushion a potential loss in output of magnitude similar to that experienced a decade ago.

The cost in terms of output during the period 1997–99 is estimated by cumulating the output gap in these years under the assumption that output would have grown at the same rate as the average before the crisis.⁴ Results suggest that the cumulative output loss for the six Asian economies most affected by the crisis was 19 percent of GDP on average (Table 2). This was significantly higher in the case of Indonesia and Thailand, where the cumulative cost amounted to around 30 percent of GDP. These estimates may however underestimate the total output loss of the Asian crisis if the recession lowered the level of output permanently, rather than being a temporary deviation from trend. Indeed, Cerra and others (2005) finds evidence of permanent losses in the levels of output in six Asian economies following the 1997–98 crisis. The magnitude of the permanent losses is found to be economically significant for all economies, except perhaps the Philippines. For instance, in the case of Indonesia, the contemporaneous output loss is estimated at 22 percent of GDP, and the total loss including the losses beyond the crisis period reached 42 percent of GDP.

In addition, if sudden stops in capital flows trigger banking crisis, the cost could be substantially higher. According to Beim and Calomiris (2000), the resolution costs (bailouts and restructuring) following the Asian crisis reached 50 percent of GDP in Indonesia, above 40 percent in Thailand, and 20 percent in Malaysia and Korea. Similarly, Caprio and Klingebiel (2003) estimates the fiscal costs of the banking crisis at 55 percent of GDP in Indonesia, 35 percent of GDP in Thailand, 28 percent of GDP in Korea, and 16 percent of GDP in Malaysia.

Based on these results, the assumption of 10 percent of GDP output loss in the benchmark calibration in Jeanne (2007) appears too low. The exercise in this paper assumes a potential output loss of 19 percent of GDP, in line with the average output loss estimate from the Asian crisis experience, although a higher estimate would also be reasonable.

³ Risk aversion is assumed to be equal to 2, in line with the previous literature.

⁴ Results are robust to using averages corresponding to different time periods. The real GDP series are detrended with a Hodrik Prescott filter.

	Average Growth	Difference between actual growth and average growth			Cumulative output loss
	1970–1996 1/	1997	1988	1999	1997–99
Hong Kong SAR	7.4	-2.2	-12.8	-3.4	18.4
Indonesia	6.9	-2.2	-20.0	-6.1	28.2
Korea	8.1	-3.5	-15.0	1.4	17.1
Malaysia	7.6	-0.3	-14.9	-1.4	16.6
Philippines	3.6	1.6	-4.2	-0.2	4.4
Thailand	7.6	-9.0	-18.1	-3.2	30.3
<i>Average</i>	6.9	-2.6	-14.2	-2.2	19.2

1/ Real GDP series have been detrended using Hodrik Prescott filter. Results are robust to different time period averages.

Estimating the Probability and Size of a Sudden Stop

Consistent with the benchmark calibrations in Jeanne and Rancière (2006) and Jeanne (2007), the average probability of crisis is set to 10 percent, equal to the unconditional frequency of sudden stops in a large sample of emerging economies during the period 1975–2003.⁵ In this exercise, the probability of crisis is assumed to be exogenous and thus independent of the level of reserves. It is, however, plausible that reserves could have a crisis prevention role by reducing the likelihood of crises. If this were the case, the optimal level of reserves could be significantly larger.

During the historical sudden stop episodes, the average size of the capital outflows is estimated at around 10 percent of GDP. This estimate is relatively close to the weighted average short-term external debt in our sample and could, therefore, be a good predictor of the potential immediate rollover needs. The calibrations in this paper use this estimate, except for Hong Kong SAR and Singapore (where short-term liabilities significantly exceed 10 percent of GDP) and for Indonesia (where short-term debt is estimated at around 6.5 percent of GDP). In these cases, the actual ratio of short-term external debt to GDP is used instead.

Nevertheless, it is worth noting that the potential size of a capital flight in Asia could be significantly larger than 10 percent of GDP or the level of short term external debt. In some economies, such as Hong Kong SAR and Singapore, gross external liabilities exceed 700 percent and 400 percent of GDP, respectively. As discussed earlier, total foreign

⁵ Jeanne identifies sudden stops as those years in which net capital inflows fell by more than 5 percent of GDP.

liabilities could capture Asia's vulnerability to reversals in capital flows better than short-term debt.

Estimating the Opportunity Cost of Holding Reserves

The opportunity cost of reserves is the difference between the return on reserves and the return on capital or an alternative investment. In absence of a broad consensus over how to best capture this cost, several measures have been used in the literature, namely:

The spread between private foreign borrowing costs and yields on reserve assets. Rodrik (2006), Levy Yeyati (2006) and others have argued that the alternative use of one dollar of reserves is one less dollar of foreign debt or, alternatively, reserves can be accumulated by issuing foreign debt. The opportunity cost of reserves can, therefore, be viewed as the return that the government has to pay in excess of the return on liquid foreign assets to finance the purchase of reserves. This is proxied in our paper by the sovereign risk premium (as measured by EMBI or the 10-year government bond spreads). Since the sovereign risk premium reflects also the probability of default, and hence of less than full repayment, these spreads are likely to overstate the real opportunity cost of holding reserves. Moreover, as discussed in the next section of the paper, increases in reserves reduce the spread paid on the stock of foreign debt, thereby reducing the marginal cost of reserve accumulation and increasing the propensity to hold reserves. As shown in Table 3, sovereign interest rate spreads for foreign debt have averaged less than 4 percent during 2007 in emerging Asia, and in some economies (e.g., Singapore, Hong Kong SAR, and Taiwan Province of China) the risk premia has been negative.

China	71
Hong Kong SAR	-44
India	332
Indonesia	197
Korea	73
Malaysia	87
Philippines	178
Singapore	-175
Taiwan Province of China	-230
Thailand	-4

1/ Average for 2007. EMBI spreads for Indonesia, Malaysia, Philippines. Ten-year government bond spreads for others.

The term premium. Assuming a zero probability of default, the opportunity cost of reserves is simply the difference between a long-term foreign rate (such as the U.S. 10-year Treasury rate) and a short-term foreign rate (such as the 3-month U.S. T-bill rate or the Federal Funds rate). Based on this measure, the financial cost of accumulating reserves does not appear to have been large: the average term premium in the United States during 2007 was less than ¼ percent, reflecting the flattening of the yield curve over the past two years.

The fiscal cost of sterilizing reserves. This is computed as the difference between the domestic financing rate the central bank pays to withdraw liquidity from the local market as a result of reserve accumulation and the interest in the foreign reserves (assumed to be the yield on the 1-year U.S. Treasury bill or other short-term foreign rate). On average, the opportunity cost did not seem too high over the last year, except perhaps in Indonesia, where the sterilization rate exceeded by more than 4 percent the return on reserves. Other economies, such as China and Singapore, experienced a positive income gain (net positive

carry) during 2007, as the cost of domestic financing was lower than the rate earned on foreign reserves (Table 4).

Our baseline scenario assumes the opportunity cost of reserves is equal to the interest spread on foreign debt. The other two measures are used as robustness tests.

	Domestic Financing Costs (Sterilization Rate)	Net Carry (Interest on Foreign Reserves Minus Sterelization Rate) 2/	Carry Income on Total Reserves (% GDP) 3/
China	3.24	0.10	0.05
India	6.00	-2.66	-0.7
Indonesia	8.00	-4.66	-0.6
Korea	5.00	-1.66	-0.5
Malaysia	3.50	-0.16	-0.1
Philippines	5.25	-1.91	-0.4
Singapore	0.98	2.36	2.5
Taiwan Province of China	3.38	-0.04	0.0
Hong Kong SAR	5.75	-2.41	-1.8
Thailand	3.25	0.09	0.0

Sources: Country authorities; IMF, *APDCORE* database and *World Economic Outlook*; Fund staff calculations.

1/ As of December 2007.

2/ The rate on foreign reserve holdings is assumed to be the yield on the one-year U.S. Treasury note (3.34 percent at the end of 2007).

Calibration Results

The findings of the paper suggest that a simple insurance model performs relatively well in explaining the stock of reserves in emerging Asia. Except in China and possibly Malaysia, reserves in emerging Asia cannot be considered excessive, when compared to what would be optimal from a precautionary motive standpoint. Figure 9 shows the optimal level of reserves (in nominal terms) predicted by the model against the actual level at the end of 2007 in each of the Asian economies and Table 5 presents the same comparison in terms of GDP. The current level of reserves in Hong Kong SAR, Korea, the Philippines, and Singapore appear to be at or very close to optimal levels. Furthermore, the model can explain about 80 percent of current reserves in Thailand, 70 percent of total reserves in India and 60 percent of the reserves in Taiwan Province of China. There are, however, notable exceptions: the model can only explain about half of the reserve accumulation that has taken place in China (Table 4). Similarly, reserve levels in Malaysia at the end of 2007 had exceeded by more than twice the optimal levels predicted by the model. This suggests that factors other than insurance motives may be at play in these economies. On the other hand, the current level of reserves in Indonesia seems to be lower than predicted by the model, suggesting scope for further accumulation from an insurance motive point of view alone.

These results contrast with those in Jeanne and Rancière (2006) and Jeanne (2007) that find reserves in Asia to be significantly above optimal. The choice of the model parameters is crucial in delivering our results: by acknowledging that the potential size of the output loss in the event of a crisis may be larger than 10 percent of GDP and that the opportunity cost of reserves in Asia does not appear to have been very elevated in the recent period, we can go a long way in explaining the current stock of reserves. Furthermore, for some of the newly industrialized emerging economies (NIEs), the size of the potential capital flight might be larger than 10 percent of GDP, as assumed in the original authors' model.

Notwithstanding the power of the model, we cannot explain the entire buildup in Asia, particularly in the most recent period. Table 5 shows the year where the optimal threshold level was breached in those economies with relative high levels of reserves. In most cases, this took place between 2002 and 2005. For instance, China's reserves before 2004 had not reached the optimal level predicted by the model, and India breached the

	Optimal (in percent of GDP)	2007	2006	Above optimal since
China	26	47	40	2004
Hong Kong SAR	66	75	70	2001
India	16	22	20	2003
Indonesia	17	14	11	...
Korea	26	28	27	2004
Malaysia	25	57	53	1998
Philippines	21	22	17	...
Singapore	102	98	103	...
Taiwan POC	43	71	73	2002
Thailand	29	37	32	2005

threshold in 2003. Our results suggest that most economies in Asia were closer to their optimal levels in 2003 than they were at the end of 2007. This is depicted graphically in Figure 10, which shows a smaller dispersion around the 45 degree line (where actual reserves equal optimal reserves) in 2003 than in 2007. This could to some extent explain the pattern described in the introduction, which suggests that the accumulation of reserves in emerging Asia (excluding China) has started to decelerate recently. In few economies where the level of reserves had overshot recommended levels (e.g., Taiwan Province of China, Korea) the trend has started to reverse, which is a rational response from the cost-benefit analysis discussed before. Another indication that some economies have reached adequate levels is the emergence of sovereign wealth funds (SWFs). This trend would be in line with the recommendations in WEO (2003) that concluded that a slowdown in the pace of accumulation was desirable.

The discussion of the findings of the model is more meaningful when reserves are presented in terms of adequacy ratios rather than in dollar terms or in percent of GDP. Several conclusions emerge from Figure 11. First, the optimal levels predicted by the model are above the standard rules of thumb in most economies. For instance, the average optimal level of reserves for Asia is estimated at around 6 months of imports, twice as large as the traditional benchmark. Estimated optimal ratios for Indonesia, India, China, and Taiwan Province of China are above 6 months. With regards short-term external debt, all economies' optimal reserve levels are above the 100 percent Greenspan-Guidotti rule. Indeed, the average optimal level in Asia is more than three times this level. Similarly, the average optimal level of reserves to broad money is around 30 percent, above the 5–20 percent range

usually proposed in the literature. This suggests that these rules of thumb may no longer be relevant and that economy-specific indicators that accounts for economy-specific vulnerabilities and opportunity costs may be preferable to standardized rules.

Second, actual reserve ratios are not substantially above adequate levels, except in the economies discussed above (e.g., China, Malaysia, Taiwan Province of China). The difference seems to be smaller when expressed in terms of months of imports, broad money, short-term debt, or gross external liabilities than when presented in nominal terms or in percent of GDP. This suggests that the evolution of reserves cannot be assessed independently of the trade and capital account flows against which reserve provide an insurance. In light of these results, we can conclude that much of the recent increase in reserves can be explained by the precautionary motive, and has paralleled the sharp expansion of trade and capital flows, as well as the increase in the volatility of gross capital flows.

Third, the model tends to perform better in terms of explanatory power when the ratio of reserves to total external liabilities is used as the indicator of reserve adequacy. In particular, a higher fraction of the current reserves in China, Taiwan Province of China and Malaysia can be explained and the dispersion of excess reserves, defined as the difference between actual reserves and optimal reserves, around the mean is smaller when reserves are measured against total external liabilities than when measured against any other metric.

IV. A THRESHOLD MODEL OF SPREADS-RESERVES ELASTICITY

To the extent that reserves lower the spreads on the economy's privately held external debt, the opportunity cost of holding reserves is reduced and the incentives to accumulate reserves become higher (Levy Yeyati, 2006). This prevention aspect has been neglected in the model presented in the previous section as well as in other theoretical models on optimal reserve holdings. Alternatively, one could argue that holding reserves reduces the probability of a sudden stop. In either case, this would increase the desired level of reserve holdings. This section estimates how significant this "prevention" effect is and whether the current stock levels can be justified in terms of the benefits of reduced borrowing costs.

We estimate spreads-reserves elasticities for a panel of 34 emerging economies for the period 1997–2006. Because the marginal effect of reserves on spreads might be different at different levels of reserves, we look for a non-linear relation between spreads and international reserves applying threshold estimation as in Hansen (1996, 2000). By applying this methodology, we can endogenously determine the threshold level(s) of reserves (and confidence intervals) at which the relation between reserves and spreads changes. In particular, these threshold levels will provide information about the maximum level of reserves where no further gains from lower spreads could be realized. We will then be able to compare them with the optimal levels found in the previous section as well as with the traditional rules of thumb.

Methodology

Threshold estimation takes the form:

$$\begin{aligned}
 S_{it} &= \beta_1' X_{it-1} + \beta_2 R_{it-1} + \varepsilon_{it} & R_{it-1} &\leq \gamma \\
 S_{it} &= \alpha_1' X_{it-1} + \alpha_2 R_{it-1} + \varepsilon_{it} & R_{it-1} &> \gamma
 \end{aligned}$$

where S is J.P. Morgan's EMBI spreads; R is a reserve ratio indicator, which is used both as a regressor and as the threshold variable that splits the sample into two groups; γ is the endogenously determined threshold level; and X is a vector of control variables. The vector of control variables includes: (i) two exogenous global factors: the international risk-free asset (proxied by the 10-year U.S Treasury rate) and global risk aversion (proxied by the Credit Swiss First Boston's High Yield spread); and (ii) the country's GDP growth rate and the ratio of debt to GDP to control for country-specific and time varying characteristics. All the variables are estimated in logs and are lagged one period to reduce potential endogeneity concerns. The regressions also include country-specific fixed effects. A description of the variables and their sources can be found in the Appendix.

The main feature of the model is that it allows the regression parameters to differ depending on the value of R . We are interested in estimating the threshold level beyond which the marginal impact of reserves on spreads stops being significant. If needed, we perform multiple threshold regressions proceeding in a sequential way. First, we fit a threshold model to the data to estimate a first reserve ratio threshold level and the least square coefficients of each subsample. We compute confidence intervals for the parameters, including the reserve threshold coefficient, and provide an asymptotic simulation test of the null hypothesis of linearity against the alternative of a threshold. If the spreads-reserves elasticity beyond the threshold is not statistically significant, the procedure stops. If we find evidence of a first threshold, we proceed to the second stage (provided the number of observations allows doing so): drop the subsample below the threshold and repeat the procedure just described but applying it to the rest of the sample in search for a second threshold. This allows us to compute estimates for the two remaining sub-samples and test the null hypothesis of no second reserve threshold. In all cases there is no need to proceed beyond the second stage.

Empirical Results

To summarize, holding reserves has a significant impact in reducing spreads, and hence in lowering the economies' interest rate bills. This effect continues to be important even at relative high levels of reserves. The estimated thresholds beyond which there are no gains in holding reserves in terms of reduced cost of borrowing are significantly above the levels implied by the standard rules of thumb and closer to the optimal reserve levels found in Section III. This, together with the insurance motive discussed earlier, further contributes to explain the levels of reserves currently observed in emerging Asia and other emerging economies.

The findings for six different reserve adequacy indicators are presented in Tables 6–8 and Figure 12.⁶ A first set of indicators includes the traditional measures, but other liability metrics are also explored. As discussed earlier, given the extent of financial globalization and the potential for both internal and external drains, reserves as ratio of total foreign liabilities or as ratio of financial system deposits and stock market capitalization may be better determinants of reserve holdings than more traditional reserve adequacy indicators. What follows is a more detailed description of the results for each of the reserve indicators:

Reserves to GDP: There is only one relevant threshold at 49 percent of GDP.⁷ Below this level, the elasticity of spreads with respect to reserves is 43 percent. That is, a 1 percent increase in the ratio of reserves to GDP leads to a 0.43 percent decline in spreads. Reserves in excess of 49 percent of GDP do not longer have an impact on spreads. It is worth noting that most observations in the sample fall below this threshold (except Hong Kong SAR, Malaysia, Lebanon, and Algeria for some recent years). This means that most economies continue to benefit from reserve accumulation, even at current levels.

Reserves to months of imports: The threshold level of reserves above which they no longer reduce spreads is estimated at 6.3 months of imports, twice as large as the traditional rule of thumb. This threshold is very close to the average optimal level of reserves found in Section III. The spreads-reserves elasticity below 6 months of imports is 33 percent. In 2006, the level of reserves of some important Asian economies (e.g., Indonesia, Thailand, the Philippines, and Hong Kong SAR) fell short of the estimated threshold, which provides a rationale for continued accumulation of reserves.

Reserves to broad money: For economies with reserves to broad money below 28 percent, the elasticity of spreads is 46 percent. Beyond this level, there is no evidence that further reserve accumulation contributes to reduce spreads. Again, the estimated threshold level is close to the average optimal level for Asia (32 percent of broad money) and is above the current reserve levels of many Asian economies, including China, Indonesia, India, Hong Kong SAR, and Vietnam.

Reserves to short-term debt: We find two significant thresholds using reserves in terms of short-term debt, both of them higher than the Guidotti rule. The estimates of the first and second reserve thresholds are 125 and 534 percent of short-term debt, respectively. The effect of the reserve ratio on spreads is found to be negative for the intermediate regime (elasticity of 31 percent) and insignificant for the first and third regimes. In other words, reserves need to be sufficiently high in order to find a significant effect in terms of

⁶ For the sake of simplicity and presentation, only the economies with the highest reserve ratios are presented in the Figure. Results for the remaining emerging economies in the analysis are available upon request.

⁷ The test of the null hypothesis of no threshold against the alternative of threshold is performed using a Wald test under the assumption of homoskedastic errors. Using 1000 bootstrap replications, the p-value for the threshold model was 0. This suggests that there is evidence of a regime change at the specified level of reserves.

reduced cost of borrowings. However, beyond the second threshold, there are no additional gains. In Asia, only China's reserves are above the second threshold level.

Table 6. Thresholds in the spreads-reserves relation

Reserves to	Threshold 1		Threshold 2		Reserve Adequacy Benchmark
	Estimate	Confidence interval	Estimate	Confidence interval	
GDP 1/	49	[23, 51]
Months of imports 2/	6	[2, 9]	3
Broad money 2/	28	[6, 85]	5-20
Short-term debt 2/	125	[112, 692]	534	[534, 535]	100
Foreign liabilities 3/	12	[12, 12.4]	52	[52, 66]	...
Fin. system deposits and equities 3/	13	[12, 14]	30	[14, 40]	...

1/ The marginal impact of reserves is negative and significant below threshold 1; there are insufficient observations to estimate the impact above the threshold.
2/ The marginal impact is negative below threshold 1 and not significant above the threshold.
3/ The marginal impact is not significant below threshold 1, negative between threshold 1 and 2, and insignificant above threshold 2.

Reserves to total foreign liabilities: A sample split based on the level of reserves to total external liabilities produces a first threshold at 12 percent, and a second threshold at 52 percent. The middle point of this range coincides with the average optimal level found in the previous section. We find a very negative and significant impact of reserves on spreads in the intermediate range (elasticity of 42 percent). Under the first and third regimes the debt coefficients are not statistically different from zero. It is worth noting that the thresholds are estimated with a higher level of precision than the previous indicators, as evidenced by the narrow 95 percent confidence intervals. Under this indicator, only the current levels of reserves in China and Taiwan Province of China cannot be explained in terms of their benefits in reducing spreads.

Reserves to financial system deposits and stock market capitalization: Two relevant thresholds are found, at 13 percent and 30 percent, respectively. The elasticity in the intermediate regime is 61 percent and is not statistically significant from zero in the other two. As before, the coefficients are estimated with great precision, as indicated by the thresholds' confidence intervals.

A word of caution regards the use of some of the threshold point estimates as benchmark values for policy purposes: the confidence intervals for some of the threshold parameters are sufficiently large that there is considerably uncertainty regarding their true values. However, the estimates using the new reserve adequacy indicators are estimated with much higher precision than the more traditional ones, especially in terms of gross foreign liabilities.

This exercise has analyzed the impact of the accumulation of reserves on the service costs of the stock of sovereign debt. Therefore, it provides a lower bound estimate of the benefits of reserves in terms of lower financing costs, since it does not incorporate similar gains in the private sector.

V. CONCLUSIONS

The paper has presented evidence that to a large extent explains Asia's large reserve accumulation since the 1997–98 crisis through the precautionary motive. Current reserve holdings in most of Asia (excluding China) are not seen excessive when compared with levels predicted by a simple model of optimal reserves applied to specific country and regional characteristics. By mitigating the potentially large welfare costs of crises, reserves provide benefits in terms of insurance that more than compensates economies for the opportunity cost of holding liquid assets. The reserve accumulation observed so far in Asia (excluding China) reflects largely (though not entirely) this favorable trade-off, which has continued even at relatively high levels of reserves as a result of moderate opportunity costs.

When the large increase in the size and volatility of foreign liabilities—against which reserves provide insurance—is taken into consideration, the case for a precautionary motive behind the reserve accumulation over the last decade is reinforced. Furthermore, the benefits of reserves in terms of reduced spreads on privately held external debt, and thus borrowing costs, further justifies most of the observed growth in reserves. The paper finds that a majority of economies in Asia continue to benefit from reduced spreads, as evidenced by the high estimated threshold levels beyond which no further gains are realized.

Notwithstanding these results, the paper concurs with the conclusions in WEO 2003 that a slowdown in the pace of accumulation in Asia is now desirable. Even though current reserves are not “too high” in most economies, they are close to or have recently reached optimal reserves levels as predicted by the insurance model, suggesting that going forward accumulation at the same rapid pace could result in excess reserves. Nevertheless, there is some indication that a deceleration has already started to take place, as evidenced by the leveling off of some reserve indicators and the decline in some others since 2003–04, which makes reserves in Asia (excluding China) in line with emerging market in the rest of the world. To the extent that capital flows and economies' foreign liabilities continue to increase we should expect reserves to continue to mount in nominal terms. However, assuming an optimal response according to the predictions of the model, we are likely to see stabilization or even a moderate decline in reserve ratios going forward.

The paper casts doubt on the use of the traditional rules of thumb to assess reserve adequacy. The reason is three-fold: first, country-specific optimal reserve ratios are found to be significantly above 3 months of imports, 100 percent of external short-term debt or 20 percent of broad money. In light of these findings, the traditional rules of thumb appear more arbitrary than ever. Second, these indicators fail to capture recent developments in financial markets, namely: increased vulnerability to large capital flows and the different nature of the potential balance of payments shocks against which reserves provide insurance. We have argued that the precautionary aspect of reserves is better captured by measuring reserves against total foreign liabilities. Finally, country-tailored reserve adequacy indicators seem more appropriate than standardized rules of thumb, in particular given the different country exposure and vulnerability to sudden stops as well as the heterogeneity in opportunity costs (as measured by external spreads or sterilization costs) across Asian economies.

As other papers before, our analysis cannot fully explain the large stock of reserves in China, neither from an insurance standpoint nor when accounting for the benefits of reserves in terms of reduced spreads. This paper has attempted to differentiate China from the rest of emerging Asia, usually lumped together in the literature, and has largely focused on explaining reserve accumulation in the latter. The motivations, other than precautionary, behind the reserve buildup in China are to be explored in future research.

A word of caution regards the use of the estimated country-specific optimal reserve ratios or the threshold point estimates as benchmark values for policy purposes: the results of the calculation are sensitive to the choice of model parameters and the confidence intervals for threshold estimates are often sufficiently large that there is uncertainty about their true value. Moreover, in some cases regional averages, rather than country-specific estimates, were used for consistency purposes or data limitation reasons.

An aspect not discussed in the paper, but with potential implications for the current global credit crunch, is the positive spillover dimension of reserve accumulation. The reserve buildup has contributed to reduce external vulnerabilities in all emerging market economies in Asia and, as a result, is helping to maintain financial stability in the region as a whole. Not only are individual economies better prepared to weather a sudden stop of capital flows, but the risk of financial contagion in the region may have decreased as a result of the reserve accumulation.

Finally, this paper has abstracted from addressing issues surrounding the emergence of sovereign wealth funds (SWFs). However, the fact that the largest funds in Asia are China, Singapore, and Malaysia is not surprising in view of our results that suggest that these economies have just reached or exceeded recommended reserves levels. Our paper has also implications for the near future growth of these funds. Since other Asian economies are close to their optimality thresholds, the same rapid pace of accumulation observed so far could result in a very large growth in the pool of assets managed by SWFs, assuming excess reserves are directed to SWFs. The potential impact of this trend for the global economy and global financial stability is an aspect to be explored in future research.

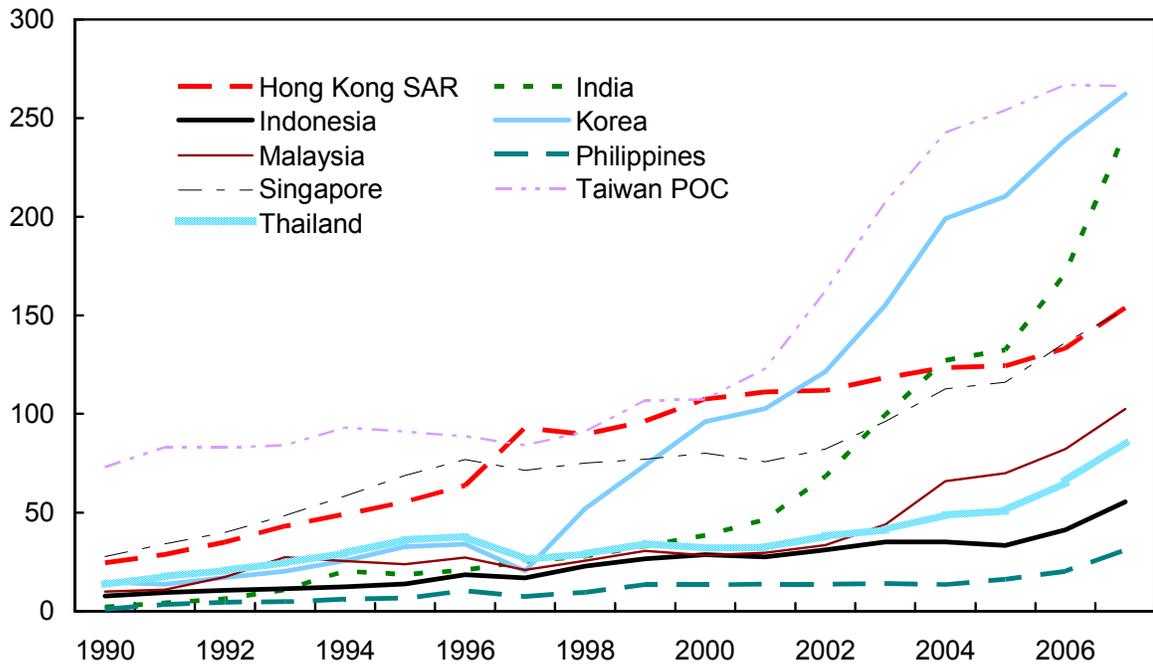
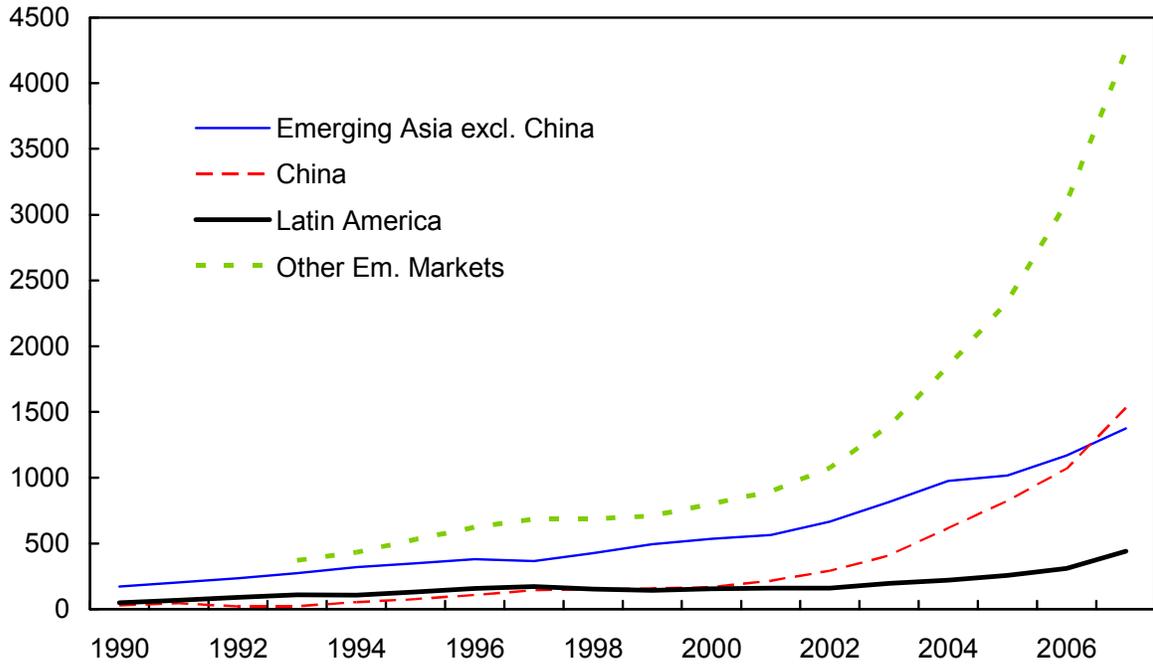
	GDP	Months of Imports		Broad Money		Short term debt		
Thresholds	< 49	< 6.3	> 6.3	< 28.3	> 28.3	< 125	[125, 534]	> 534
Spreads-reserves elasticity	-0.425*** (0.11)	-0.329*** (0.12)	-0.004 (0.37)	-0.463*** (0.17)	0.167 (0.25)	-0.31 (0.20)	-0.311* (0.19)	-0.531 (0.37)
Observations	286	176	112	151	144	80	169	38
R-squared	0.53	0.5	0.46	0.42	0.46	0.24	0.6	0.7

Note: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

	Total foreign liabilities			Financial system deposits and equities		
Thresholds	< 12	[12, 52]	> 52	< 13	[13, 30]	> 30
Spreads-reserves elasticity	-0.13 (0.15)	-0.419** (0.19)	-0.253 (0.71)	0.035 (0.18)	-0.609* (0.32)	0.259 (0.24)
Observations	82	182	12	47	132	74
R-squared	0.33	0.6	0.77	0.46	0.49	0.6

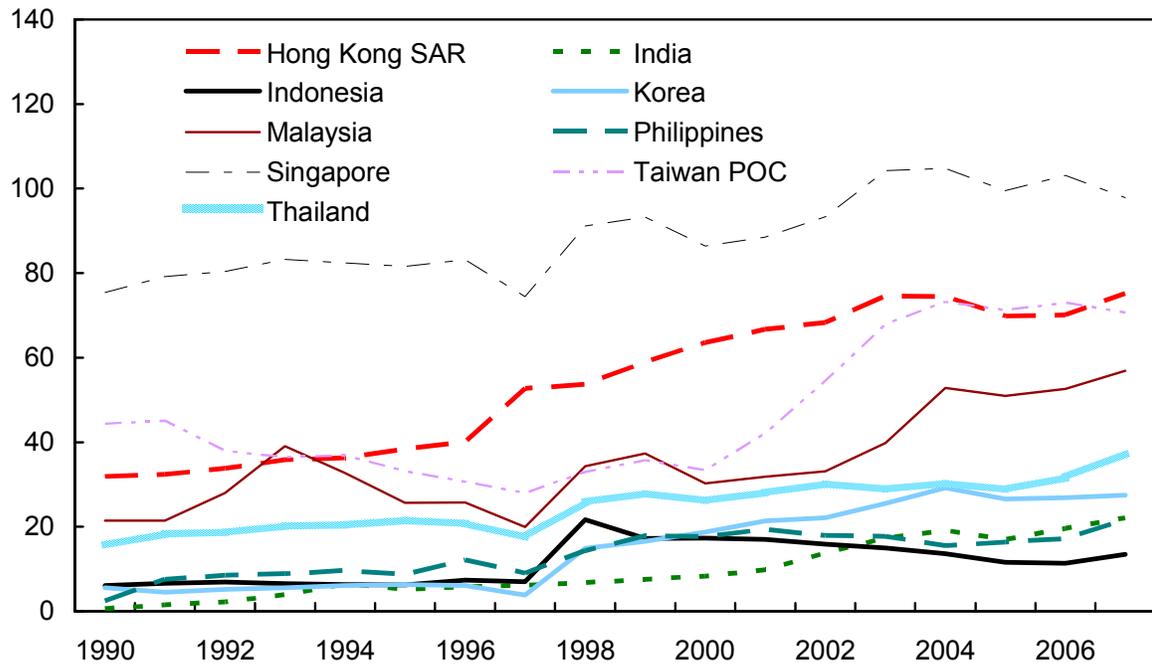
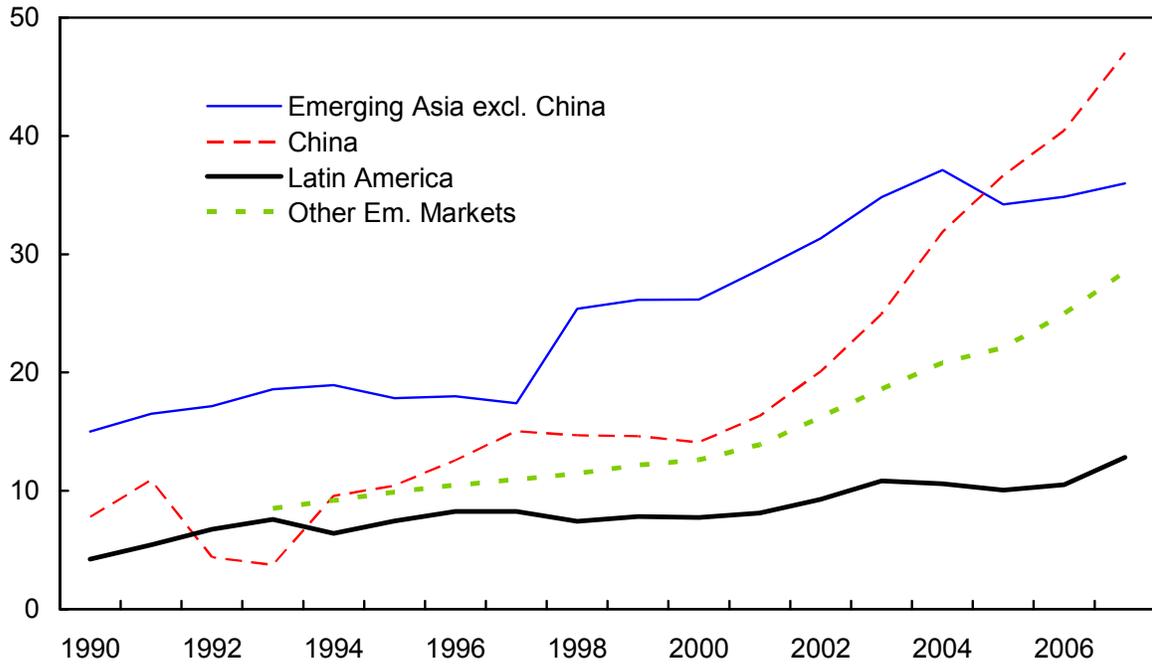
Note: Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Figure 1. Reserves, 1990–2007
(In millions US dollar)



Sources: IMF, *World Economic Outlook*; and Fund staff calculations.
Note: Taiwan POC stands for Taiwan Province of China.

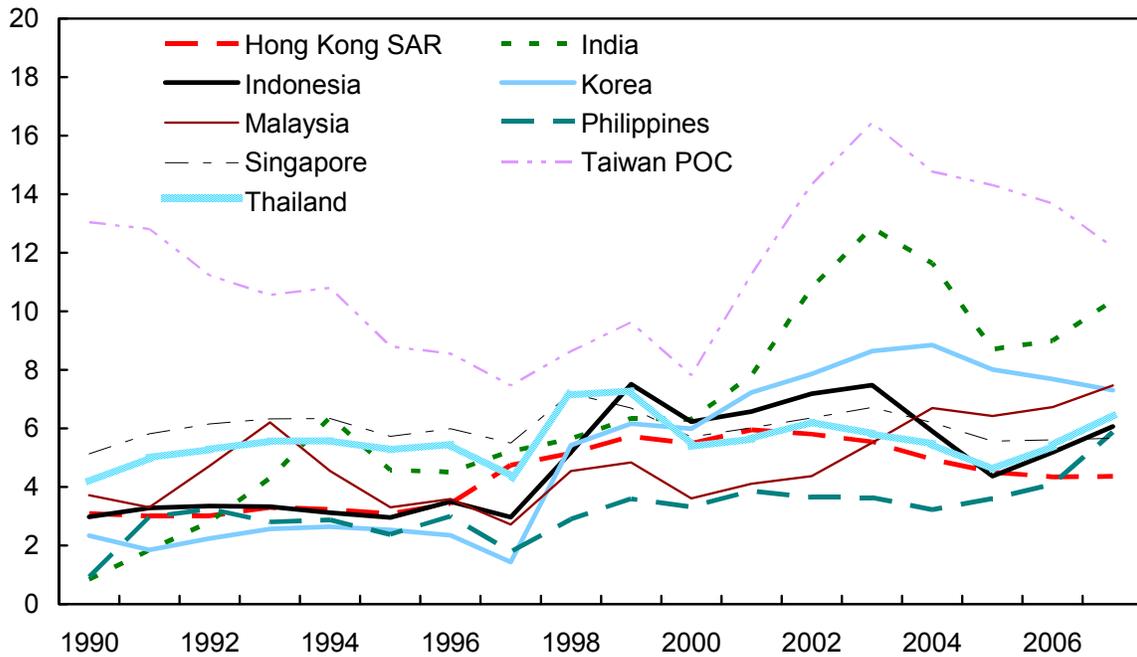
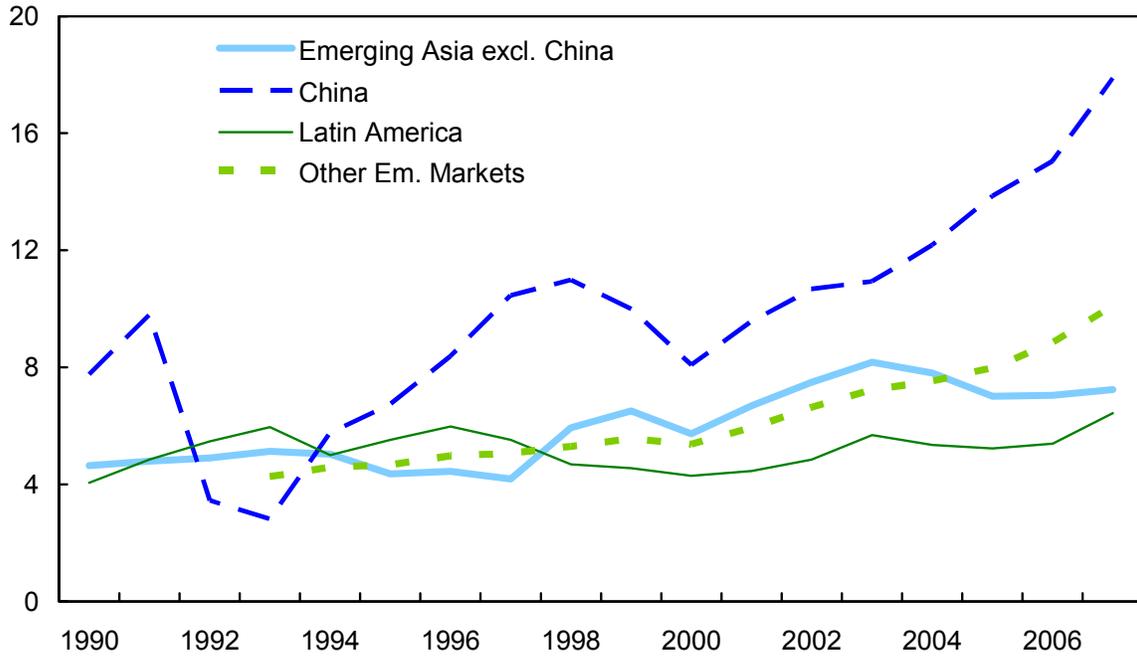
Figure 2. Reserves, 1990–2007
(In percent of GDP)



Sources: IMF, *World Economic Outlook*; and Fund staff calculations.

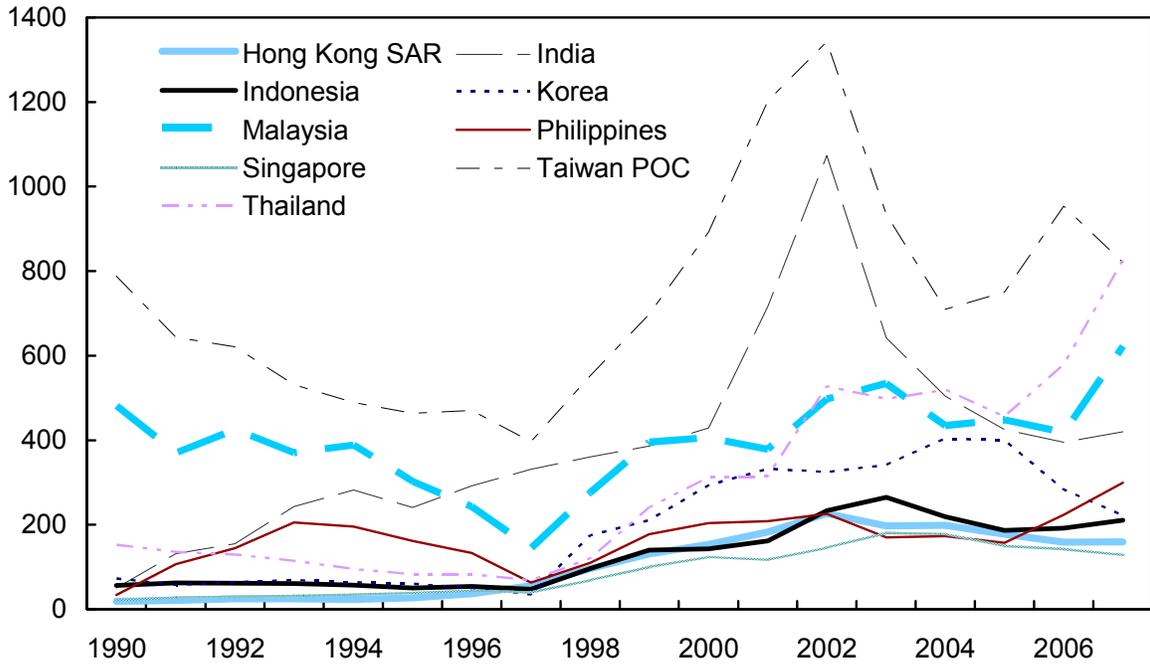
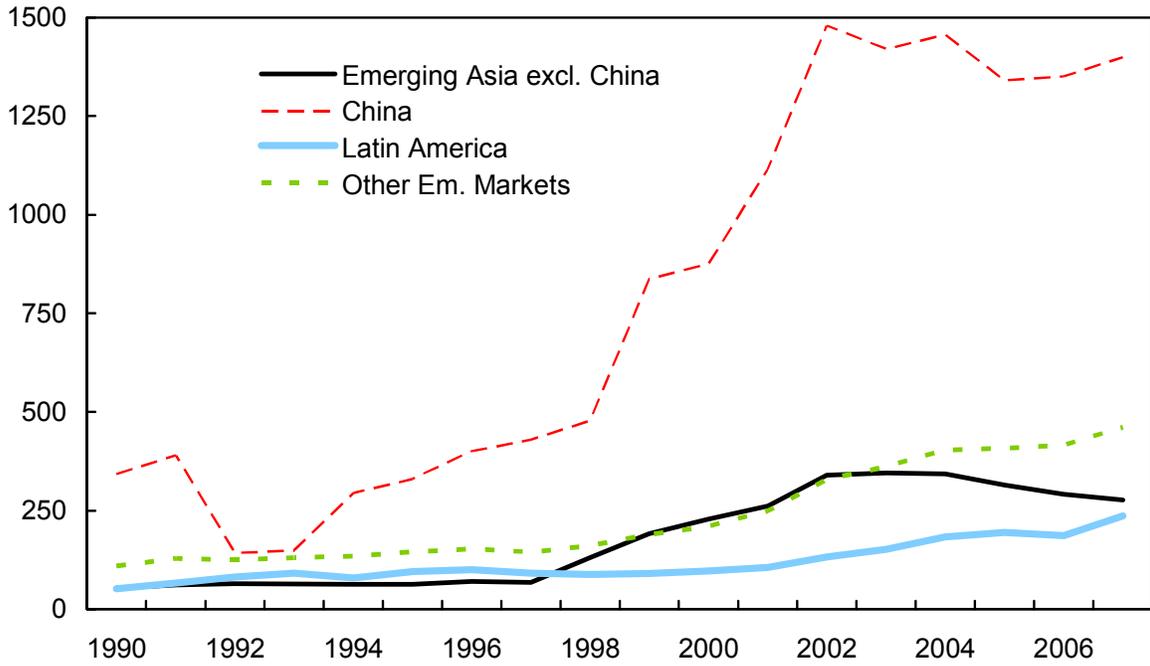
Note: Taiwan POC stands for Taiwan Province of China.

Figure 3. Reserves, 1990–2007
(In months of imports of goods and services)



Sources: IMF, *World Economic Outlook*; and Fund staff calculations.
Note: Taiwan POC stands for Taiwan Province of China.

Figure 4. Reserves, 1990–2007 1/
(In percent of short term debt)

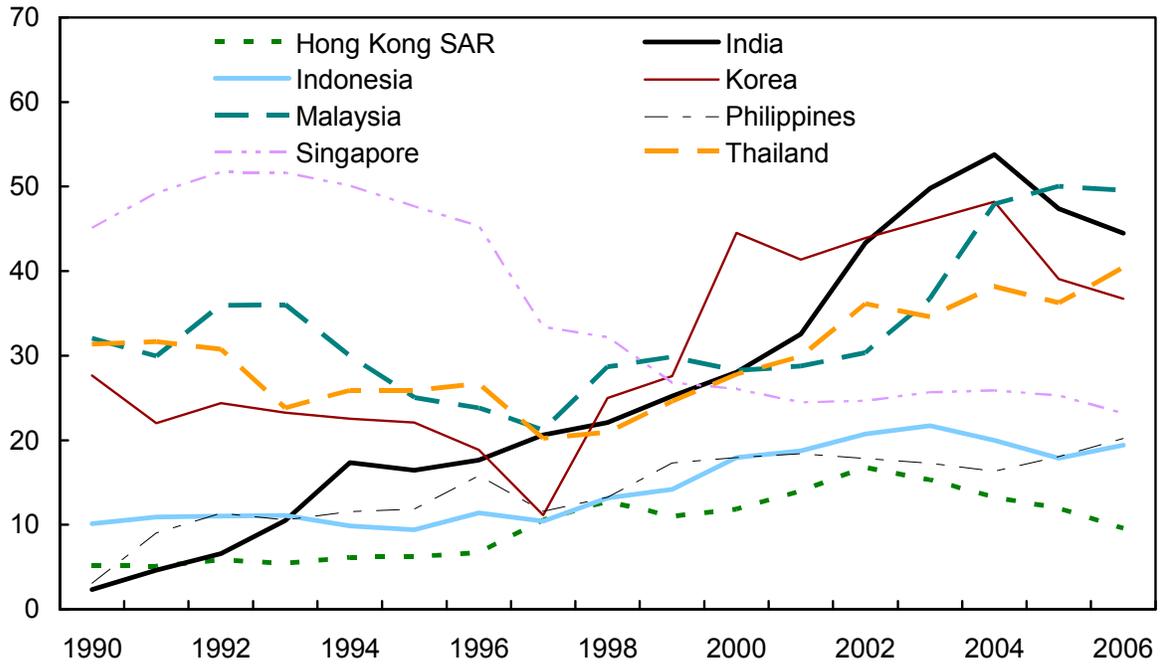
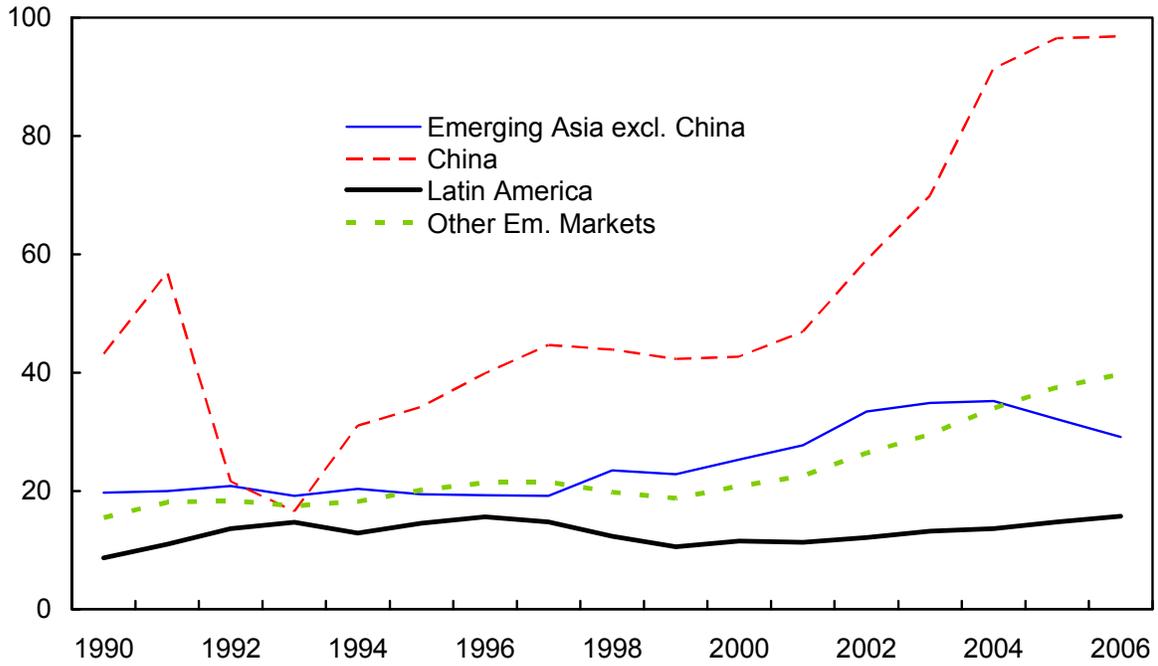


Sources: IMF, *World Economic Outlook*; Bank for International Settlements; and Fund staff calculations.

Note: Taiwan POC stands for Taiwan Province of China.

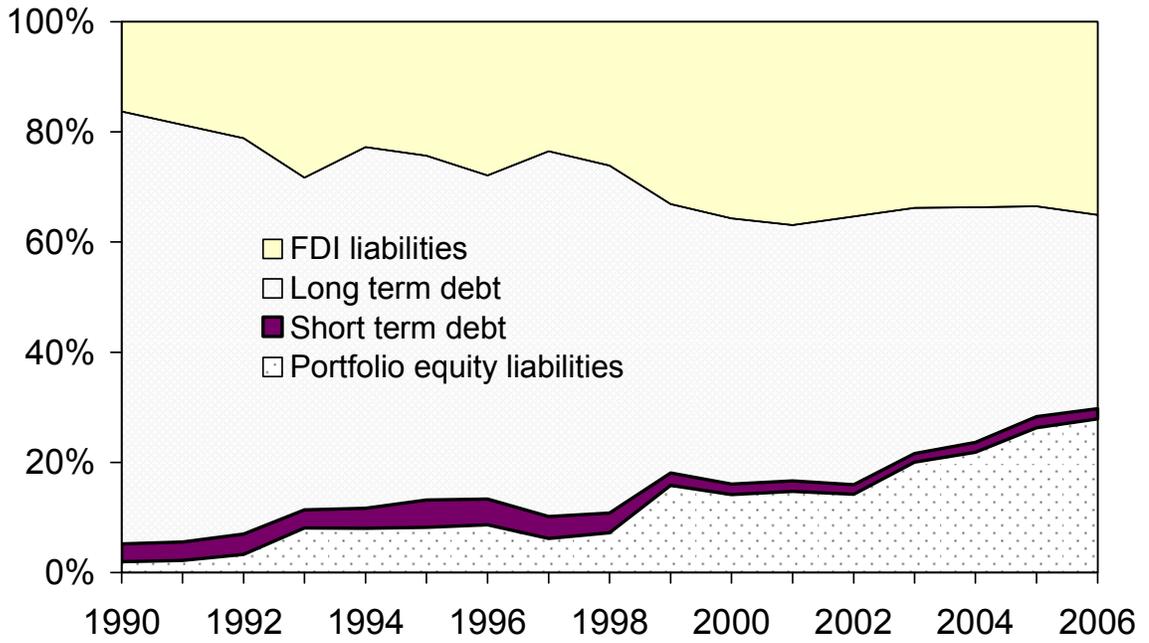
1/ 2007 data is as of September.

Figure 5. Reserves, 1990–2006
(In percent of gross external liabilities)



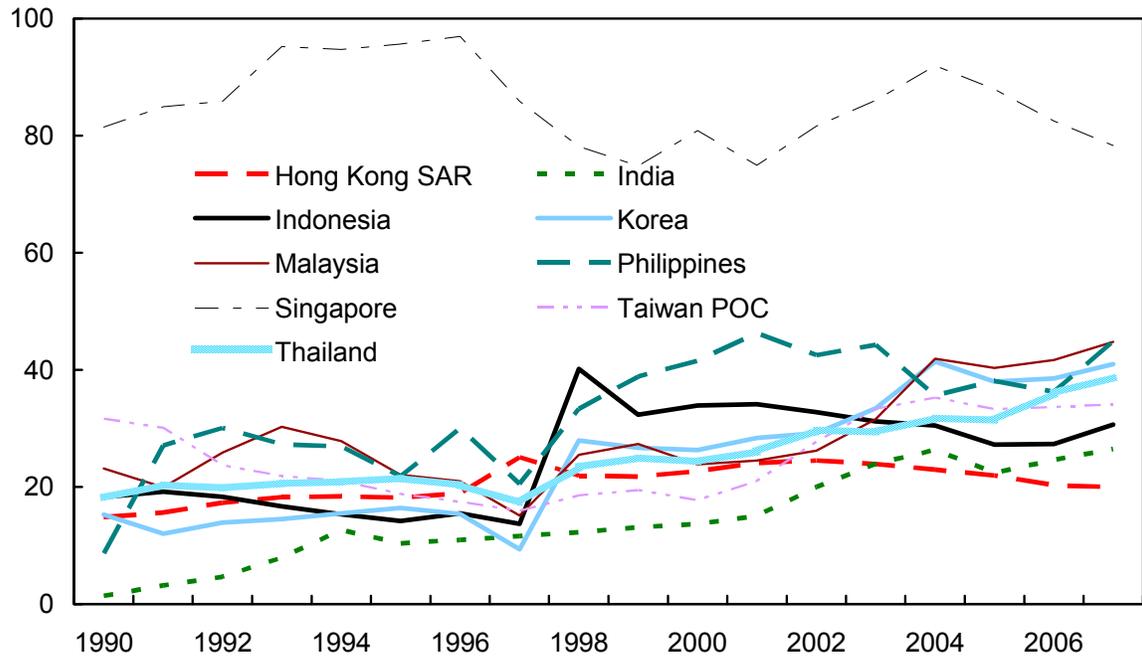
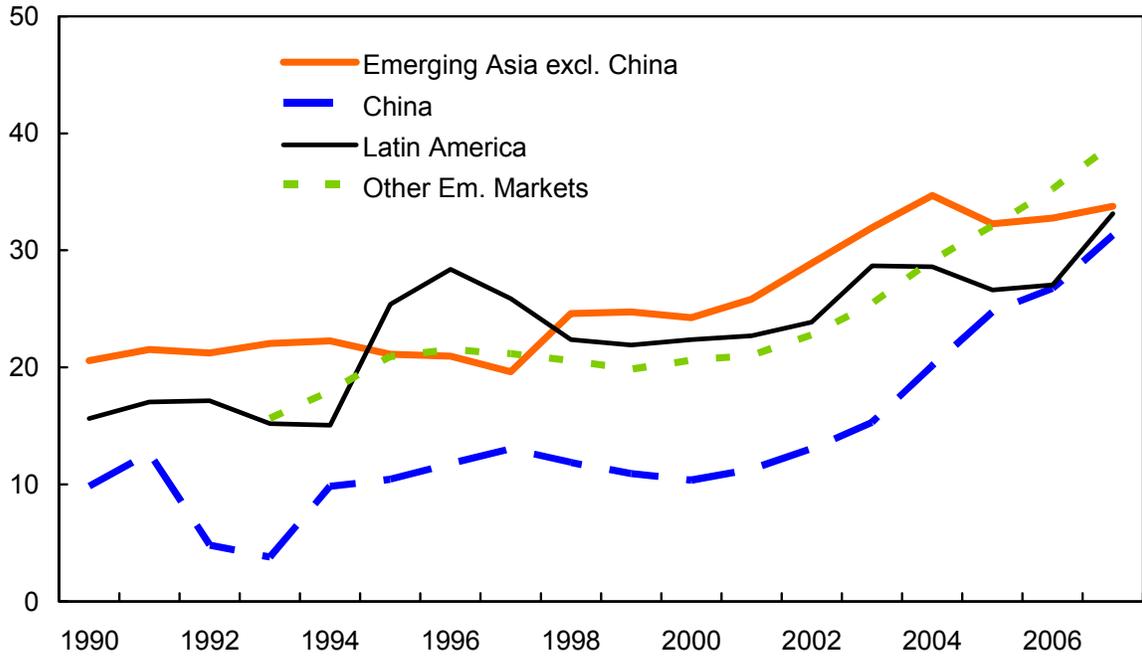
Sources: IMF, *World Economic Outlook*; Milesi-Ferretti data; and Fund staff calculations.
Note: Taiwan POC stands for Taiwan Province of China.

Figure 6. Asia Emerging Markets: External Liabilities, 1990–2006



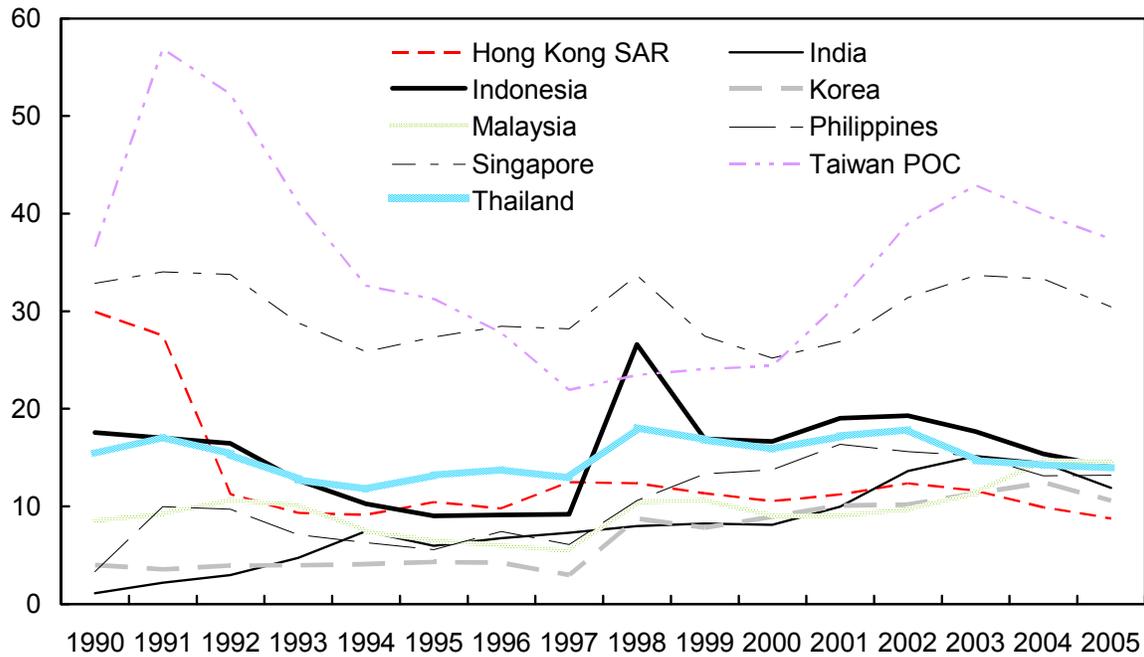
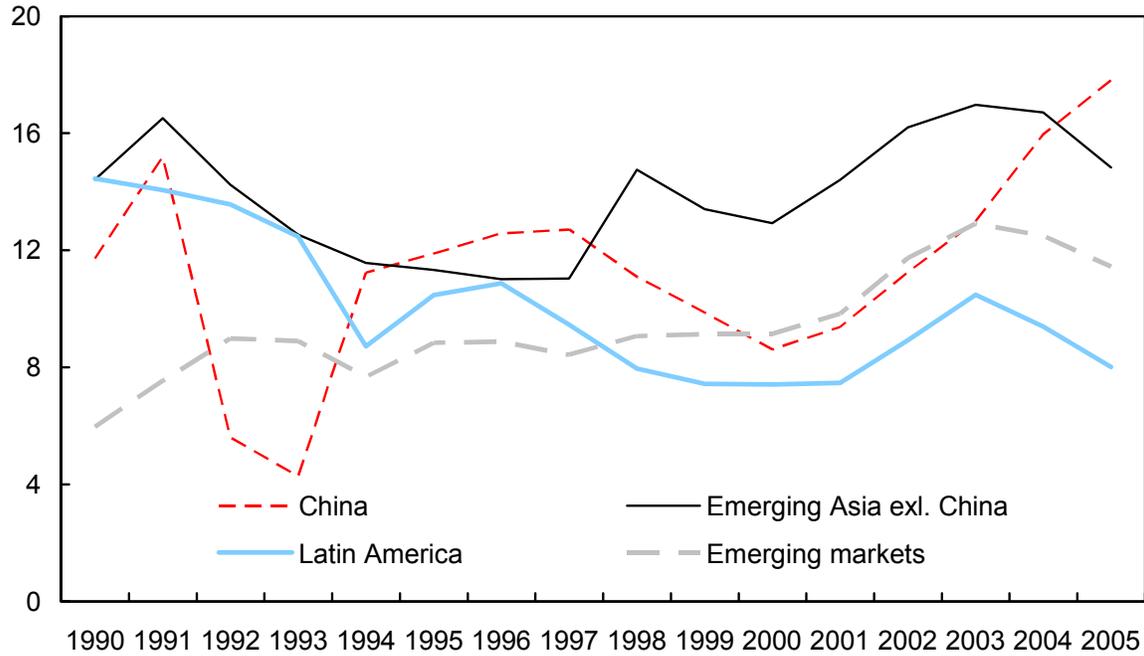
Sources: IMF, *World Economic Outlook*; Milesi-Ferretti data; and Fund staff calculations.

Figure 7. Reserves, 1990–2007
(In percent of broad money)



Sources: IMF, *World Economic Outlook*; and Fund staff calculations.
Note: Taiwan POC stands for Taiwan Province of China.

Figure 8. Reserves to Financial System Deposits, Equities, and Bonds, 1990–2005
(In percent)



Sources: IMF, *World Economic Outlook*; World Bank, *Financial Development and Structure Dataset*; and Fund staff calculations.

Note: Taiwan POC stands for Taiwan Province of China.

Figure 9. The Optimal Level of International Reserves, 2007
(In billions US dollar)

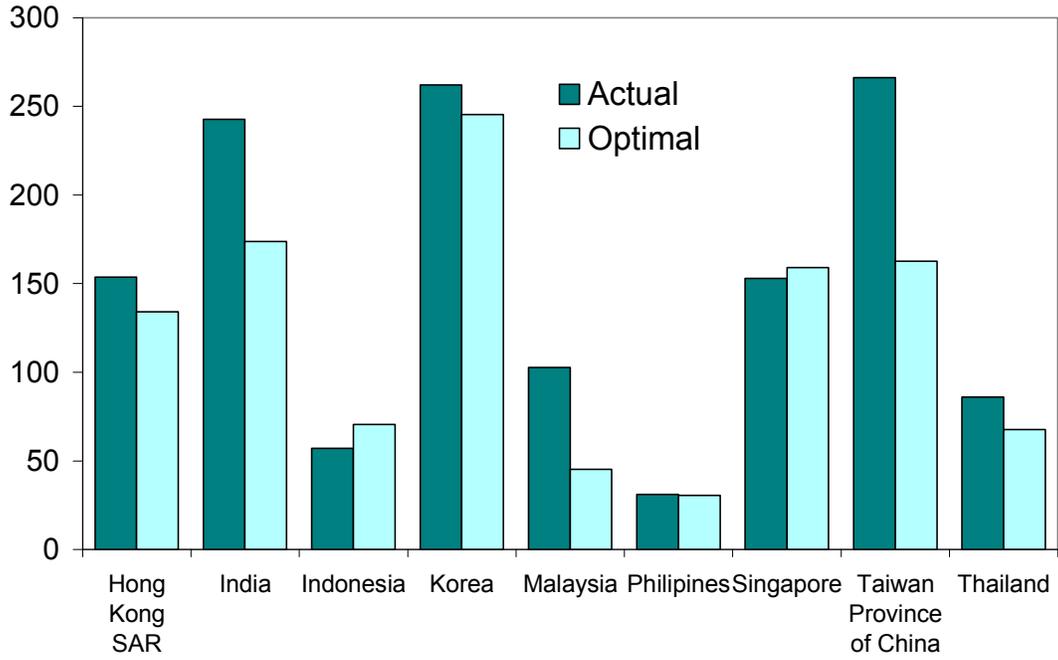


Figure 10. Optimal Vs. Actual Levels of International Reserves in Asia
(In billions US dollar)

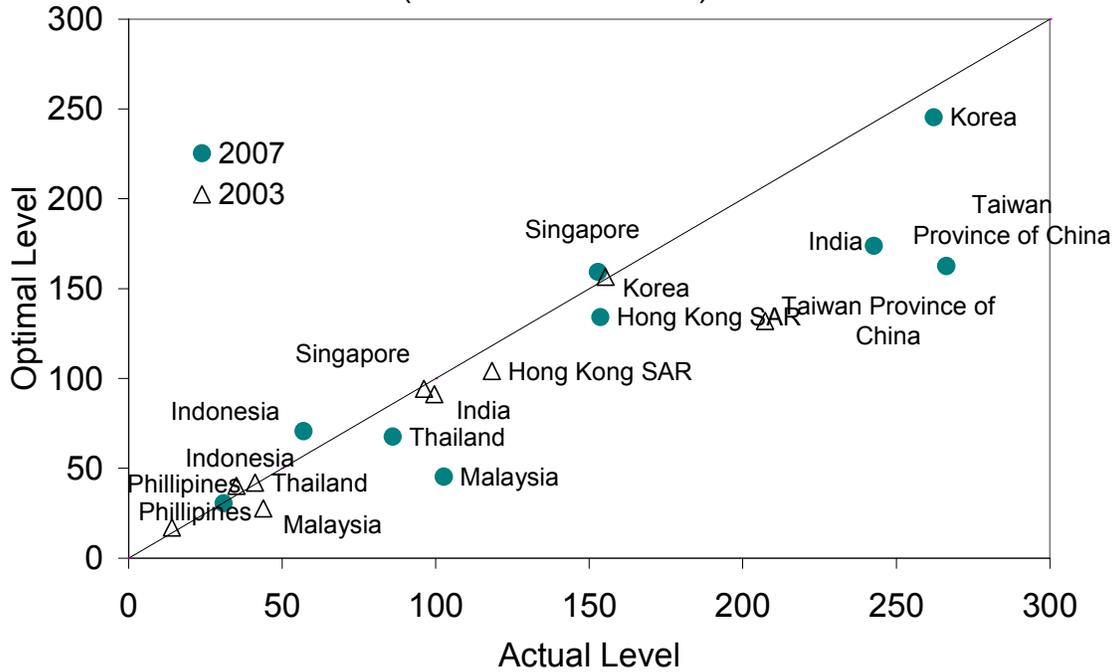
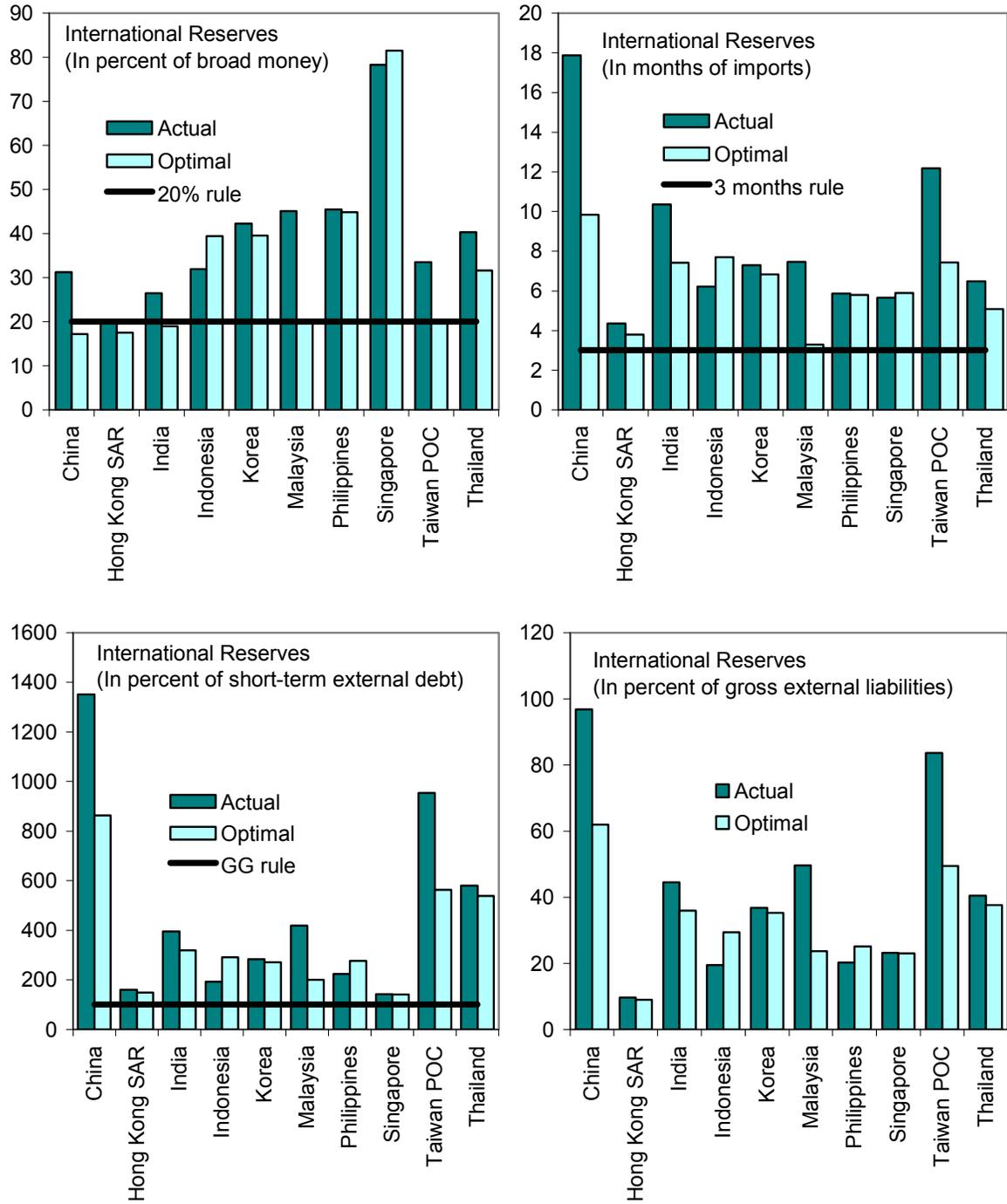
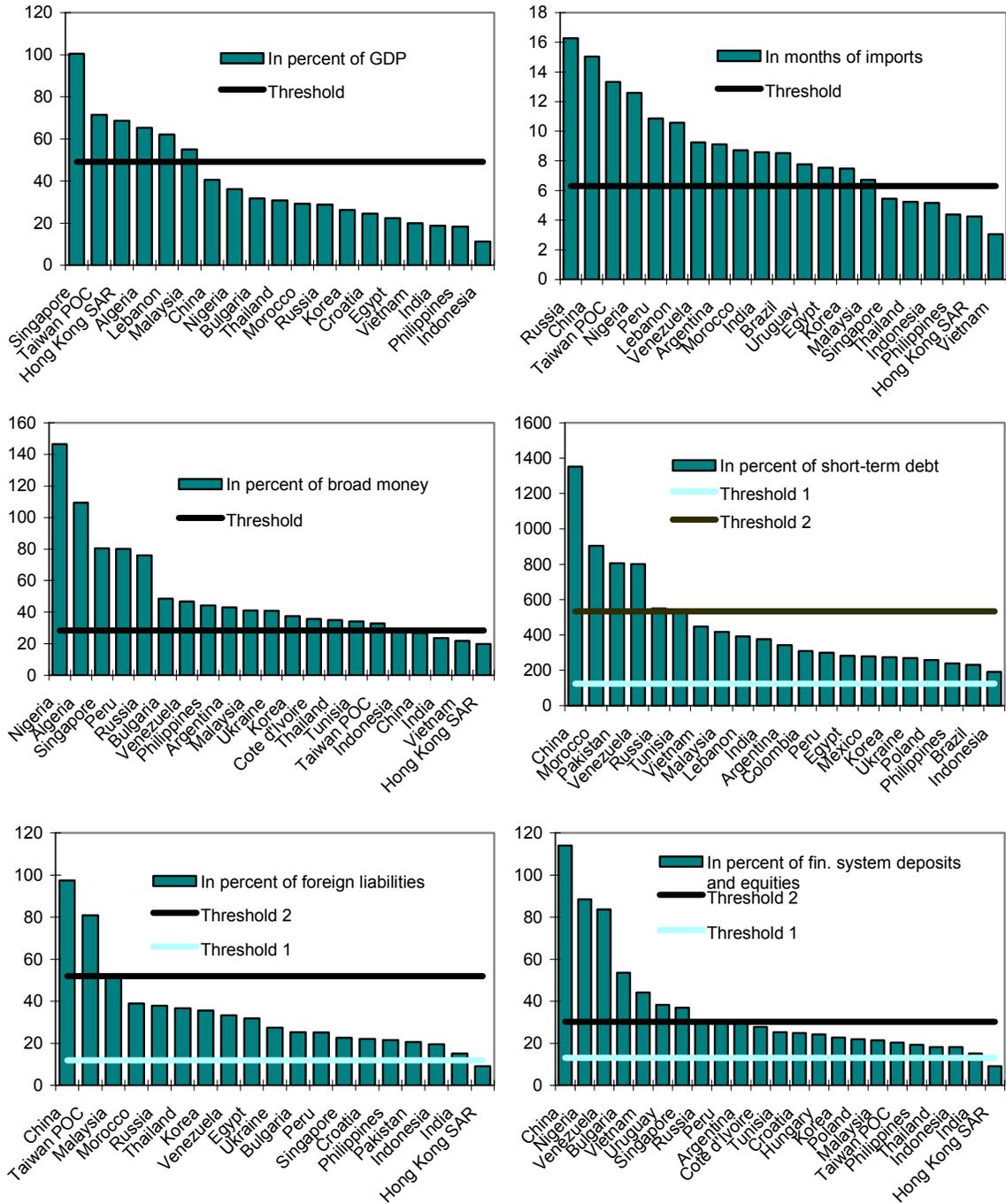


Figure 11. The Optimal Level of International Reserves and Traditional Reserve Adequacy Indicators



Sources: IMF, *World Economic Outlook*, Milesi-Feretti data; BIS; and Fund staff calculations.
 Note: Taiwan POC stands for Taiwan Province of China.

Figure 12. International Reserves and Threshold Estimates



Sources: IMF WEO; Milesi-Feretti data; BIS, and Fund staff calculations.
 Note: Taiwan POC stands for Taiwan Province of China.

APPENDIX

Table A1. Variable definitions and sources

Variable	Description	Source
Spread	JP Morgan EMBI spread in bps	Bloomberg, Datastream
10Y U.S. T-bond	U.S. Treasury note, 10 year maturity	U.S. Treasury
Risk aversion	CSFB high yield spread	Bloomberg
Reserves	International reserves	IMF, WEO
GDP growth	GDP growth	IMF, WEO
Debt	Sovereign debt stock	IMF, WEO
Imports	Imports of goods and services	IMF, WEO
Broad money	M2	IMF, WEO
Short-term external debt	External debt maturing within one year	BIS
Foreign external liabilities	Gross external liabilities	Milessi-Feretti IIP Database
Fin. System deposits and equity	Total deposits and market capitalization	World Bank

Table A2. Summary statistics

	Obs	Mean	Std. Dev.	Min	Max
Sovereign spread	320	514.9	823.8	-260.9	6182.0
U.S. 10Y bond rate	320	4.7	0.7	4.0	6.3
High yield spread	320	584.7	240.6	329.2	950.8
GDP growth	320	4.1	3.9	-11.0	18.3
Debt to GDP	310	93.5	265.5	4.9	2101.7
Reserves to GDP	320	22.0	19.9	1.5	104.5
Reserves to months of imports	320	6.4	4.1	0.3	35.3
Reserves to short-term debt	320	395.4	659.4	6.5	7530.8
Reserves to broad money	320	35.5	22.9	2.9	146.3
Reserves to foreign liabilities	298	25.8	36.8	2.0	490.5
Reserves to fin. system deposits and equities	248	28.5	22.2	1.6	113.9

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