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Are All Measures of International Reserves Created Equal? An Empirical Comparison of International Reserve Ratios

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Abstract:

Using available annual data of 174 economies since 1957, we examine the similarities and differences of seven international reserve ratios. While individual international reserve ratios display substantial variations across economies, they are associated with an economy's characteristics including geographic location, income level, stage of development, degree of indebtedness, and exchange rate regime. The association pattern varies across time and type of international reserve ratios. Interestingly, there is only limited evidence that Asian and non-Asian economies have significantly different international reserve hoarding behavior. Our results suggest that the inference about whether an economy is hoarding too many or too few international reserves depends on the choice of international reserve ratio. Further, different international reserve ratios exhibit different persistence profiles, but the evidence of dependence on structural characteristics is rather weak.

JEL: F30, F40
Keywords: International reserve ratios; structural characteristics; cross-economy analysis

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1 Introduction

In the aftermath of the 1997 East Asian financial crisis, economies in the region appear to have pursued preemptive policies against future speculative attacks and sharply boosted their international reserves. For instance, China, Japan, Korea, Malaysia and Taiwan, the economies that are commonly mentioned in the recent discussion of the extraordinary and puzzling accumulation of international reserves, increased their international reserves by, respectively, 388%, 133%, 107%, 119% and 138% between 2000 and 2005.[1] Some commentators relate the policy of building up international reserves to the observation that economies with a high level of international reserves survived the Asian financial crisis better than those with a low level (Feldstein 1999; Fischer 1999).

The steep increase in international reserves is generally difficult to reconcile with conventional measures of international reserve adequacy. One traditional indicator of the adequacy of international reserves is the reserves-to-imports ratio. The rule of thumb is to maintain international reserves worth three months of imports. At the end of 2005, the international reserves held by the five aforementioned economies covered approximately 15, 19, 10, 7, and 17 months of their imports respectively. Admittedly, the three-month rule is not based on rigorous theory. For most observers, however, the quoted reserves-to-imports ratios appear to be at an excessively high level. Although they help deter speculative attacks, excessive hoarding of international reserves can induce internal imbalances and aggravate global imbalances (Mohanty and Turner 2006; Dooley et al. 2005).

The traditional models of demand for international reserves are motivated by precautionary demand and trade financing.[2] The recent literature extends the precautionary motive and considers international reserve accumulation a policy to avoid crisis-induced output losses and investment contractions (Aizenman et al. 2004; Lee 2004). These models offer an additional reason for why the hoarding of international reserves is related to an economy's income level. Foreign liabilities are also deemed to be important determinants of the demand for international reserves. For instance, the popular Greenspan-Guidotti rule recommends that developing economies should hold sufficient international reserves to cover their short-term external debts. In general, it is advisable to cover the one year amortized value of various types of liabilities over a wide range of possible scenarios (Greenspan 1999).[3]

With increased global capital mobility, capital account transactions play an important role in determining the level of international reserves. Capital flights and flow reversals can trigger a crisis and amplify its adverse economic impacts. Calvo (1996) and de Beaufort Wijnholds and Kapteyn (2001) argue that the money stock in an economy is a proxy for potential capital flight by domestic residents. Thus, a reserves-to-money ratio is a good indicator of an economy's ability to withstand the internal drain of international reserves. In some earlier studies, the link between international

[1] At the end of 2005, Japan, China, Taiwan, and Korea were the four largest holders of international reserves. China overtook Japan to become the largest holder of international reserves in 2006.

[2] See, for example, Grubel (1971) for a survey of the pre-1970 studies. Flood and Marion (2002) review the theory and provide some recent empirical evidence.

[3] The rule follows from the former Federal Reserve Chairman Alan Greenspan's comments on Pablo Guidotti's insight into the role of external debts in 1999. Guidotti is a former Argentinean Deputy Minister of Finance.

reserves and money is motivated by the monetary interpretation of balance of payments: see, for example, Courchene and Youssef (1967) and Johnson (1958).

Dooley et al. (1995) report that the classification of capital flows into long-term and short-term categories is quite illusive. Capital reversals can happen to both short-term portfolio flows and perceived long-term foreign direct investment (FDI). One implication is that the discussion of capital reversals should be based on gross instead of net capital inflows.

Even a cursory glance at the recent literature leads to several international reserve ratios that are deemed important for assessing the adequacy of international reserves. With a multitude of measures, which one should we use? The answer to the question depends on whether we have a theory on the optimal level of an international reserve ratio. Apparently, there is no generally accepted theory yet. For example, we do not have a model that explains the wide variation of, say, reserves-to-imports ratios across economies.

A related question is: Do these different measures offer the same inference about the adequacy of an economy's holding of international reserves? If they do not, then on what basis should the adequacy of an economy's holding be evaluated?

It is hard to perceive how far one can go in discussing the adequacy of international reserves without knowing which is the appropriate measure and what to do when different measures give different inferences. Apparently, most discussions of international reserves; especially in the media and in policy debates, do not address explicitly these issues.

We have no illusion that the choice of an optimal/appropriate measure can be determined easily. Indeed, the current exercise does not address the question of an "optimal" international reserve ratio. Rather, our objective is a moderate one—to compare these international reserve ratios and assess their cross-economy variability. The exercise is of exploratory nature. We do not attempt to fit our findings to any specific theory of international reserves. Nevertheless, we conceive that an examination of the historical data on international reserves helps illustrate the complexity of the choice of a measure of international reserves and reveals useful information on cross-economy reserve holding patterns. To be sure, a deeper understanding of the issue requires an analysis that is more vigorous than the one pursued in the current study.

One of the main themes of our exercise is to examine whether the advocated measures of international reserves are related to the structural characteristics of an economy, such as its geographic location and stage of development. The dependence of economic performance on structural characteristics has been documented in the literature (Granovetter 2005; North 1990, 1994). In the current context, for example, it is commonly perceived that developing and Asian economies hold relatively more international reserves than other economies due to their unique financial market conditions, structure of external debts, and policy preferences.

Another issue to consider is whether these international reserve ratios provide essentially the same information about an economy's level of international reserves. Specifically, we investigate whether these international reserve ratios provide an economy with similar rankings relative to other economies? If they do, then we could stay with one measure and focus on the determination of its optimal level rather than working with several measures. If they offer different assessments, then we have to address the question of which ratio should be used to evaluate the adequacy of an

economy's holding of international reserves. However, there is no *a priori* reason to believe that these ratios would provide the same assessment. It is of interest to check it with the data.

The third issue the paper addresses is the persistence of international reserve ratios. It is well known that data persistence has significant implications for empirical analyses. A variable that displays a high level of persistence implies that shocks to the variable have a prolonged effect on its dynamics. The shocks are of transitory nature if, on the other hand, the variable is not persistent. Further, the interpretation of regression results can depend on whether the variables involved have a high or low level of persistence. For instance, if the variables are highly persistent, then one should be aware of the possibility of "spurious" regression. To shed some light on this dynamic property of international reserve ratios, we assess the persistence profiles of the international reserve ratios and examine if they are related to an economy's structural characteristics.

In the next section, we introduce the seven international reserve ratios and the five structural characteristics of an economy that are considered in the current exercise. Some preliminary analyses of the data on international reserve ratios and their interactions with structural characteristics are also presented. Section 3 analyzes the international reserve ratios in terms of their dependence on structural characteristics, their relative rankings, and their persistence profiles. Concluding remarks are offered in Section 4.

2 Data and Preliminary Analyses

In this and the next section, we study the annual data on international reserves including gold of 174 economies from 1957 to 2004. Due to data availability, some exercises are based on a smaller sample of economies and a shorter time period. Let $R_{i,t}$ be economy i's holding of international reserves R at time t. In most of the subsequent analyses, the subject of our investigation is an international reserve *ratio* defined by

$$r_{i,j,t} = \frac{R_{i,t}}{Z_{j,t}}$$

where $Z_{j,t}$ is the normalizing variable j at time t. Based on the existing literature, we consider seven normalizing variables: a) imports, b) total foreign liabilities, c) short-term external debts, d) cumulative (gross) FDI inflows, e) money supply M2, f) population, and g) nominal GDP in US dollar. Data on international reserves, FDI inflows, nominal exchange rates, and M2 were from *International Financial Statistics*, imports data were from the *Directions of Trade* database, data on total foreign liabilities were from Lane and Milesi-Ferretti (2006), and short-term external debts were from the *Joint BIS-IMF-OECD-WB Statistics on External Debt* database. The short-term external debts consist of liabilities to banks, debt securities issued abroad, and non-bank trade credits that have maturity of one year or less.

We focus on five structural characteristics of an economy and examine their degrees of association with the seven aforementioned international reserve ratios. These characteristics are a) geographic region, b) income level, c) level of indebtedness, d) stage of development, and e) exchange rate regime.

For geographic region, the economies are grouped into five regions: a) Asia, Pacific and South Asia, b) Europe and Central Asia, c) Latin America and Caribbean, d) Middle East and North Africa, and e) Sub-Sahara Africa. Partly due to the hype surrounding international reserve holdings among Asian economies, we also compare the behavior between Asian and non-Asian economies.

The income levels follow the World Bank classification: a) low income, b) middle income, and c) high income categories.[4]

Data on the level of indebtedness are from the *World Development Indicators* that classifies economies into three indebtedness categories: a) severely indebted, b) moderately indebted, and c) less indebted.[5]

The stage of development is identified by the IMF classification of developed and developing economies.

Our exchange rate regime classification is based on the scheme proposed by Reinhart and Rogoff (2002). To facilitate analysis, we grouped their categories into three broad classifications of a) rigid, b) limited flexibility, and c) floating exchange rate arrangements.[6]

Section A of Appendix 1 lists the economies under these classifications of structural characteristics. The economies under the exchange rate regime characteristic are listed for three sub-periods because most economies adopted more than one regime during the full sample period. Section B of Appendix 1 gives the pair-wise contingency coefficient estimates between these characteristics. The contingency coefficient is derived from the usual contingency table test statistic; the significance of the former follows from that of the latter. One benefit of using the contingency coefficient is that it allows us to gauge the strength of association. The coefficient assumes a value between 0 and 1; 0 implies no association and 1 perfect association. Section A of Appendix 4 gives a brief description of the contingency table test and the corresponding contingency coefficient. In general there is a moderate correlation between these structural characteristics—the contingency coefficient estimates are between 0.4 and 0.6. The association between the Asia and non-Asia classification and other structural characteristics appears the weakest. With the obvious exception of geographic region, the Asian and non-Asian economies do not exhibit large differences in income, indebtedness, or stage of development.

2.1 Aggregate International Reserves

By the end of 2004, there were more than US$4,100 billion global international reserves—approximately half of them were accumulated between 2000 and 2004. To gauge a general picture, we first examine the levels of international reserves $R_{i,t}$'s.

[4] The "middle income" group consists of the "lower middle" and the "upper middle" subgroups. The "high income" group is a combination of the "high income OECD" and the "high income non-OECD" subgroups.

[5] We did not consider the category "not classified."

[6] "Rigid" comprises a) no separate legal tender, b) pre-announced peg/currency board, c) pre-announced horizontal band $\leq \pm 2\%$, d) *de facto* peg, e) pre-announced crawling peg, and f) pre-announced crawling band $\leq \pm 2\%$. "Limited flexibility" comprises a) *de facto* crawling peg, b) *de facto* $\pm 2\%$ crawling band, c) pre-announced crawling band $> \pm 2\%$, d) *de facto* crawling band $> \pm 2\%$, and e) moving band $\leq \pm 2\%$. "Floating" comprises a) managed floating, and b) freely floating.

Figures 1 to 5 present the distributions of international reserves sorted by individual structural characteristics. The first four figures give the snapshots of four selected years: 1985, 1996, 2000 and 2004. Because of data availability, Figure 5 graphs the distributions across exchange rate regimes at 1975, 1985, 1995, and 2000.

Figure 1 plots the distributions of global international reserves across the five geographic regions. As expected, the "Asia, Pacific, and South Asia" region accounts for an increasing share of global international reserves. It surpassed the "Europe and Central Asia" region and became the region that held the largest share of global international reserves in 1996. In 2004, it accounted for 64% of the world's international reserves.

Figures 1.a to 1.c provide additional information on the rising clout of Asian economies. Figure 1.a shows that the share of global international reserves held by Asian economies jumped significantly from 17% in 1985 to 60% in 2004. With Japan as the only developed economy in our Asian sample, the Asian developing economies appear to be significant contributors to the increase in Asia's share of global international reserves.

Figure 1.b focuses on the role of Asian developing economies in the hoarding of international reserves. The share of global international reserves accumulated by Asian developing economies advanced from 12% in 1985 to 39% in 2004. In contrast, the share of non-Asian developing economies only inched up from 18% to 21% in the same period. Among developed economies, Japan (the only developed economy in our Asia sample) and non-Asian developed economies displayed opposite trends in their shares of global international reserves. From 1985 to 2004, Japan's share increased fourfold, while the share held by non-Asian developed economies declined steadily from 65% to 19%.

Figure 1.c highlights the shares of global international reserves held by selected Asian economies. By 2004, half of the world's international reserves were held by a handful of Asian economies: China (15%), Japan (21%), and the Asian newly industrialized economies (16%).[7] Specifically, China's international reserves experienced significant growth in the new millennium, with its share of global international reserves almost doubled between 2000 and 2004. In stark contrast, the share of non-Asian economies declined drastically from 83% in 1985 to 40% in 2004.

Figure 2 reveals that, over time, there has been a shift of global international reserves from high-income economies to middle-income economies. For instance, the share of global international reserves held by middle-income economies jumped from 23% in 1985 to 47% in 2004, while the share held by high-income economies dropped steadily from 74% to 47% in the same period. Although the share of low-income economies doubled from 3% to 6% over the 20-year span, it remained quite small compared to the shares of the other two income groups.

Among economies with external debts, Figure 3 shows that the share of international reserves increased with the level of indebtedness. The gaps between the severely indebted group and the other two groups widened over time. The observation is in accordance with the view that heavily indebted economies have strong motivation to hoard international reserves as a means of reducing the risk of speculative attacks.

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[7] The Asian newly industrialized economies (NICs) comprise Hong Kong, Singapore, South Korea, and Taiwan.

Figure 1: International Reserves—Regions

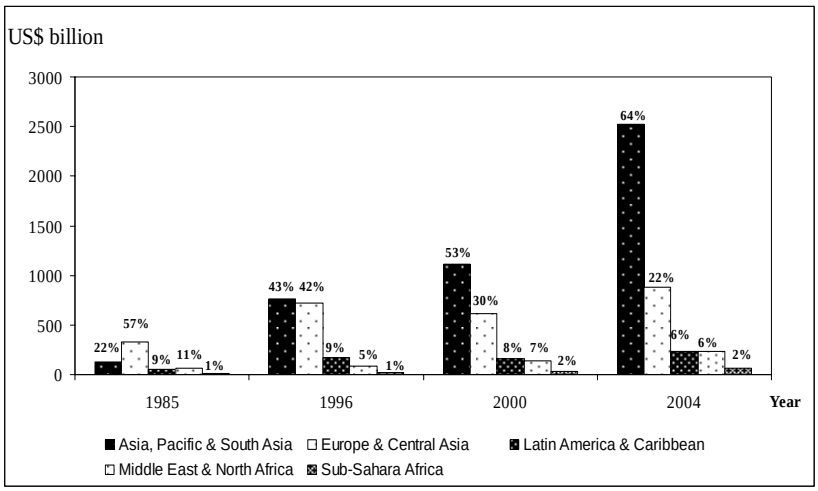


Figure 1.a: International Reserves—Asian versus Non-Asian Economies

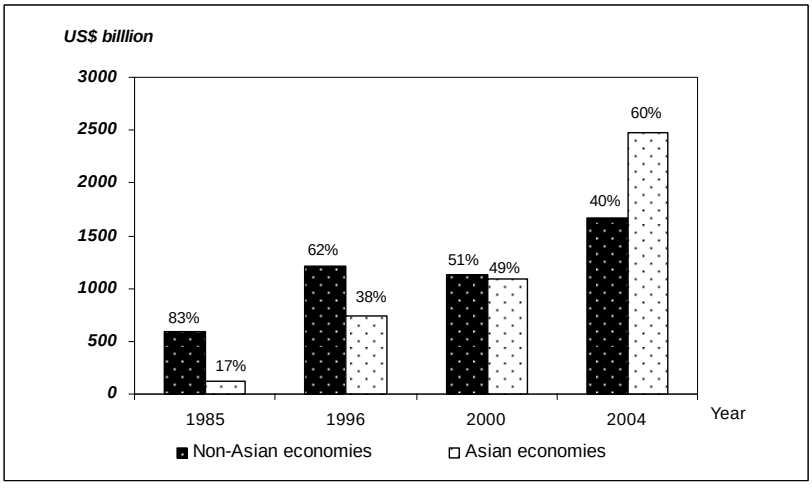


Figure 1.b: International Reserves—Developed and Developing Economies in Asian and Non-Asian Regions

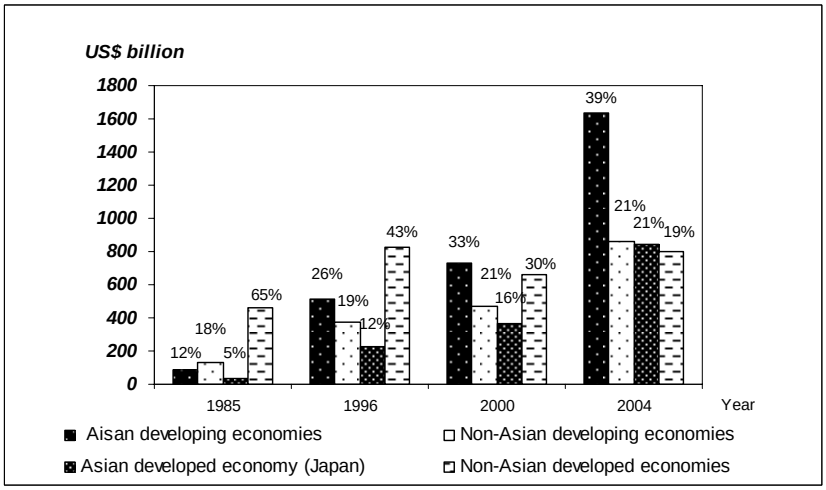


Figure 1.c: International Reserves—China, Japan, NICs, ASEAN4, Rest of Asia, and Rest of the World

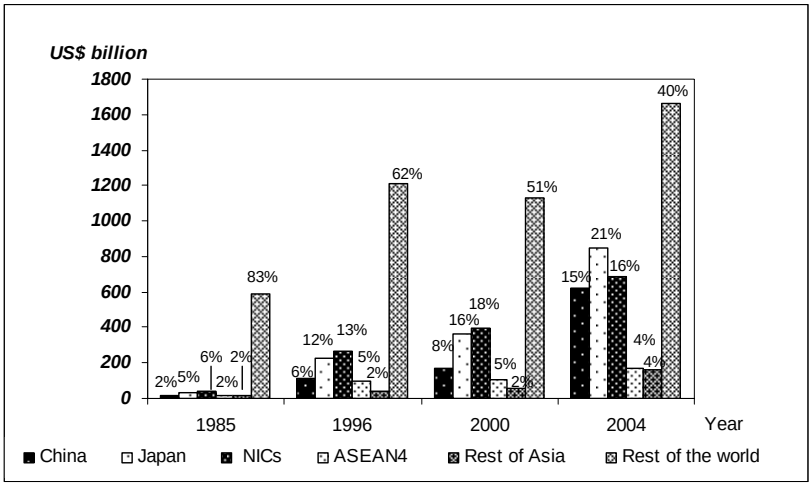


Figure 2: International Reserves—Income Levels

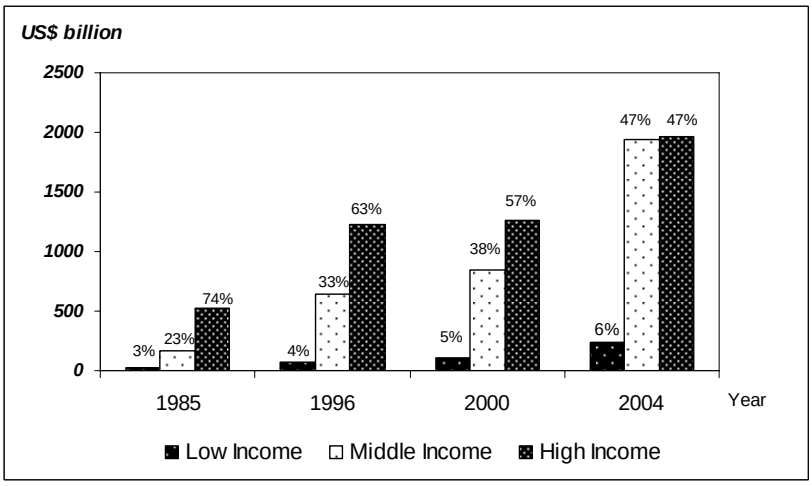


Figure 3: International Reserves—Indebtedness

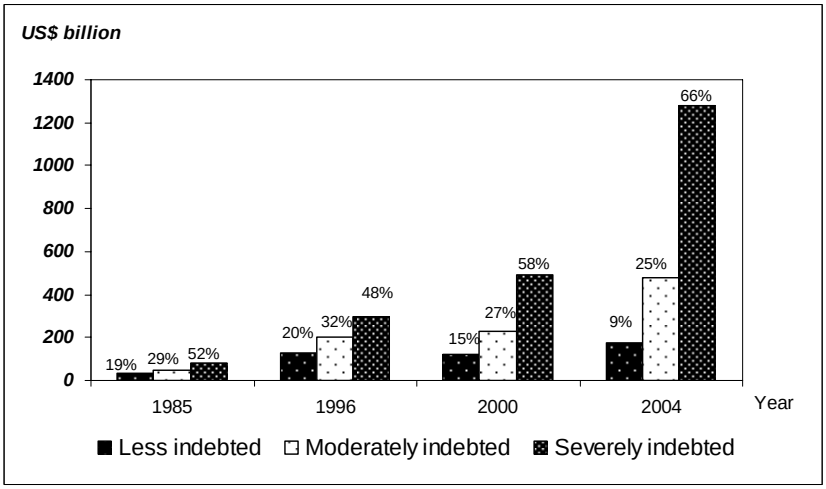


Figure 4: International Reserves—Developed versus Developing Economies

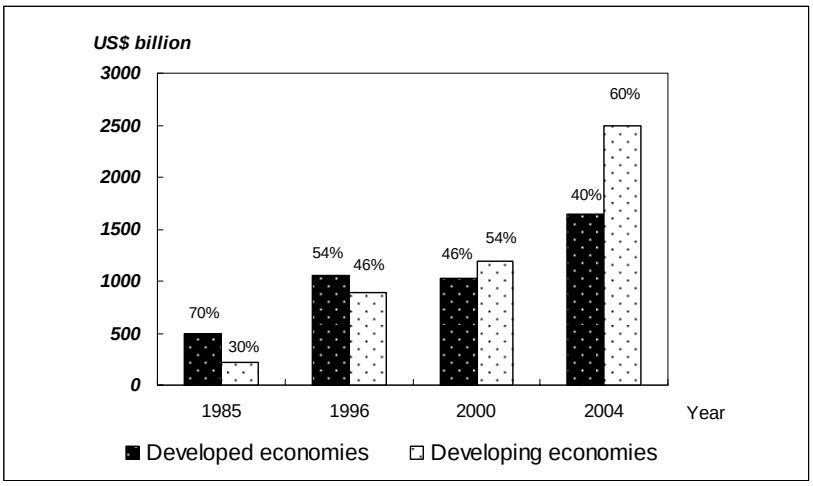


Figure 5: International Reserves—Exchange Rate Regimes

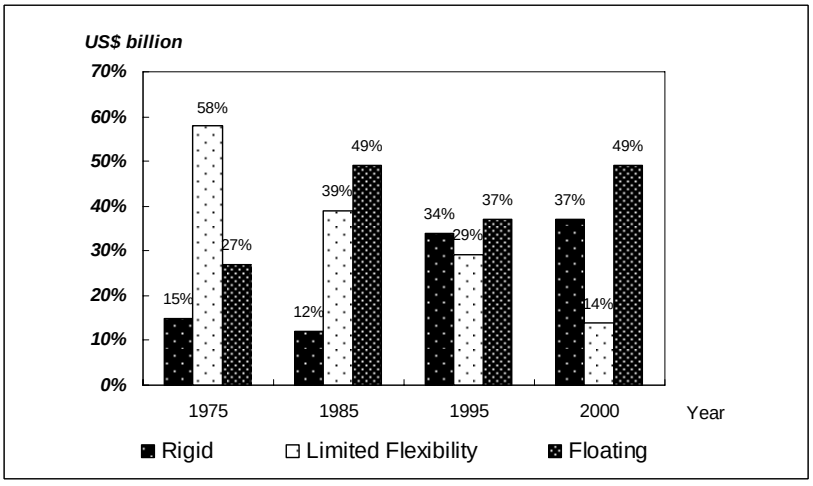


Figure 4 decomposes the holdings of global international reserves between developed and developing economies. The share of developing economies doubled from 30% in 1985 to 60% in 2004 at the expense of developed economies. As indicated in Figure 1.b, the increase is mainly driven by some developing economies in Asia.

Figure 5 presents the shares of global international reserves held by economies with different exchange rate regime arrangements.[8] Except for 1975, the group of economies with floating rates held the largest share of global international reserves; these economies accounted for 37% to 49% of global international reserves between 1985 and 2000. Theoretically speaking, an economy with exchange rate flexibility should require less international reserves because it does not have to defend its currency. The observed high percentage held by the floaters may reflect "fear of floating"—that is, an economy with *de jure* exchange rate flexibility may actually not want to see wild fluctuations in

[8] In each of these four years, the numbers of economies that fall under the three exchange rate groups are, respectively, (a) 47, 32, 48 and 56 for the rigid group, (b) 39, 40, 50 and 42 for the limited flexibility group, and (c) 12, 23, 14 and 27 for the floating group.

its exchange rate. The economies under the limited flexibility classification saw their share came down steady from 58% to 14% in the last quarter of the 20th century. The economies with rigid exchange rate arrangements, in contrast, saw a dramatic upturn in their share of global international reserves from 12% in 1985 to 37% in 2000.

2.2 International Reserve Ratios and Structural Characteristics

We now examine the international reserve ratio $r_{i,j,t}$ $(= R_{i,t}/Z_{j,t})$ and focus on the interplay of normalizing variables and structural characteristics. For a given normalizing variable j, we construct the variable $r_{.,j,t} = \Sigma_{i=1}^{N_C} r_{i,j,t} / N_C$, which is the average of the international reserve ratios across economies with the same structural characteristic C and N_C is the number of economies sharing that common structural characteristic. For instance, if income level is the structural characteristic under consideration, then C can be low-, middle- or high-income. Figure 6 to Figure 12 graph the time averages of these characteristic-specific ratios; that is, $r_{.,j,.} = \sum_{t=1}^{T_C} r_{.,j,t}/T_C$, where T_C is the data determined sample size. Essentially, these figures show the breakdown of individual average ratios according to the economies' structural characteristics.

A summary of these figures is in order. First, the implication of structural characteristics for the dispersion of international reserve ratios depends on the choice of normalizing variables. In general, the ratio variability is low when the normalizing variable is either imports or M2. Among the structural characteristics under consideration, all the seven types of international reserve ratios display the largest variation across the geographic classifications.

Second, the "Middle East and North Africa" region usually garners the largest ratio with the "Asia, Pacific and South Asia" region has the second largest one. That is, over the last forty years, the economies in these two regions tend to hold a level of international reserves that is higher than the rest of the world. Interestingly, the difference between the Asian and the non-Asian groups is not as wide as the one between the "Middle East and North Africa" and "Asia Pacific and South Asia" regions and the rest of the world.

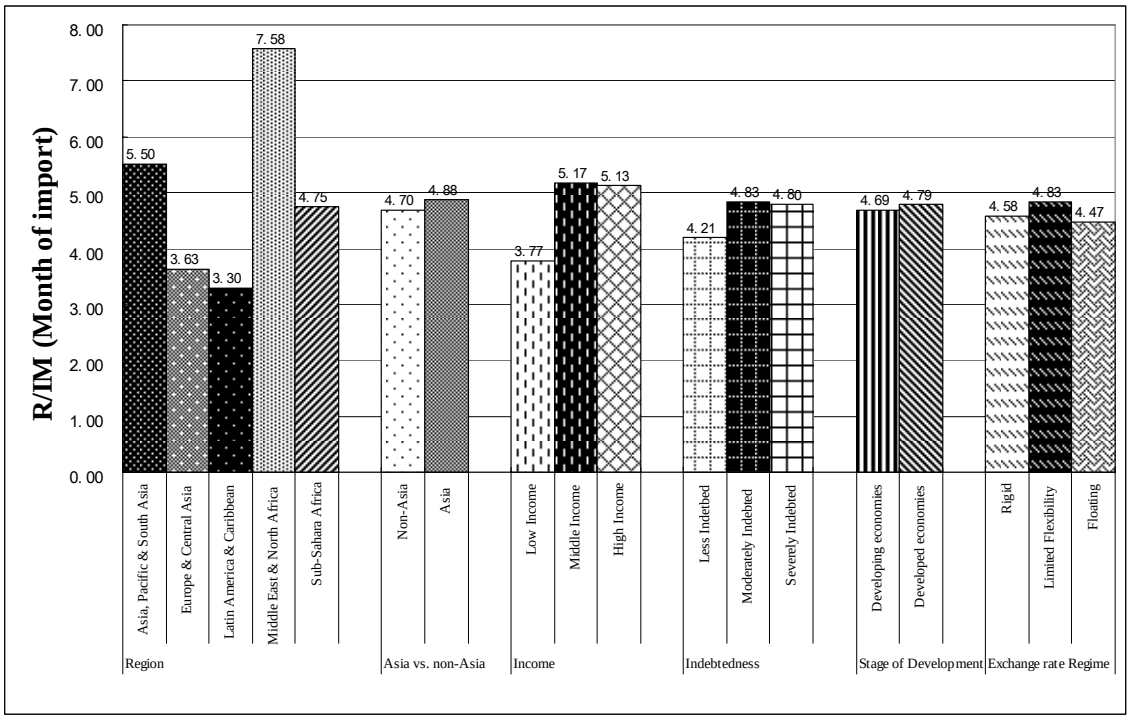
Third, the rankings of international reserve ratios across the three income groups depend on the choice of normalizing variables. For instance, the high-income group has the smallest reserves-to-short-term-external-debts and reserves-to-M2 ratios but the largest reserves-to-population and reserves-to-GDP ratios.

Fourth, under the stage of development classification, we observe that the developing economies, with the obvious exception of the reserves-to-population ratio, have a tendency to hold a higher level of international reserves than developed economies.[9]

Fifth, the severely indebted economies tend to have the highest international reserve ratio while the less indebted economies have the smallest ratio.

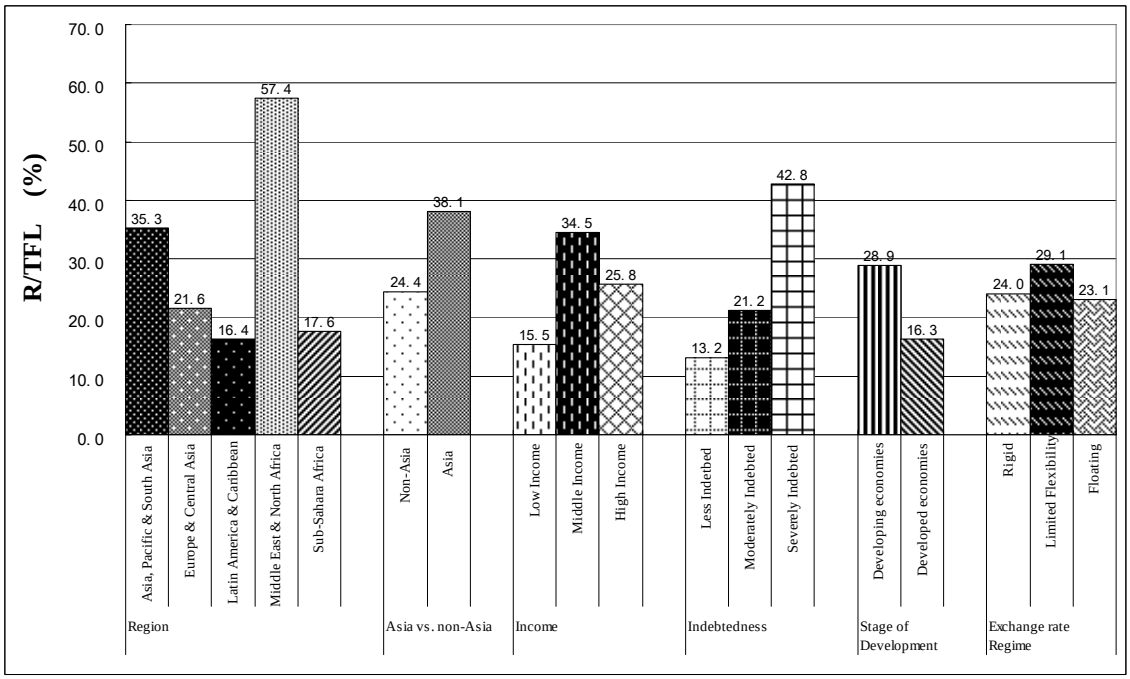
[9] The data on the short-term external debts of developed economies are not available and, hence, there is a zero reserves-to-short-term-external-debts ratio for developed economies in Figure 8.

Figure 6: International Reserves to Imports (1961–2004)[1]



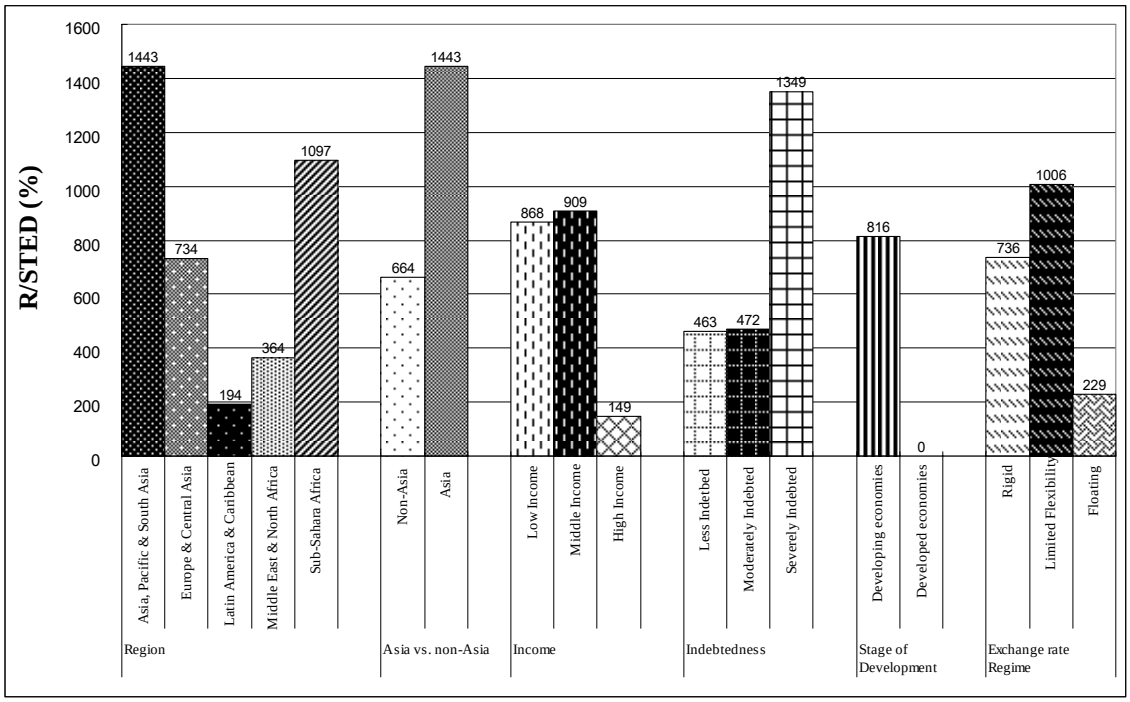
[1]For foreign exchange rate regime category, the sample period is 1961–2001.

Figure 7: International Reserves to Total Foreign Liabilities (1972–2004)[1]



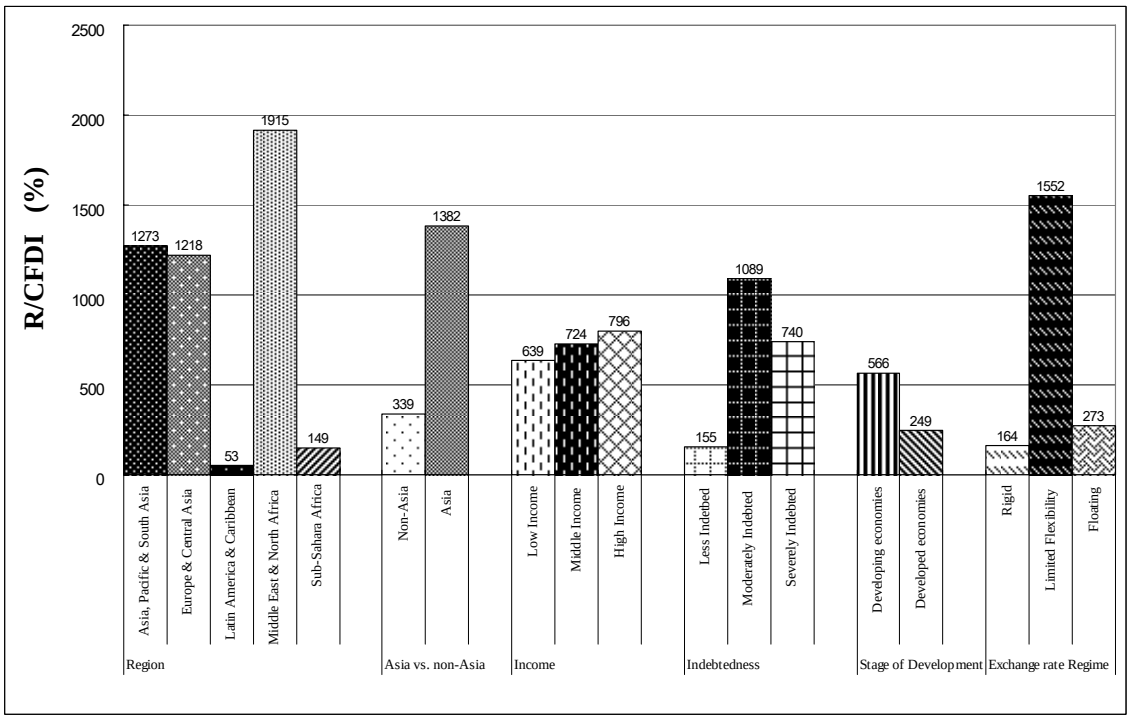
[1]For foreign exchange rate regime category, the sample period is 1972–2001.

Figure 8: International Reserves to Short-term External Debts (1990–2003)[1]



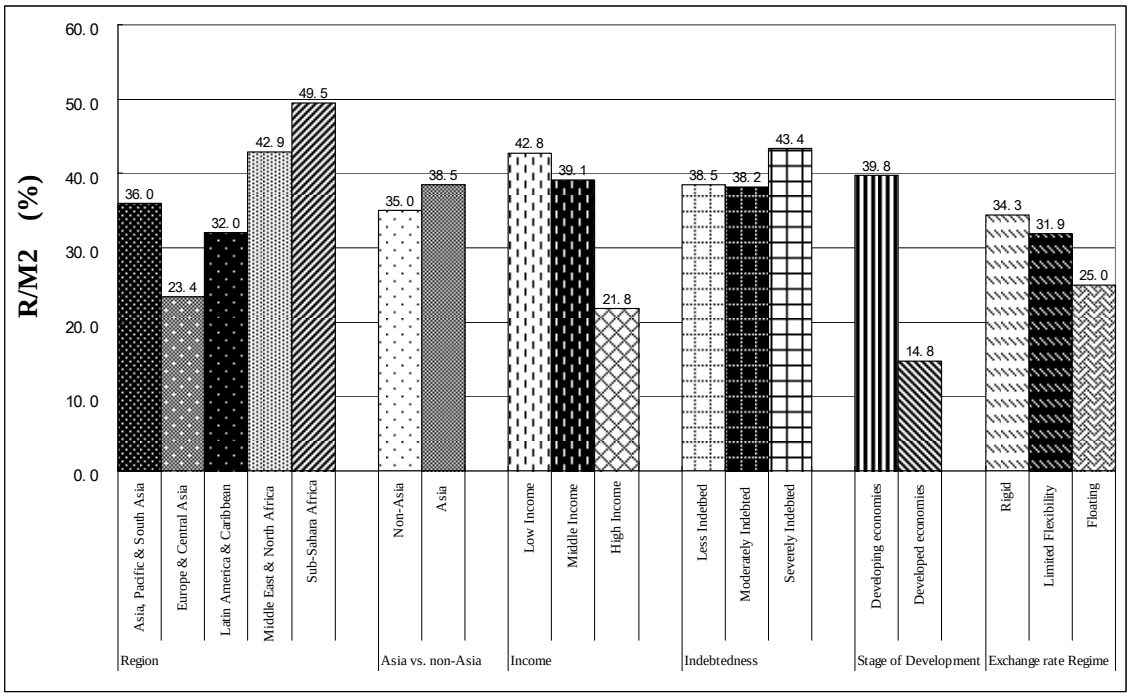
[1]For foreign exchange rate regime category, the sample period is 1990–2001.

Figure 9: International Reserves to Cumulative FDI Inflows (1980–2003)[1]



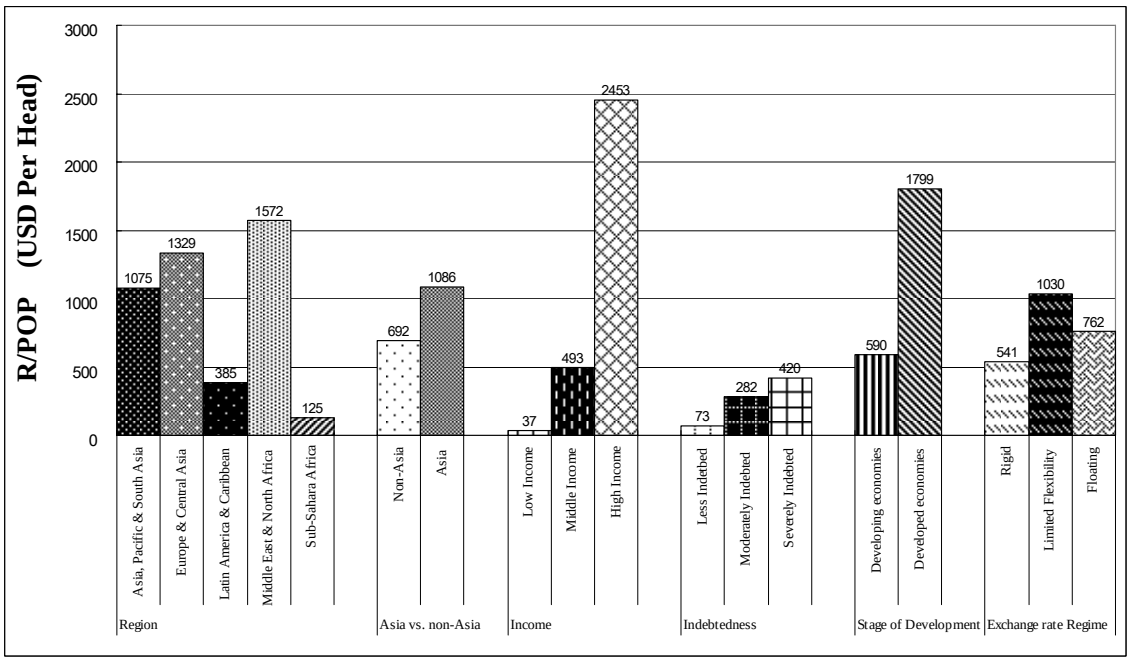
[1]For foreign exchange rate regime category, the sample period is 1980–2001.

Figure 10: International Reserves to M2 (1957–2004)[1]



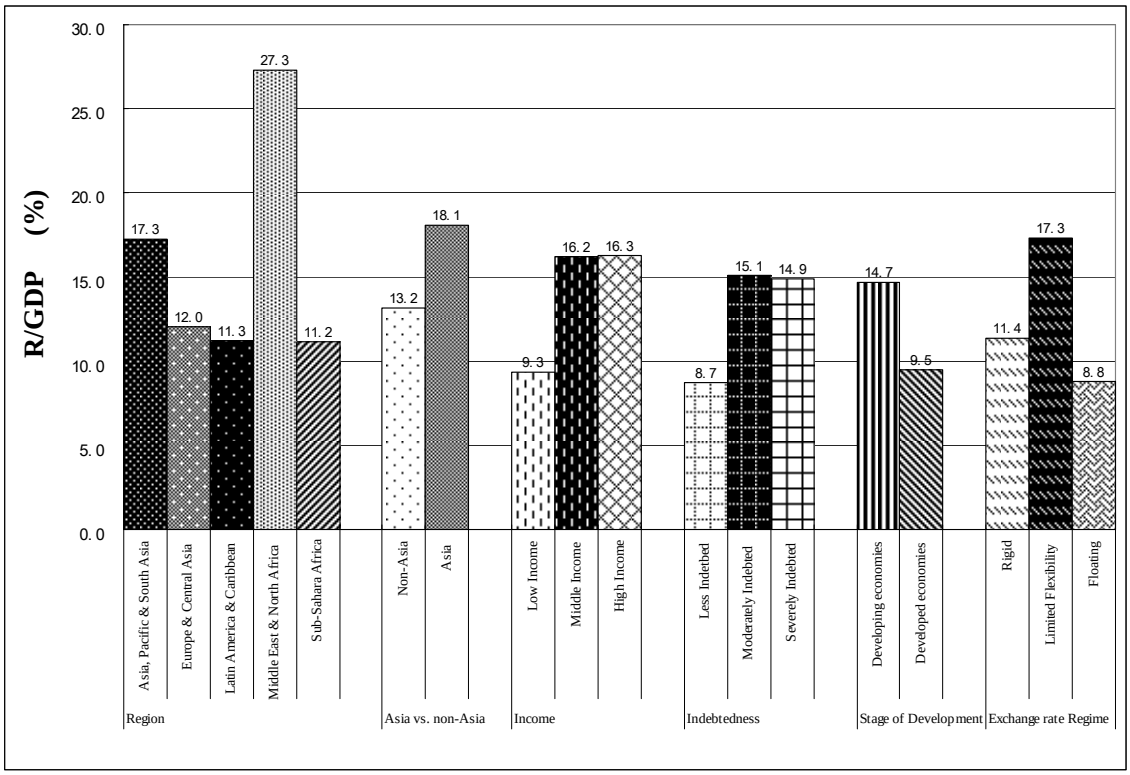
[1]For foreign exchange rate regime category, the sample period is 1957–2001.

Figure 11: International Reserves to Population (1980–2004)[1]



[1]For foreign exchange rate regime category, the sample period is 1980–2001.

Figure 12: International Reserves to GDP (1980–2004)[1]



[1]For foreign exchange rate regime category, the sample period is 1980–2001.

Sixth, the results pertaining to the exchange rate classification are quite interesting. Even economies with a rigid exchange rate regime tend to hold a higher level of international reserves than those with a floating regime—the former group has a ratio larger than the latter one in five of the seven cases, it is the economies with limited exchange rate flexibility that score six of the seven largest international reserve ratios in the exercise. The result is suggestive of the relevance of the "unstable middle" hypothesis that limited exchange rate flexibility regime is more prone to crisis than fixed or floating regimes.

In general, these graphs are suggestive of the possibility that the pattern of international reserve accumulation is associated with the selected structural characteristics. In Section 3, we will present a more formal assessment of the relationship between structural characteristics and international reserve accumulation behavior.

Undeniably, the time average plots reported in this subsection have concealed the information about the time evolution of these international reserve ratios. Economies in the "Asia Pacific and South Asia" region, for instance, are expected to have run up their holdings of international reserves. In Appendix 2, we offer a closer look at the time series of individual structural characteristic-specific international reserve ratios given by $r_{.,j,t} = \Sigma_{i=1}^{N_C} r_{i,j,t} / N_C$.

2.3 The Variation of Time Averages Across Economies

The cross-economy variation of international reserve ratios is examined using the time average of $r_{i,j,t}$ that is given by $r_{i,j,.} = \Sigma_{t=1}^{T} r_{i,j,t} / T$, where T is the sample period. Table 1 reports the cross-sectional average, median, standard deviation, coefficient of variation, skewness, and kurtosis of $\{r_{i,j,.}\}_{i=1,\ldots,N}$, where N is the number of economies. For completeness, we present the frequency distribution of $\{r_{i,j,.}\}$ in Appendix 3.

The cross-economy average of the international reserves-to-imports ratio is 4.52; that is, on the average, the level of international reserves will suffice to cover slightly more than four and a half months of imports. The median is 3.88 months. These figures are quite close to the rule of thumb that suggests a three-month coverage. The positive skewness is in accordance with the result that the average is larger than the median. These ratios are leptokurtic with a sample kurtosis larger than 3, indicating that they are more peaked around the mean and have fatter tails than a normally distribution ratio. The peakedness suggests a relatively larger proportion of economies have their ratios close to the mean value. The "fat" tails, however, suggest that "extreme" values occur quite often. Indeed, the reserves-to-imports ratio has the smallest skewness and kurtosis among the seven types of international reserve ratios, which are all positively skewed and leptokurtic.

With respect to total foreign liabilities, the cross-economy average of international reserves is 26.94% of total foreign liabilities while the median is 15.32%. For short-term external debts, the cross-economy average reaches 13.2 times of amortized annual liabilities and is thus well above the one-year coverage suggested by the Greenspan-Guidotti rule. The distribution of the reserves-to-short-term-external-debts ratio is quite skewed to the right. The median ratio, nonetheless, is at a high level of 3.6. In fact, the majority of the economies (132 of 150) have an international reserve ratio that exceeds the Greenspan-Guidotti one-year rule. It is important, however, to note that short-term external debts only include short-term debt securities, trade credits, and bank liabilities. Equity-based foreign liabilities that can be subject to sudden capital reversals are not included in this measure.

Table 1: Summary Statistics of the Time Averages of International Reserve Ratios

International reserve ratio	Number of economies	Mean	Median	Standard deviation	Skewness	Kurtosis	Coefficient of variation
AR/IM	164	4.5217	3.8816	2.7176	1.8499	7.8580	0.6010
AR/TFL	169	0.2694	0.1532	0.3527	3.2296	13.7274	1.3093
AR/STED	150	13.1970	3.6128	37.2716	5.4886	34.8850	2.8242
AR/CFDI_in	165	7.2473	1.5751	50.0097	3.5107	52.0096	6.9004
AR/M2	172	0.3978	0.3142	0.3325	3.5489	24.8173	0.8359
AR/POP	168	754.8833	202.0336	1637.6537	4.9437	32.1011	2.1694
AR/GDP	168	0.1418	0.1125	0.1391	3.7249	20.3613	0.9805

Note: The table presents the summary statistics of $\{r_{i,j,.}\}_{i=1,\ldots,N}$, where $r_{i,j,.} = \Sigma_{t=1}^{T} r_{i,j,t} / T$, N is the number of economies and T is the sample size. The international reserve ratios are AR/IM (reserves-to-imports), AR/TFL (reserves-to-total-foreign-liabilities), AR/STED (reserves-to-short-term-external-debts), AR/CFDI_in (reserves-to-cumulative-FDI-inflows), AR/M2 (reserves-to-M2), AR/POP (reserves-to-population), and AR/GDP (reserves-to-GDP). Annual data are used to construct these ratios. AR/IM is reported as the number of months of imports.

The average level of international reserves is 7.25 times of cumulative FDI inflows and the median is 1.58 times. Indeed, this ratio has the most skewed distribution among the seven ratios. Despite the high skewness, 61% of the economies have enough international reserves to cover all of their cumulative FDI inflows during the sample period. Even though FDI is perceived to be non-volatile, many economies are well covered for FDI flow reversals.

On the average, economies hold international reserves that are about one third of their M2 figures. Apparently, the average international reserve holding suffices to handle mild internal drains caused by domestic capital flight. As mentioned earlier, compared with developing economies, developed economies tend to have a lower international reserves-to-M2 ratio. In fact, six of the ten economies with the smallest ratios of reserves-to-M2 are OECD economies.

The average international reserve holding per capita is also quite skewed. The cross-economy per capita average is US$755 (and the median is US$202), Singapore, for example, stands at the high per capita level of US$12,586 and Sudan, in contrast, at the low level of US$5.430. Indeed, about 35% of economies have less than US$100 of international reserves per capita while 20% of economies have more than US1,000 per capita.

During the sample period, these economies on the average hold international reserves equal to 14% of their GDPs measured in US dollar. The median holding level is at the 11% mark. Unexpectedly (at least for the authors), Lebanon is the largest holder of international reserves according to this measure; its reserves-to-GDP ratio is 1.0574.[10] In contrast, Sudan's international reserves are less than 2% of its GDP measured in US dollars.

The dispersion of each individual international reserve ratio is quite wide. The coefficient of variation suggests the reserves-to-cumulative-FDI-inflows ratio has the largest degree of variation and the reserves-to-imports ratio has the smallest variability. A detailed examination of these summary statistics gives the impression that the economies that display an extremely large or small ratio are more likely to be developing economies.

The summary statistics reported in Table 1 and the figures in Appendix 3 reveal that the time averages of international reserve ratios exhibit substantial cross-economy variations. Further, their distributions contain outliers and are quite different from the normality assumption. Thus, a statistical study of the ratios should account for these data properties.

3 Ratio Comparison

3.1 Dependence on Structural Characteristics

The preliminary analysis in Section 2 shows that international reserve ratios display a high degree of cross-economy variability and at the same time show some discernable patterns with respect to various structural characteristics. In this subsection, we offer a formal assessment of the association between these ratios and structural characteristics.

[10] Lebanon holds a high level of gold reserves, three times larger than its non-gold international reserves. Further, from 1980 to 1991, the value of its international reserve holding was larger than its GDP.

Given the non-normality and the presence of outliers noted in the previous section, a nonparametric procedure is adopted.

For each type j international reserve ratio, we rank the time averages $\{ r_{i,j,.}\}_{i=1,\ldots,N}$. Then we assign a LOW or HIGH label to each time average $r_{i,j,.}$, depending on whether it is below or above the median of $\{ r_{i,j,.}\}$. A non-parametric contingency table test of independence is used to test the null hypothesis that the LOW and HIGH rankings are independent of an economy's structural characteristics. Section A of Appendix 4 describes the test procedure and the related contingency coefficient. The test is conducted for time averages computed from the full sample period (1957–2004) and from the two sub-periods (1957–1989 and 1990–2004). Table 2 reports the contingency coefficients and Appendix 5 presents the corresponding observed proportions of economies with a LOW and HIGH label.

Panel A in Table 2 contains results for the four structural characteristics: (a) region, (b) income, (c) indebtedness, and (d) stage of development. Under the region category, we also compare the behavior of Asian and non-Asian economies. Panel B presents results for the exchange rate regime effect.

Table 2: International Reserve Ratios and Structural Characteristics

		AR/IM	AR/TFL	AR/STED	AR/CFDI_in	AR/M2	AR/POP	AR/GDP
A. Non-Exchange Rate Regime Effects								
1. 1957–2004	Region	0.2721**	0.3097***	0.3099***	0.3721***	0.1672	0.4553***	0.3207***
	Asian	0.0164	0.0203	0.1174	0.0666	0.0306	0.0319	0.0638
	Income	0.2102**	0.2969***	0.2246**	0.2513***	0.2661***	0.5946***	0.2791***
	Indebtedness	0.0286	0.2813**	0.2217**	0.1680	0.1369	0.3864***	0.2712***
	Stage of development	0.0909	0.0609	n.a.	0.1968**	0.2890***	0.3536***	0.1942**
2. 1957–1989	Region	0.2443*	0.3221**	n.a.	0.4409***	0.2916**	0.4316***	0.2992***
	Asian	0.1609	0.2798	n.a.	0.3049	0.1544	0.5853	0.3121
	Income	0.0551	0.2428**	n.a.	0.1535***	0.0642	0.4183***	0.2794***
	Indebtedness	0.1021	0.0960*	n.a.	0.2437	0.2896	0.3901***	0.0202**
	Stage of development	0.0776	0.1000	n.a.	0.1160***	0.0382***	0.0564***	0.0188
3. 1990–2004	Region	0.2618**	0.3615***	0.3099***	0.3718***	0.2025	0.4524***	0.2684**
	Asian	0.0493	0.1012	0.1174	0.0819	0.0612	0.0319	0.1267*
	Income	0.1395	0.4076***	0.2246**	0.0885	0.3815***	0.5946***	0.2579***
	Indebtedness	0.1459	0.4206***	0.2217**	0.1661	0.1741	0.3864***	0.1796
	Stage of development	0.0909	0.2557***	n.a.	0.0182	0.3494***	0.3536***	0.2606***
B. Exchange Rate Regime Effects								
	Bretton Woods 1957–1972	0.2406*	0.2465*	n.a.	0.2498*	0.2844**	n.a.	n.a.
	Early post-B.W. 1973–1989	0.1646	0.1304	n.a.	0.2673**	0.0829**	0.3429***	0.2421**
	Recent years 1990–2004	0.1988*	0.3489***	0.1053	0.2059*	0.2378*	0.1121	0.2881***

Note: The table presents the contingency coefficients between international reserve ratios and structural characteristics. See the note to Table 1 and the text for definitions of the ratios and structural characteristics. Significance at the 1%, 5%, and 10% levels is indicated by "***," "**," and "*," respectively. "n.a." means data are not available.

3.1.1 Region

The contingency table analysis indicates that an economy's geographic region has implications for its holding of international reserves. With the exception of the reserves-to-M2 ratio, the geographic location is significantly related to the magnitudes of the international reserve ratios in the three sample periods. Indeed, among the 20 contingency coefficients under the "region" heading, only the two computed for the reserves-to-M2 ratios are insignificant at the 10% level. Despite a large number of significant relations between an economy's international reserve ratio and the region in which it is located, the contingency coefficients are all less than 0.5, with 16 of them less than 0.4. That is, the association between these two attributes, although significant, is not that strong in absolute terms.

The breakdown of economies in LOW and HIGH proportions in the full sample period (Table A5.1, Appendix 5) indicates that the sources of significant contingency coefficients vary across international reserve ratios. Despite the much-heralded accumulation of the Asian economies, the distribution of the economies in the "Asia, Pacific, and South Asia" region between the LOW and HIGH categories is quite even compared with those in the other four regions. The largest difference between the LOW and HIGH proportions observed for this region is 24% under the reserves-to-short-term-external-debts ratio. However, for the same ratio, the "Europe and Central Asia" region has a larger gap between the LOW and HIGH classifications.

The "Middle East and North Africa" economies tend to have a large international reserve ratio. In four of the six significant cases, this group has the largest gap between the LOW and HIGH proportions: in fact, over 80% of economies in this group have a HIGH international reserve ratio label. The breakdowns in the two sub-periods (Tables A5.2 and A5.3, Appendix 5) give a similar distribution pattern. It is noted that more than 50% of the economies in the "Middle East and North Africa" region have a HIGH label in all seven ratios under consideration. For the other four regions, different international reserve ratios give different relative distributions between the LOW and HIGH groups.

The contingency table test results in Table 2 do not suggest that the Asian and non-Asian economies have different types of international reserve hoarding behavior. Only one of the 20 contingency coefficients is significant at the 10% level. Most of the contingency coefficients are quite small—16 of them are less than 0.2. The significant dependence relation is found in the second sub-period with respect to the reserves-to-GDP ratio. The observed proportions indicate that the dependence is mainly driven by non-Asian economies (Table A5.3, Appendix 5). The HIGH category is 24% larger than the LOW category for the non-Asian economies, and is 6% less for the Asian economies. In other cases, the proportions of Asian economies in the HIGH and LOW categories are quite close to the 50-50 benchmark for independence.

3.1.2 Income Level

The level of income is the second most influential structural characteristic that affects the accumulation of international reserves. Significant contingency coefficients are found for all the seven ratios in the full sample period. In the two sub-periods, 9 of the 13 statistics are significant. Two of the four insignificant statistics are from the reserves-

to-imports ratio, indicating that income level has no substantial association with reserve accumulation relative to imports. The other two insignificant statistics are related to the reserves-to-cumulative-FDI-inflows ratio in the second sub-period and the reserves-to-M2 ratio in the first sub-period. The contingency coefficients pertaining to the level of income characteristic have an order of magnitude comparable to those reported for the region characteristic.

The observed proportions presented in Appendix 5 indicate that the dependence of international reserve ratios on income levels is largely driven by the behavior of low- and high-income economies. Compared with the 50-50 benchmark and the economies in the other two income groups, the middle-income economies tend to be more evenly distributed between the LOW and HIGH categories.

The low- and high-income economies tend to give different LOW and HIGH distributions. For instance, in the full sample period when international reserves are measured relative to imports, total foreign liabilities, cumulative FDI inflows, and population, the low-income economies tend to have a small international reserve ratio while the high-income economies tend to have a high ratio. However, the opposite is true when short-term external debts and M2 are used to normalize international reserves.

3.1.3 Level of Indebtedness

The classification of international reserve ratios depends on the level of indebtedness when the normalizing factor is either total foreign liabilities, short-term external debts, population, or GDP in the full sample and the two sub-periods. As data on short-term external debts are available only in the second sub-period, the contingency coefficients pertaining to this ratio are the same for the full sample and the second sub-period. Appendix 5 shows that the severely indebted economies, compared with the less indebted economies, tend to hold a higher level of international reserves relative to total foreign liabilities or to short-term external debts, which is consistent with the recommendation of holding sufficient international reserves to service short-term obligations.

3.1.4 Developed versus Developing Economies

The international reserve accumulation of the developed economies and developing economies appears different. The contingency coefficient is significant a) in all three sample periods when the normalizing factor is M2 or population, b) in the full sample and one of the sub-periods when the normalizing factor is cumulative FDI inflows or GDP, and c) in the second sub-period when the normalizing factor is total foreign liabilities. There is no result for the short-term-external-debts ratio because data for the developed economies are not available.

The observed proportions reported in Appendix 5 suggest that the significant results are mainly driven by the skewed distribution of LOW and HIGH ratios among developed economies. At least for the full sample, whether the developed economies have a high or low international reserve ratio depends on which normalizing factor is used. For instance, when imports, cumulative FDI flows, and population are the normalizing factors, the developed economies tend to have a large ratio. For the other ratios, they tend to have a small ratio.

3.1.5 Exchange Rate Regime

Compared with the other four structural characteristics, the exchange rate arrangement is the one that experiences the most variation during the sample period. Under the Bretton Woods system, fixed exchange rates were the norm. With the demise of the Bretton Woods system and after the transition period from 1971 to 1973, some economies, especially developed economies, have adopted a flexible exchange rate policy. However, throughout our sample period, there are economies switched back and forth between floating and fixed rates. Further, there is a discrepancy between *de jure* and *de facto* exchange rate arrangements. The "fear of floating" phenomenon points to the observation that despite the official stance of a floating or limited floating regime, some economies continue to actively manage their exchange rates.

In view of these developments, we divide the period in which we have data on exchange rate arrangements into three sub-periods. The first is the Bretton Woods period from 1957 to 1972. For the post-Bretton Woods period, we consider an "early period" from 1973 to 1989 and a "recent period" from 1990 to 2001. To determine an economy's exchange rate arrangement, we rely on the *most frequently observed* arrangement because some economies altered their exchange rate arrangements several times within each sub-period.

The empirical association between exchange rate regime choices and international reserve holdings is reported in panel B of Table 2. The corresponding observed LOW and HIGH proportions are given in Table A5.4 in Appendix 5. The results attest to the effects of the exchange rate regime on international reserve holding behavior.

During the Bretton Woods period, we do not have sufficient data to conduct the tests for the reserve ratios relative to short-term external debts, population, and GDP. For the other four ratios, the LOW/HIGH rankings are significantly associated with an economy's exchange rate regime. Panel I of Table A5.4 shows that these dependence relations are mainly driven by the fact that in the four cases that we have data, all of the economies with floating rates have an international reserve ratio lower than the median. The economies with rigid exchange rate arrangements, in contrast, have the highest proportion of "HIGH" ranking in three of four cases.

In the post Bretton Woods era, the dependence between exchange rate regimes and ranking of international reserves is not time invariant. In the 1973–89 period, significant dependence relations are detected for the reserves-to-cumulative-FDI-inflows, reserves-to-population, and reserves-to-GDP ratios. In the 1990–2001 period, the reserves-to-short-term-external-debts and the reserves-to-population ratios are not associated with exchange rate regimes.

The proportions reported in panels II and III of Table A5.4 give some clues on the differences in hoarding behavior. Among the ratios that display a significant relationship with exchange rate regimes, the economies with floating rates tend to have the highest percentage of the LOW label. The two exceptions are the reserves-to-cumulative-FDI-inflows and reserves-to-population ratios in the 1973–1989 sample. In these two cases, economies with rigid exchange rate regimes have the highest percentage of LOW label. The results are broadly in line with the belief that, compared with others, floaters require a lower level of precautionary demand for international reserves.

One interesting observation is that for all the six international reserve ratios that are significantly associated with an economy's exchange rate arrangement, the economies that have limited exchange rate flexibility tend to give the largest proportion of HIGH

ratios. Why is an economy that adopts a regime of limited flexibility likely to hold a high level of international reserves? If the "unstable middle" hypothesis (Willett 2003) that suggests crawling peg regimes are more susceptible to currency crisis than the flexible or fixed exchange rate regimes is true, then an economy with limited exchange rate flexibility has the incentive to hold a high level of precautionary demand for international reserves.

3.1.6 A Subsection Summary

In the previous subsections, we found significant associations between the chosen structural characteristics and the relative magnitudes of international reserve ratios. The geographic location and income effects are pervasive and are detected in all the seven international reserve ratios. It is also noted that for some structural characteristics, such as the exchange rate regime, the pattern of associations is not constant over time.

In addition to the time average $r_{i,j,.}$, we also conducted the analysis using the variance, the skewness, and the kurtosis of these international reserve ratios. In general, the empirical associations between structural characteristics and the variance of international reserve ratios are broadly similar to those of the average. Compared with averages and variances, the third and fourth moments yield a substantially smaller number of significant cases and less discernable patterns among specific pairs of structural characteristics and international reserve ratios. For brevity, these results are not reported but are available upon request.

3.2 Rankings across Economies

When commenting on the adequacy of an economy's international reserves, economists and policymakers often have in mind a certain normalizing factor such as the number of months of imports. Could the level of international reserves held by an economy be deemed excessive according to one ratio but deficient according to another? Because we do not know the optimal level of an international reserve ratio, we modify the question to whether it is possible that the level of international reserves held by an economy is relatively high according to one ratio but relatively low according to another.

Given a multitude of international reserve ratios, do they provide similar information about an economy's level of international reserves relative to other economies' holdings? Suppose the type j international reserve ratio indicates that an economy has a relatively high level of international reserves. Does another ratio, say the type j* ratio, also suggest the economy has a relatively high level of international reserves? If it does, then it is likely that different international reserve ratios offer similar information on whether an economy's international reserve holding is excessive. If it does not, then we have to decide which international reserve ratio is relevant in assessing the adequacy of international reserves.

3.2.1 Rank Correlation: The Entire Sample of Economies

The rank correlation is a non-parametric measure of association. It is used to assess whether different ratios provide similar rankings of an economy's level of international

reserves. Again consider the time averages $\{r_{i,j,.}\}_{i=1,\ldots,N}$. Let $r_{|i|,j,.}$ be the rank of $r_{i,j,.}$ among N economies. Then, for the type j and type j* international reserve ratios, their degree of association is measured using the correlation between $\{r_{|i|,j,.}\}$ and $\{r_{|i|,j,.}\}$. A rank correlation close to one indicates that the two ratios tend to give similar rankings: that is, a relatively large international reserve ratio $r_{i,j,.}$ will tend to imply a relatively large ratio $r_{i,j^*,.}$. A rank correlation close to zero suggests that the ranking of an economy's international reserve ratio $r_{i,j,.}$ bears no implication for the ranking of its other ratio $r_{i,j^*,.}$. If the rank correlation is negative, then a large $r_{i,j,.}$ implies a small $r_{i,j^*,.}$. The rank correlation is used to ensure the inference is robust to non-normality and outliers. A brief technical description of the rank correlation is given in Section B of Appendix 4.

The rank correlation estimates calculated from three sample periods (1957–2004, 1957–1989, and 1990–2004) are presented in Table 3. Again, note that we do not have data on short-term external debts for the 1957–1989 period.

For the 1957 to 2004 period, 18 of the 21 rank correlation coefficients are statistically significant and they are all positive. Thus, in general, if one ratio indicates that an economy has a high level of international reserves, the other ratios are likely to give a high ranking.

Table 3: Rank Correlations Between Time Averages of International Reserve Ratios

		AR/IM	AR/TFL	AR/STED	AR/CFDI_in	AR/M2	AR/POP
A.1957–2004	AR/TFL	0.7234***					
	AR/STED	0.2574***	0.3666***				
	AR/CFDI_in	0.3783***	0.4704***	0.2088**			
	AR/M2	0.3053***	0.3617***	0.3250***	0.0497		
	AR/POP	0.2929***	0.5055***	0.0025	0.1865**	–0.1229	
	AR/GDP	0.5147***	0.7524***	0.3274***	0.2304***	0.5214***	0.5030***
B. 1957–1989	AR/TFL	0.8512***					
	AR/STED	n.a.	n.a.				
	AR/CFDI_in	0.2668***	0.4051***	n.a.			
	AR/M2	0.5037***	0.5614***	n.a.	0.0411		
	AR/POP	0.4276***	0.5815***	n.a.	0.0775	0.1370	
	AR/GDP	0.5959***	0.7775***	n.a.	0.1307	0.5928***	0.7324***
C. 1990–2004	AR/TFL	0.6390***					
	AR/STED	0.2976***	0.4423***				
	AR/CFDI_in	0.4743***	0.5765***	0.3248***			
	AR/M2	0.3555***	0.3929***	0.3675***	0.2840***		
	AR/POP	0.2359***	0.3714***	0.0004	0.1008	–0.2490***	
	AR/GDP	0.5648***	0.7701***	0.3587***	0.3816***	0.4801***	0.4091***

Note: The table presents estimates of rank correlation between international reserve ratios. See the note to Table 1 and the text for definitions of the ratios. Significance at the 1%, 5%, and 10% levels is indicated by "***," "**," and "*," respectively. "n.a." means data are not available.

Although these estimates suggest that the rankings of these international reserve ratios tend to move in tandem, the strength of co-movement requires further scrutiny. If the magnitude of the rank correlation estimate is used as a proxy for the intensity of association, then the pattern of co-variation is diverse. The significant estimates range from a low of 0.1865 between the reserves-to-cumulative-FDI-inflows and reserves-to-population ratios to a high of 0.7524 between the reserves-to-GDP and reserves-to-total-foreign-liabilities ratios. There are 6 estimates above 0.5 and 12 estimates below 0.5. Thus, while the rankings of these ratios tend to move in the same direction, the evidence confirms that they have unique behavior that is not captured by other ratios. Thus, it is possible that different ratios give different assessments of the relative international reserve holding positions, and thus of the adequacy of international reserves.

To gain further insight into the issue, we list the top 10 and bottom 10 economies for each of the seven international reserve ratios in Table 4. The rankings are based on the averages over the 1957–2004 period.[11] Most of the top 10 and bottom 10 economies are developing economies. Developed economies are well represented only in the case of reserves-to-M2 ratio where they account for six of the bottom 10 spots. Despite their reputation as large holders of international reserves, Asian economies are not very visible in the top 10 lists. For instance, China, Hong Kong, and Singapore appear in the top 10 list in only two of the seven international reserve ratios. Indeed, only a few economies show up three times in these lists. The result reinforces the general impression that each international reserve ratio has its own unique extreme value membership.

The data in the 1957–1989 sample give a smaller number of significant rank correlation estimates—11 of 15 estimates are significant. Three of the four insignificant estimates are related to the reserves-to-cumulative-FDI-inflows ratio. Among the significant estimates, eight of them are larger than 0.5.

For the 1990–2004 sample, there are only two insignificant estimates, both of which are associated with the reserves-to-population ratio. In contrast to results in the first sample, most of the significant estimates are less than 0.5. That is, the degree of association between these ratios tends to decline across the two sample periods. Further, the rank correlation estimate between the reserves-to-population and reserves-to-M2 ratios is significantly negative; hence, an economy with a large reserves-to-population ratio tends to have a small reserves-to-M2 ratio.

These results show that, in general, the rankings of these international reserve ratios tend to move in the same direction but the association of these rankings is not very strong. In passing, it is noted that both the number of significant cases and the magnitude of correlation are reduced substantially if actual ratios, rather than their ranks, are used to conduct the analysis.

[11] The top 10 and bottom 10 economies in the 1957–1989 and 1990–2004 periods are presented in Appendix 6.

Table 4: International Reserve Ratios: Lists of Top 10 and Bottom 10 Economies, 1957–2004

	Economies	AR/IM	Economies	AR/TFL	Economies	AR/STED	Economies	AR/CFDI_in
Top 10	Libya	17.9963	Portugal	1.9588	Bhutan	287.9412	Nepal	458.6906
	Saudi Arabia	14.7749	Libya	1.9354	Botswana	238.8081	Hungary	192.892
	Lebanon	13.8578	Taiwan	1.7429	Cambodia	197.2221	Kuwait	143.2899
	Malta	12.4657	Saudi Arabia	1.6032	Micronesia	162.7468	Bangladesh	112.222
	Venezuela	11.7758	Nepal	1.49	China	74.9268	Bhutan	91.5317
	Switzerland	11.5231	Botswana	1.419	India	61.6449	Myanmar	82.487
	Uruguay	11.1867	Kuwait	0.994	Grenada	56.7141	Uruguay	81.5918
	Macao	10.1359	China	0.9769	Eritrea	51.1339	Tonga	68.9866
	Portugal	9.9665	Malta	0.8334	Moldova	41.7143	Mongolia	27.1862
	Nepal	9.7280	Mauritius	0.6938	Swaziland	30.3089	Jordan	25.9827
Bottom 10	Liberia	0.2117	Equatorial Guinea	0.016	Liberia	0.0009	Cape Verde	–305.7931
	Belarus	0.6801	Panama	0.0179	Netherlands Antilles	0.0282	Sudan	–85.2858
	Bahamas	0.8370	Congo	0.0184	Bahamas	0.0692	Lebanon	–70.5284
	Congo	1.0656	Sudan	0.0198	Congo	0.1038	Bosnia & Herzegovina	–12.0025
	Haiti	1.3157	United Kingdom	0.0334	Cameroon	0.2185	Venezuela	–10.7475
	Tajikistan	1.3447	Angola	0.0334	Gabon	0.3826	São Tomé & Príncipe	–6.9795
	Equatorial Guinea	1.3944	Laos	0.0363	St. Vincent & Grenadines	0.4533	Bolivia	–5.3983
	Netherlands Antilles	1.5361	Guinea	0.0397	Zimbabwe	0.5562	Philippines	–3.8582
	Seychelles	1.5441	Senegal	0.0448	Angola	0.6024	Niger	–2.3077
	Panama	1.5706	Côte d'Ivoire	0.0457	Côte d'Ivoire	0.6063	Grenada	–0.8567

	Economies	AR/M2	Economies	AR/POP	Economies	AR/GDP
Top 10	Botswana	3.0187	Singapore	12586.0444	Lebanon	1.0574
	Bhutan	1.5197	Hong Kong	11693.7165	Botswana	0.8291
	El Salvador	1.3137	Switzerland	8641.9747	Singapore	0.7697
	Kyrgyz Rep	1.1496	Norway	4316.2100	Malta	0.7499
	Madagascar	1.1206	Malta	4155.8131	Hong Kong	0.5168
	Armenia	1.1031	Taiwan	3857.2832	Bhutan	0.4493
	Saudi Arabia	1.0457	Kuwait	3114.8094	Taiwan	0.4147
	Tajikistan	1.0441	United Arab Emirates	3092.2726	Libya	0.3852
	Cambodia	0.9974	Bahrain	2817.7479	Switzerland	0.3117
	Libya	0.9541	Denmark	2536.6661	Bahrain	0.2996
Bottom 10	United States	0.0346	Sudan	5.4360	Sudan	0.0122
	Japan	0.0427	Sierra Leone	6.9415	Cameroon	0.0160
	Liberia	0.0745	Myanmar	8.1544	Congo	0.0196
	United Kingdom	0.0768	Ethiopia	8.2354	United States	0.0262
	France	0.0842	Bangladesh	11.0422	Haiti	0.0285
	Canada	0.0922	Haiti	11.5324	Belarus	0.0324
	Eritrea	0.0937	Cameroon	12.0352	Gabon	0.0348
	South Africa	0.0944	Madagascar	12.7807	Sierra Leone	0.0354
	Panama	0.0951	Malawi	13.1565	Dominican Republic	0.0367
	Italy	0.0974	Tajikistan	14.4081	Canada	0.0369

Note: The rankings are based on the averages of ratios from 1957 to 2004. See the note to Table 1 and the text for definitions of the ratios. The negative reserves-to-cumulative-FDI inflows ratios are due to the presence some extreme reversals of FDI inflows. A complete list of economies with a negative reserves-to-cumulative-FDI inflows ratio is available upon request.

3.2.2 Developed versus Developing Economies and Asian versus non-Asian Economies

To illustrate the possibility that the degree of association between these international reserve ratios varies between different groups of economies, we present two sets of results in Tables 5 and 6. Table 5 compares the rank correlation estimates computed from developed and developing economies and Table 6 compares those from Asian and non-Asian economies.

The international reserve ratios of developed economies appear to have a strong degree of association. Indeed, the developed economies have a rank correlation estimate larger than that of the developing economies in 13 of the 15 cases in which we have estimates for both groups of economies. Further, it is more likely to have a significant

estimate in Table 5 than in Table 3. One possible reason is that the correlation between developed economies is different from the one between developing economies. Thus, if we mix the two groups together, the resulting correlation is weaker than the correlation within each individual group.

Table 5: Rank Correlations between International Reserve Ratios: Developed Vs. Developing Economies, 1957 to 2004

		AR/IM	AR/TFL	AR/STED	AR/CFDI_in	AR/M2	AR/POP
A. Developed Economies	AR/IM						
	AR/ TFL	0.8383***					
	AR/STED	n.a.	n.a.				
	AR/CFDI_in	0.6761***	0.6841***	n.a.			
	AR/M2	0.3103***	0.4056***	n.a.	0.2043***		
	AR/POP	0.3612***	0.4570***	n.a.	0.5875***	0.6013***	
	AR/GDP	0.5296***	0.6282***	n.a.	0.4904***	0.8127***	0.7525***
B. Developing Economies	AR/TFL	0.7061***					
	AR/STED	0.1850**	0.3389***				
	AR/CFDI_in	0.3516***	0.5038***	0.1964**			
	AR/M2	0.3969***	0.4339***	0.3116***	0.1640**		
	AR/POP	0.3336***	0.6050***	–0.0086	0.1315*	0.0811	
	AR/GDP	0.5216***	0.7614***	0.3442***	0.2527***	0.5266***	0.6490***

Note: The table presents estimates of rank correlation between international reserve ratios. See the note to Table 1 and the text for definitions of the ratios. Significance at the 1%, 5%, and 10% levels is indicated by "***," "**," and "*," respectively. "n.a." means data are not available.

Table 6: Rank Correlations between International Reserve Ratios: Asian versus Non-Asian Economies, 1957 to 2004

		AR/IM	AR/TFL	AR/STED	AR/CFDI_in	AR/M2	AR/POP
A. Asian	AR/TFL	0.7753***					
	AR/STED	0.2728***	0.3259***				
	AR/CFDI_in	0.4860***	0.2998***	0.4435***			
	AR/M2	–0.1388*	0.1090	0.4530***	–0.0277		
	AR/POP	0.2351***	0.4462***	–0.2108***	–0.1804**	0.1622**	
	AR/GDP	0.2602***	0.5061***	0.0748	–0.1764**	0.5873***	0.6773***
B. Non-Asian	AR/TFL	0.7211***					
	AR/STED	0.1955**	0.3488***				
	AR/CFDI_in	0.3597***	0.5058***	0.1123			
	AR/M2	0.3692***	0.4135***	0.3088***	0.0385		
	AR/POP	0.3074***	0.4595***	0.0238	0.3375***	–0.2445***	
	AR/GDP	0.5435***	0.7669***	0.3679***	0.3066***	0.5453***	0.4115***

Note: The table presents estimates of rank correlation between international reserve ratios. See the note to Table 1 and the text for definitions of the ratios. Significance at the 1%, 5%, and 10% levels is indicated by "***," "**," and "*," respectively.

The contrast between Asian and non-Asian economies is quite obvious (Table 6). The international reserve ratios of Asian economies tend to display a weaker degree of association than those of non-Asian economies. Specifically, in 13 of 21 cases the Asian rank correlation estimates are smaller than the non-Asian estimates. The Asian economies also have a higher frequency of significant negative estimates—four for Asian economies versus one for non-Asian economies. Thus, compared with non-Asian

economies, the rankings of Asian economies' international reserves could be quite sensitive to the choice of normalizing variables.

3.2.3 Rank Correlation: A Summary

In this subsection, we examine the relative rankings of the seven international reserve ratios. The results in Tables 3, 4, 5, and 6 illustrate that in terms of their rankings the international reserve ratios share some commonalities but also display certain idiosyncrasies that are not captured by others.

It is conceivable that the economies face different economic and political realities and thus have different responses to similar conditions. The results buttress the idea that the seven international reserve ratios, which measure international reserves with respect to different aspects of an economy, could offer different views on the adequacy of international reserve holdings. For instance, it is possible that an economy is deemed to have accumulated an excessive amount of international reserves according to one ratio, but only a moderate amount according to the other. Is there one ratio that is more relevant than another for evaluating the adequacy of international reserve holdings? The answer depends on the specific circumstances that an economy is facing and the relevant models of demand for international reserves—these issues are beyond the scope of the current study.

3.3 Persistence Pattern

In this subsection, we compare the persistence patterns of the seven international reserve ratios. It is well known that the presence of unit root persistence has significant implications for both theoretical and empirical models. For instance, a persistent process is suggestive of the dominance of permanent instead of transitory shocks. In the current exercise, the augmented Dickey-Fuller (ADF) unit root test is used to assess persistence. Specifically, we apply the test to individual time series $\{ r_{i,j,t} \}_{t=1,\ldots,T}$ for each economy and each international reserve ratio type. Section C in Appendix 4 gives a brief description of the ADF test.

Before discussing the unit root test results, we note that the standard unit root tests are notorious for their inability to offer a sharp inference to differentiate a unit root process from a stationary but highly persistent one. It is quite inconceivable that these international reserve ratios drift around without bounds—a property implied by unit root persistence. Thus, we prefer to interpret non-rejection of the unit root hypothesis as an indication of strong persistence rather than as an unambiguous evidence of a unit root in the data.

Table 7 presents the proportions of economies for which the unit root null is rejected at the 10% level of significance. Only the full sample period from 1957 to 2004 is considered because the sample sizes of the two sub-periods are too short to yield reliable estimates. Panel A of Table 7 summarizes the results for all the economies in the sample. The rejection proportions vary quite widely among the seven ratios; from 9.50% to 48.50%. The reserves-to-population ratio is the only series that has a rejection proportion less than the 10% level of significance. In contrast, the reserves-to-cumulative-FDI-inflows ratio yields the highest proportion of rejection, indicating that it has

the lowest average degree of persistence among all ratios. Three other international reserve ratios have a rejection proportion larger than 20%, with the remaining two between 10% and 20%.

Table 7: Persistence Patterns, 1957 to 2004

	AR/IM	AR/TFL	AR/STED	AR/CFDI_in	AR/M2	AR/POP	AR/GDP
A. Overall	25%	27.90%	12.70%	48.50%	20.30%	9.50%	16.10%
B. By structural characteristics							
I. Region							
Asia, Pacific & South Asia	27.6%	21.7%	20.7%	48.3%	15.6%	3.3%	20.0%
Europe & Central Asia	28.6%	38.1%	7.7%	34.1%	19.5%	2.4%	11.9%
Latin America & Caribbean	24.2%	23.8%	9.4%	46.9%	18.2%	18.8%	21.9%
Middle East & North Africa	29.4%	31.3%	11.8%	58.8%	29.4%	11.8%	23.5%
Sub-Sahara Africa	15.4%	19.4%	13.6%	59.5%	20.5%	14.0%	11.6%
Non-Asia	24.8%	30.4%	10.7%	48.6%	21.8%	10.7%	15.7%
Asia	25.9%	14.3%	20.7%	48.1%	13.3%	3.6%	17.9%
II. Income							
Low income	20.4%	14.0%	14.0%	47.3%	19.6%	8.9%	12.5%
Middle income	27.4%	24.2%	14.3%	48.0%	17.9%	10.4%	18.2%
High income	28.6%	56.7%	0.0%	51.5%	25.7%	9.1%	18.2%
III. Indebtedness							
Less indebted	27.0%	10.7%	13.5%	57.1%	30.6%	13.9%	13.9%
Moderately indebted	19.5%	25.0%	12.2%	48.8%	15.0%	9.8%	14.6%
Severely indebted	26.5%	22.5%	14.8%	40.7%	14.3%	7.3%	18.2%
IV. Stage of Development							
Developing	23.1%	21.7%	12.7%	47.9%	19.2%	10.2%	16.3%
Developed	38.1%	61.9%	n.a.	52.4%	28.6%	4.8%	14.3%

Note: The table presents the proportion of economies for which the unit root hypothesis is rejected at the 10% significance level.

To formally assess the dependence between rejection frequencies and ratio types, we apply the contingency table test to the sample of 107 economies that have data on all the seven international reserve ratios. The test statistic is significant at the 1% level and the associated contingency coefficient estimate is 0.28. That is, the test result confirms that the choice of normalizing factor is related to the rejection frequency of an international reserve ratio.

Panel B of Table 7 lists the rejection percentages of each category of the four structural characteristics: region, income, indebtedness and stage of development. The exchange rate regime characteristic is not included because most economies changed their exchange rate arrangements during the 1957–2001 period.

With a few exceptions, the rejection proportions of individual categories are quite close to the corresponding overall rejection proportions in Panel A. The largest variation of rejection frequencies across different categories within individual structural characteristics is found with data on the reserves-to-total-foreign-liabilities ratio.

Another observation is that within each of the four structural characteristics, the rankings of the rejection frequencies vary across international reserve ratios. For example, the “Asia, Pacific and South Asia” region has the highest rejection rate among the five regions when international reserves are normalized by short-term external debts but has the lowest rejection rate when the normalizing factor is M2. Indeed, for a given structural characteristic, we do not have an economy group that has the highest (or the lowest) rejection frequency for all the seven international reserve ratios.

Is the persistence profile related to an economy's structural characteristics? Table 8 presents the contingency coefficients of rejection frequencies and structural characteristics. The evidence of dependence is quite limited. In general, these contingency coefficients are small and only 3 of them are statistically significant. Compared with the results in Table 2, those in Table 8 suggest that the implication of structural characteristics for persistence is much weaker than for the magnitude of international reserve ratios.

Table 8: Persistence and Structural Characteristics, 1957 to 2004

	AR/IM	AR/TFL	AR/STED	AR/CFDI_in	AR/M2	AR/POP	AR/GDP
Region	0.124	0.171	0.131	0.192	0.092	0.214**	0.133
Asia/Non-Asia	0.009	0.129	0.117	0.003	0.080	0.090	0.022
Income	0.081	0.333*	0.123	0.031	0.074	0.024	0.073
Indebtedness	0.079	0.144	0.032	0.132	0.179	0.090	0.053
Stage of Development	0.115	0.308**	n.a.	0.030	0.076	0.061	0.018

Note: The table presents the contingency coefficients between persistence and structural characteristics. See the note to Table 1 and the text for definitions of the ratios and structural characteristics. Significance at the 5% and 10% levels is indicated by "**" and "*" respectively. "n.a." means data are not available.

In sum, the seven international reserve ratios display different persistence profiles. The result adds to the perception that there are intrinsic differences between the ratios. Unlike the relative magnitude, the persistence pattern of international reserve ratios is only weakly related to structural characteristics.

4 Concluding Remarks

Usually, the level of international reserves is measured against some economic variables such as imports and foreign liabilities. In this study, we examine the similarities and differences of seven international reserve ratios that are mentioned in the recent discussion of the hoarding of international reserves. Our exercise is empirical, and the results allow us to compare facts to the anecdotal hype about international reserve accumulation.

One basic observation is that each of these international reserve ratios displays substantial variations across economies. Notwithstanding high variability, the average international reserve ratios are associated with an economy's structural characteristics. In addition to the difference between developed and developing economies, the hoarding of international reserves is found to be related to an economy's geographic location, income level, degree of indebtedness, and exchange rate regime. The pattern of dependence varies across time and international reserve ratios. Interestingly, there is only limited evidence that the Asian and the non-Asian economies have different reserve hoarding behavior.

Besides their average magnitudes, the international reserve ratios exhibit different persistence profiles. We do not have an answer to the question of, say, why persistence differs across international reserve ratios. There is also only weak evidence of the association between persistence and structural characteristics.

Do we have a "grand" theory that explains the vast differences of international reserve holdings across economies and across time? Our tentative answer is "quite unlikely." Admittedly, we are not walking in fresh snow and our stance is similar in spirit to, say, Fritz Machlup's one advocated in the 1960s. After studying several international reserve ratios, Machlup (1996) proclaimed that the observed reserve accumulation behavior is not related to "any of the purposes emphasized by either theorists or practitioners." Indeed, he forwarded the "Mrs. Machlup's Wardrobe" theory of international reserves, which ascribes reserve accumulation to psychological factors.[12]

Our results underscore the difficulty in assessing whether an economy is holding an excessive amount of international reserves. When one international reserve ratio indicates an economy holds a relatively high level of international reserves, another international reserve ratio may suggest otherwise. Furthermore, the holding of international reserves depends on an economy's structural characteristics. In evaluating an economy's level of international reserve holding, the inference depends on the choice of international reserve ratios as well as an economy's characteristics. Indeed, some recent studies have emphasized the importance of structural characteristics including the political economy, financial market conditions, and energy concerns (Willet 2007; Mendoza et al. 2007; Kenen 2007).

So far, our empirical findings lead to more questions than answers. This is partly because the exercise is an empirical one that does not get much guidance from theory; the theory of the demand for international reserves is silent on most of the issues considered here. Despite these drawbacks, our empirical findings shed some light on the complexity behind the discussion of the adequacy of international reserves and the challenges one may face in building a general theory of international reserves. An implication of our results for assessing the adequacy of international reserves is that, in paraphrasing Frankel (1999), no single international reserve ratio is right for all economies at all times.

[12] See Cheung and Qian (2007) for an update on the Mrs. Machlup's theory of international reserves.

Appendix 1: Economy Classifications

A Economies listed under various structural characteristic classifications

I Region Classification

Region 1: Asia, Pacific and South Asia (32 economies)
Australia, Bangladesh, Bhutan, Cambodia, China, Fiji, Hong Kong, India, Indonesia, Japan, Korea, Laos, Macao, Malaysia, Maldives, Federated States of Micronesia, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Tonga, Vanuatu, Vietnam.

Region 2: Europe and Central Asia, (42 economies)
Albania, Armenia, Austria, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Macedonia, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Tajikistan, Turkey, Ukraine, United Kingdom.

Region 3: Latin America and the Caribbean, (34 economies)
Anguilla, Argentina, Aruba, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela.

Region 4: Middle East and North Africa, (17 economies)
Algeria, Bahrain, Djibouti, Egypt, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, United Arab Emirates, Yemen.

Region 5: Sub-Sahara Africa, (44 economies)
Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, São Tomé and Príncipe, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe.

II Income Classification

Low-income economies (57 economies)
Angola, Armenia, Azerbaijan, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Cameroon, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Eritrea, Ethiopia, Gambia, Georgia, Ghana, Guinea-Bissau, Haiti, India, Indonesia, Kenya, Kyrgyz Republic, Laos, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Moldova, Mongolia, Mozambique, Myanmar, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Rwanda, São Tomé and Príncipe, Senegal, Sierra Leone, Solomon Islands, Sudan, Tajikistan, Tanzania, Togo, Uganda, Ukraine, Vietnam, Yemen, Zambia, Zimbabwe.

Middle-income economies (79 economies)
Albania, Algeria, Anguilla, Argentina, Bahrain, Belarus, Belize, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Cape Verde, Chile, China, Colombia, Costa Rica, Croatia, Czech Republic, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Estonia, Fiji, Gabon, Grenada, Guatemala, Guyana, Honduras, Hungary, Jamaica, Jordan, Kazakhstan, Korea, Latvia, Lebanon, Libya, Lithuania, Macedonia, Malaysia, Maldives, Mauritius, Mexico, Federated States of Micronesia, Morocco, Namibia, Oman, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Romania, Russia, Samoa, Saudi Arabia, Seychelles, Slovak Republic, South Africa, Sri Lanka, St. Kitts and Nevis, St. Lucia, St. Vince and the Grenadines, Suriname, Swaziland, Taiwan, Thailand, Tonga, Trinidad and Tobago, Tunisia, Turkey, Uruguay, Vanuatu, Venezuela.

High-income economies (35 economies)
Aruba, Australia, Austria, Baham, Barbados, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Macao, Malta, Netherlands Antilles, Netherlands, New Zealand, Norway, Portugal, Qatar, Singapore, Slovenia, Spain, Sweden, Switzerland, United Arab Emirates, United Kingdom, United States.

III Indebtedness Classification

Less-Indebted Economies (37 economies)
Angola, Argentina, Benin, Brazil, Burundi, Cameroon, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Ecuador, Ethiopia, Gabon, Guinea-Bissau, Guyana, Indonesia, Jordan, Kyrgyz Republic, Laos, Liberia, Madagascar, Malawi, Mauritania, Myanmar, Nicaragua, Niger, Nigeria, Pakistan, Peru, Rwanda, São Tomé and Príncipe, Sierra Leone, Sudan, Tajikistan, Tanzania, Zambia.

Moderately-indebted Economies (41 economies)
Algeria, Belize, Bolivia, Bosnia and Herzegovina, Bulgaria, Burkina Faso, Cambodia, Chile, Colombia, Croatia, Estonia, Gambia, Ghana, Haiti, Honduras, Hungary, Jamaica, Kenya, Lebanon, Malaysia, Mali, Mauritius, Moldova, Mongolia, Mozambique, Panama, Papua New Guinea, Philippines, Russia, Samoa, Senegal, St. Vincent and the Grenadines, Thailand, Togo, Tunisia, Turkey, Uganda, Uruguay, Venezuela, Zimbabwe, Yemen.

Severely-indebted Economies (56 economies)
Albania, Anguilla, Armenia, Azerbaijan, Bahrain, Bangladesh, Belarus, Bhutan, Botswana, Cape Verde, China, Costa Rica, Czech Republic, Djibouti, Dominica, Dominican Republic, Egypt, El Salvador, Equatorial Guinea, Eritrea, Fiji, Georgia, Grenada, Guatemala, India, Kazakhstan, Korea, Latvia, Lesotho, Libya, Lithuania, Maldives, Macedonia, Mexico, Morocco, Namibia, Nepal, Oman, Paraguay, Poland, Romania, Saudi Arabia, Seychelles, Slovak Republic, Solomon Islands, South Africa, Sri Lanka, St. Kitts and Nevis, St. Lucia, Suriname, Swaziland, Tonga, Trinidad and Tobago, Ukraine, Vanuatu, Vietnam.

IV Stage of Development and Asia Versus Non-Asia Classifications

Developing Non-Asian Economies (124 economies)
Albania, Algeria, Angola, Anguilla, Antigua and Barbuda, Argentina, Armenia, Aruba, Azerbaijan, Bahamas, The, Bahrain, Barbados, Belarus, Belize, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Chile, Colombia, Comoros, Congo, Costa Rica, Côte d'Ivoire, Croatia, Cyprus, Czech Republic, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Estonia, Ethiopia, Gabon, Gambia, The, Georgia, Ghana, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, Israel, Jamaica, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyz Republic, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Macedonia, Madagascar, Malawi, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Montserrat, Morocco, Mozambique, Namibia, Netherlands Antilles, Nicaragua, Niger, Nigeria, Oman, Panama, Paraguay, Peru, Poland, Qatar, Romania, Russia, Rwanda, São Tomé and Príncipe, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Slovak Republic, Slovenia, South Africa, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Sudan, Suriname, Swaziland, Tajikistan, Tanzania, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, Uruguay, Venezuela, Yemen, Zambia, Zimbabwe.

Developing Asian Economies (29 economies)
Bangladesh, Bhutan, Cambodia, China, Fiji, Hong Kong, India, Indonesia, Korea, Laos, Macao Malaysia, Maldives, Federated States of Micronesia, Mongolia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Tonga, Vanuatu, Vietnam.

Developed Non-Asian Economies (20 economies)
Australia, Austria, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

Developed Asian Economies (1 economy)
Japan.

V Exchange Rate Regime Classification

V.1 Bretton Woods period, 1957–1972

Rigid exchange rate regimes (84 economies)
Antigua and Barbuda, Argentina, Australia, Austria, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Canada, Central African Republic, Chad, Côte d'Ivoire, Cyprus, Denmark, Dominica, Equatorial Guinea, Gabon, Gambia, Germany, Ghana, Greece, Grenada, Guatemala, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong, India, Ireland, Israel, Italy, Jamaica, Jordan, Kenya, Kuwait, Lesotho, Liberia, Libya, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Morocco, Myanmar, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Pakistan, Panama, Peru, Philippines, Portugal, Saudi Arabia, Senegal, Singapore, South Africa, Spain, Sri Lanka, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Swaziland, Sweden, Switzerland, Tanzania, Thailand, Togo, Tunisia, Uganda, United Kingdom, United States, Venezuela, Zambia.

Limited flexibility exchange rate regimes (17 economies)
Algeria, Bolivia, Colombia, Costa Rica, Ecuador, Egypt, El Salvador, Finland, France, Hungary, Iceland, Japan, Korea, Lao, Lebanon, Paraguay, Turkey.

Floating exchange rate regimes (6 economies)
Brazil, Chile, China, Congo, Dominican Republic, Indonesia.

V.2 Early Post-Bretton Woods period, 1973–1989

Rigid exchange rate regimes (44 economies)
Antigua and Barbuda, Argentina, Austria, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Côte d'Ivoire, Dominica, Ecuador, Equatorial Guinea, Gabon, Gambia, Grenada, Guatemala, Guinea-Bissau, Guyana, Haiti, Honduras, Jamaica, Jordan, Kenya, Lesotho, Liberia, Madagascar, Mali, Mexico, Federated States of Micronesia, Nicaragua, Niger, Pakistan, Panama, Saudi Arabia, Senegal, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Swaziland, Thailand, Togo, Uruguay, Venezuela.

Limited flexibility exchange rate regimes (46 economies)
Algeria, Australia, Botswana, Brazil, Canada, Colombia, Congo, Costa Rica, Cyprus, Denmark, Dominican Republic, Egypt, El Salvador, Finland, France, Greece, Hong Kong, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Korea, Kuwait, Lebanon, Malaysia, Malta, Mauritania, Mauritius, Morocco, Myanmar, Nepal, Netherlands, New Zealand, Norway, Paraguay, Philippines, Portugal, Singapore, Spain, Sri Lanka, Suriname, Sweden, Tunisia.

Floating exchange rate regimes (17 economies)
Bolivia, China, Germany, Ghana, Japan, Laos, Libya, Malawi, Nigeria, South Africa, Switzerland, Tanzania, Uganda, United Kingdom, United States, Zambia, Zimbabwe.

V.3 Recent years, 1990–2004

Rigid exchange rate regimes (49 economies)
Antigua and Barbuda, Argentina, Austria, Benin, Bosnia and Herzegovina, Brazil, Bulgaria, Burkina Faso, Cameroon, Central African Republic, Chad, China, Côte d'Ivoire, Cyprus, Dominica, Egypt, El Salvador, Equatorial Guinea, Estonia, Finland, France, Gabon, Greece,Grenada, Guinea-Bissau, Hong Kong, Korea, Latvia, Lebanon, Lesotho, Lithuania, Mali, Federated States of Micronesia, Moldova, Netherlands, Niger, Panama, Portugal, Saudi Arabia, Senegal, Spain, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Swaziland, Tajikistan, Thailand, Togo, Venezuela.

Limited flexibility exchange rate regimes (60 economies)
Algeria, Armenia, Azerbaijan, Bolivia, Botswana, Burundi, Canada, Chile, Colombia, Costa Rica, Croatia, Czech Republic, Denmark, Dominican Republic, Ecuador, Gambia, Guatemala,Guyana, Honduras, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Jamaica, Kazakhstan, Kuwait, Kyrgyz Republic, Lao, Liberia, Libya, Macedonia, Malaysia, Malta, Mauritania, Mauritius, Mongolia, Morocco, Myanmar, Nepal, Nicaragua, Pakistan, Paraguay, Peru, Philippines, Poland, Romania, Russia, Singapore, Slovak Republic, Slovenia, Sri Lanka, Switzerland, Tanzania, Tunisia, Turkey, Uganda, Uruguay.

Floating exchange rate regimes (20 economies)
Albania, Australia, Georgia, Germany, Ghana, Haiti, Japan, Kenya, Madagascar, Malawi, Mexico, New Zealand, Nigeria, Norway, South Africa, Sweden, United Kingdom, United States,
Zambia, Zimbabwe.

B Correlation between Structural Characteristics

	Region	Income	Indebtedness	Stage of Development
Income	0.572***			
Indebtedness	0.410***	0.4732***		
Stage of development	0.448***	0.594***	n.a.	
Asian/non-Asian	0.693***	0.09	0.132	0.121

Notes: "***" indicates significance at the 1% level. All reported correlations are contingency coefficients except for the "income" and "indebtedness" pair for which rank correlation is reported instead because all economies in the high income group are in the "not classified" indebtedness category that is not used in the current study. No correlation coefficient of indebtedness and stage of development is reported because data are not available. The coefficients related to exchange rate regimes are not computed because most economies changed their exchange rate arrangements during the sample period.

Appendix 2: Structural Characteristic-Specific International Reserve Ratios

The appendix describes the variable $r_{.,j,t} = \Sigma_{i=1}^{N_c} r_{i,j,t} / N_C$, which is the average of international reserve ratios calculated according to an economy's structural characteristics. The time series plots of $r_{.,j,t}$ for each of the five structural characteristics and for each of the seven international reserve ratios are given in Figures A2.1 to A2.6. Because of the presence of some extreme observations, we have two sets of graphs for the reserves-to-short-term-external-debts ratio. The extreme observations are excluded from the second set of graphs.

A summary of these graphs is in order. For most international reserve ratio types, the "Asia, Pacific, and South Asia" and "Middle East and North Africa" regions held higher levels of international reserves than the other three regions, especially in recent years (Figure A2.1). An obvious exception is the "Sub-Sahara" region, which had a larger reserves-to-M2 ratio in, say, the post-1990s period.

When the Asian group is compared with the non-Asian group, the general impression is that the Asian group's reserve ratios are higher than the non-Asian group's ratios—the exception again is the reserves-to-M2 ratio for which the Asian group's ratio is slightly lower after, say, 1995 (Figure A2.2).

When the economies are classified according to their levels of income, the ranking of international reserve ratios depends on the choice of the normalizing variable (Figure A2.3). For instance, the high-income group has the smallest ratio when short-term external debts are the normalizing variable but the largest ratio when population is used. Further, the evolution of the ratios from different income groups displays considerable variation across the normalizing variables.

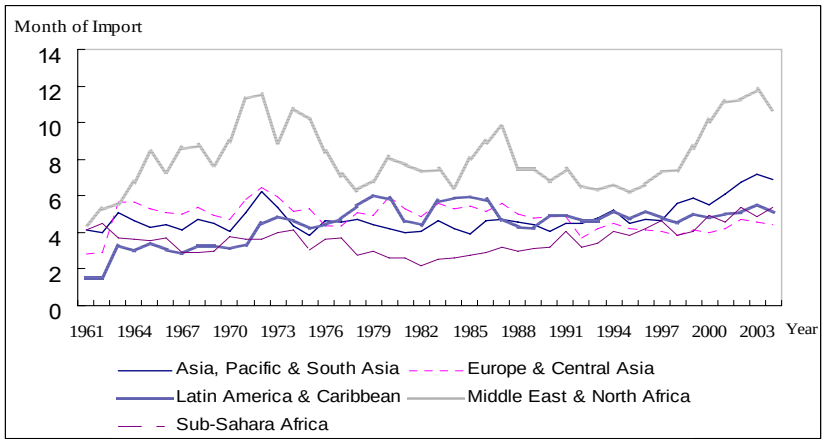
For the level of indebtedness, the severely indebted economies tend to have an international reserve ratio that is higher than those of the less indebted and the moderately indebted economies when total foreign liabilities, short-term external debts, and population are the normalizing variables (Figure A2.4). For other normalizing variables, the rankings of these three groups are not that clear-cut, even though the less indebted economies usually have a smaller ratio than the other two groups.

Between the developed and developing economies, the latter tends to have a larger international reserve ratio when total foreign liabilities, cumulative FDI inflows, M2, and GDP are the normalizing variables (Figure A2.5). According to the reserves-to-population ratio, however, the developed economies hold more international reserves than developing economies. In the later part of the sample period, the developing economies tend to have a reserves-to-imports ratio larger than that of the developed economies. Note that data on the short-term external debts of developed economies are not available.

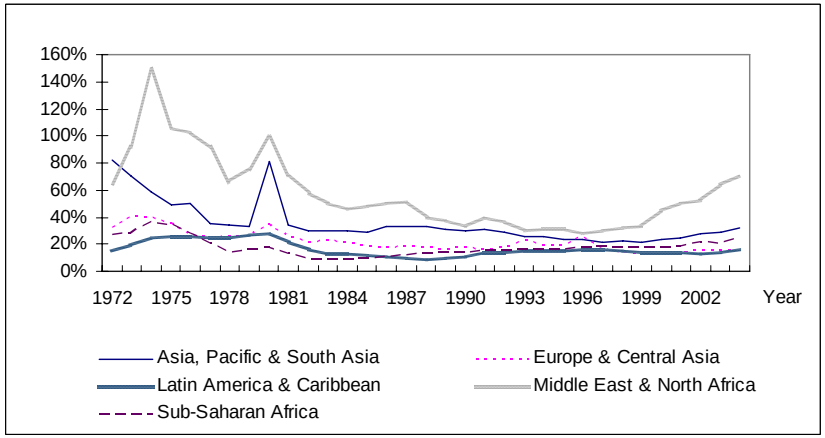
With respect to exchange rate arrangements, the group of economies with limited exchange rate flexibility has a higher international reserve ratio than the other two groups in the later part of the sample—the only exception is the case in which population is the normalizing factor (Figure A2.6). The relative ranking between the rigid and floating groups is not unambiguous. Using the end of the sample period as a reference point, there is no substantial evidence that, compared with the rigid group, the floating group has either a larger or a smaller ratio.

Figure A2.1: International Reserve Ratios by Regions

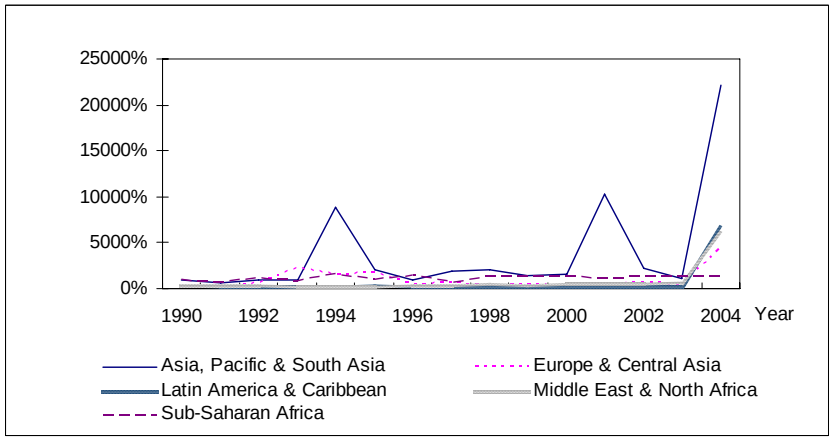
a. International Reserves to Imports



b. International Reserves to Total Foreign Liabilities



c.1 International Reserves to Short-Term External Debts



c.2 International Reserves to Short-Term External Debts

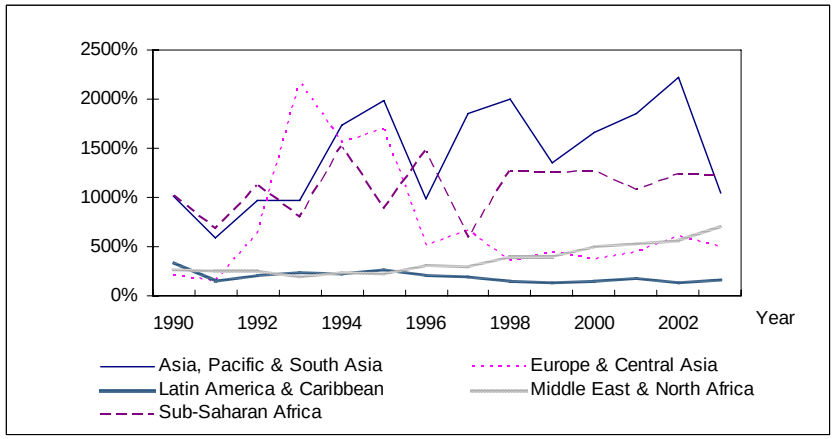
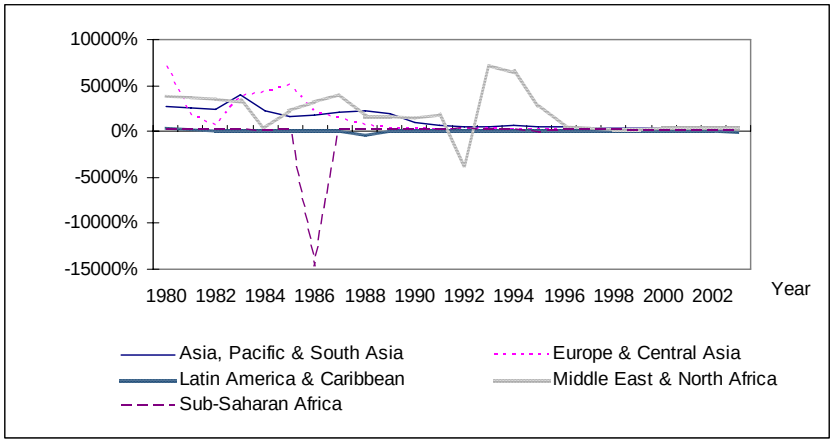
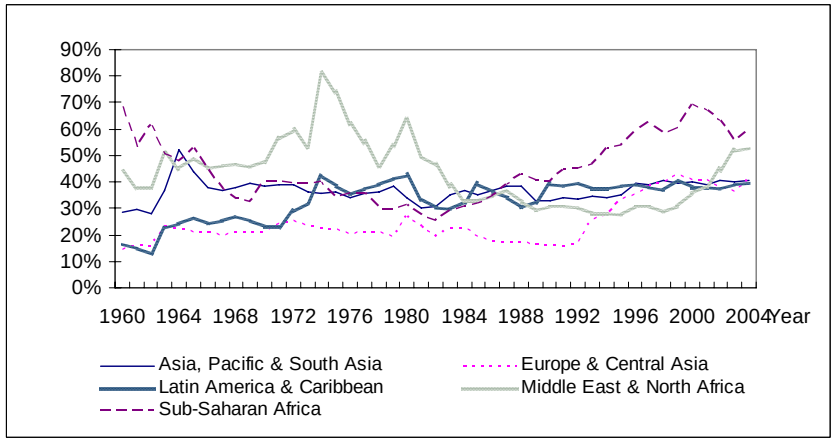


Figure A2.1 continued

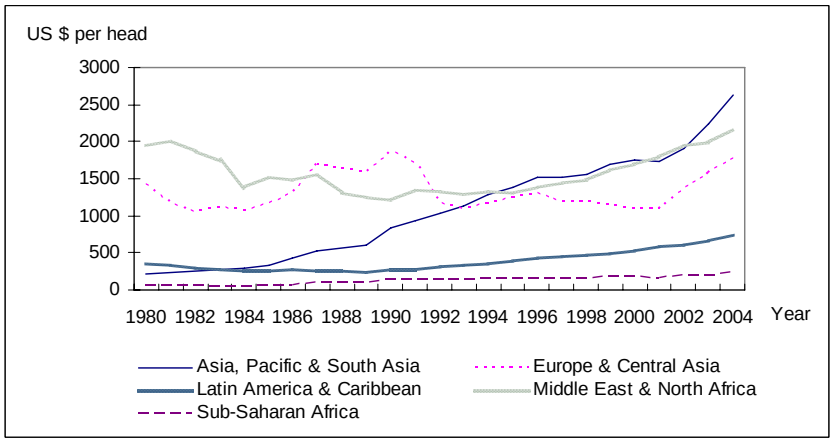
d. International Reserves to Cumulative FDI Inflows



e. International Reserves to M2



f. International Reserves to Population



g. International Reserves to GDP

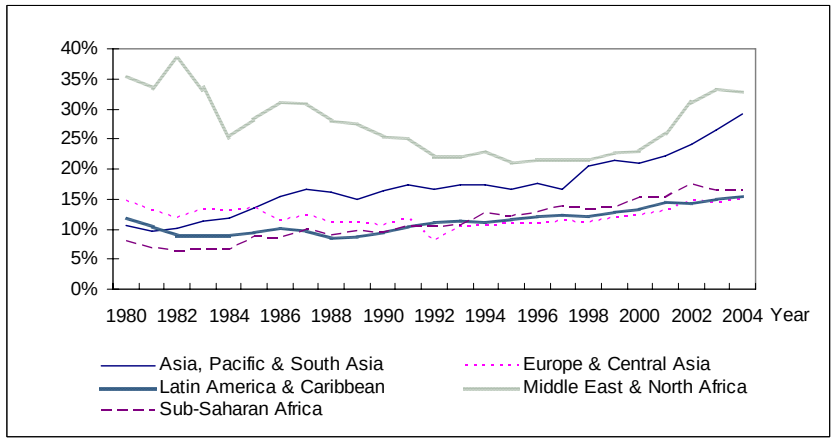
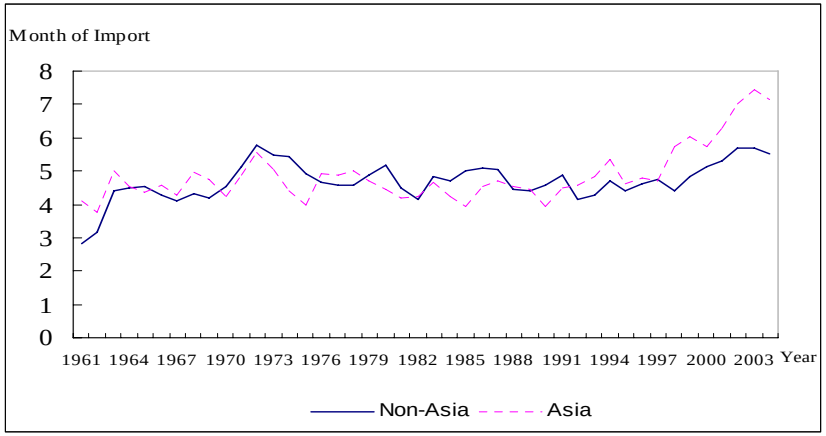
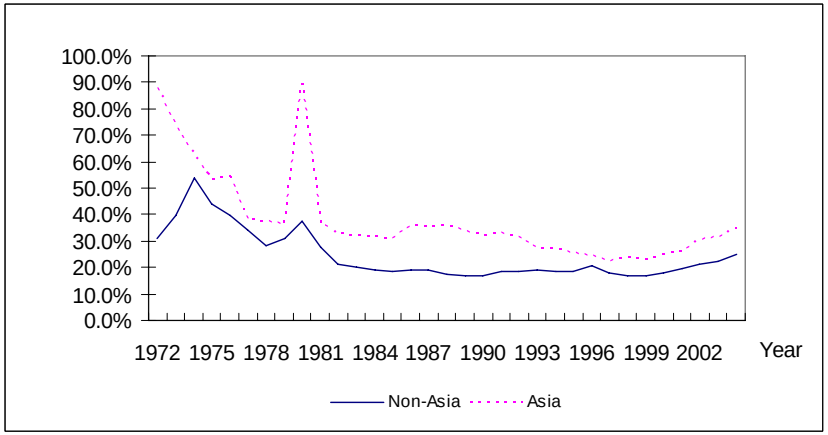


Figure A2.2: International Reserve Ratios: Asian versus Non-Asian Economies

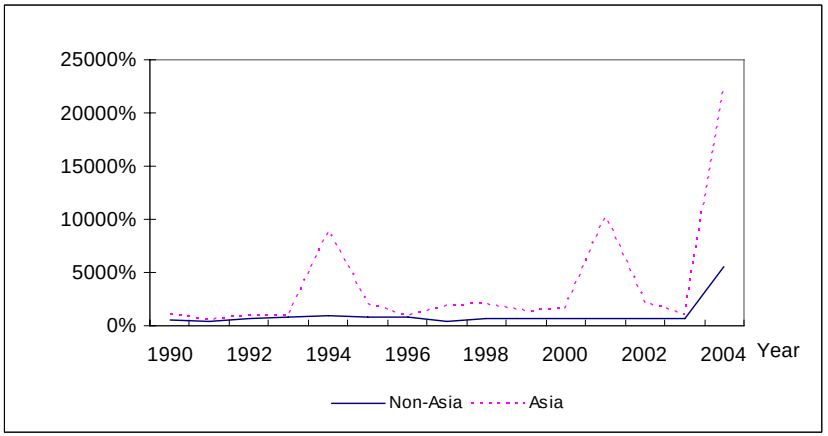
a. International Reserves to Imports



b. International Reserves to Total Foreign Liabilities



c.1 International Reserves to Short-Term External Debts



c.2 International Reserves to Short-Term External Debts

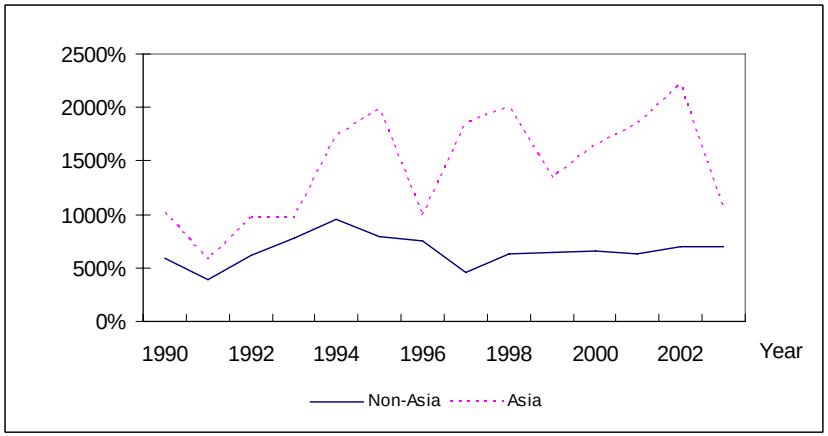
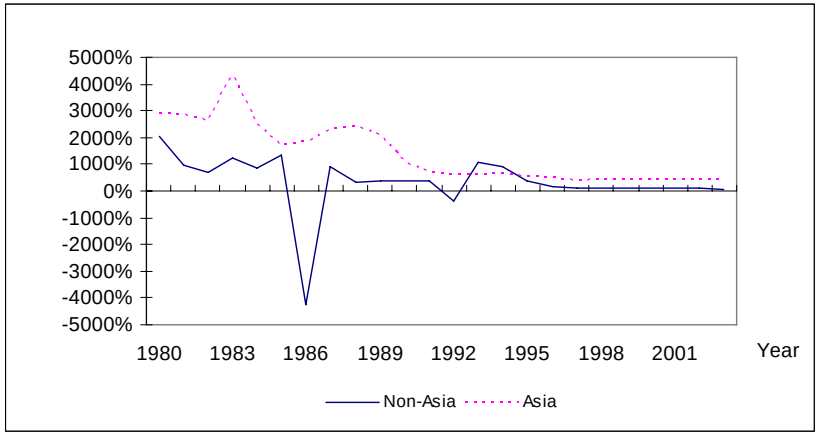
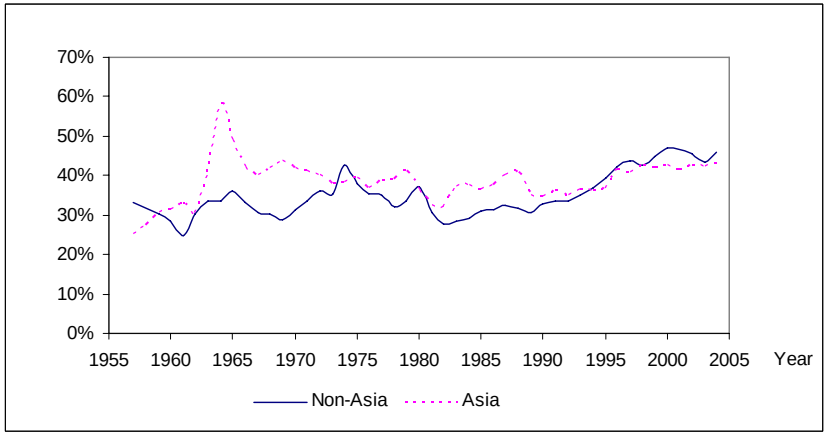


Figure A2.2 continued

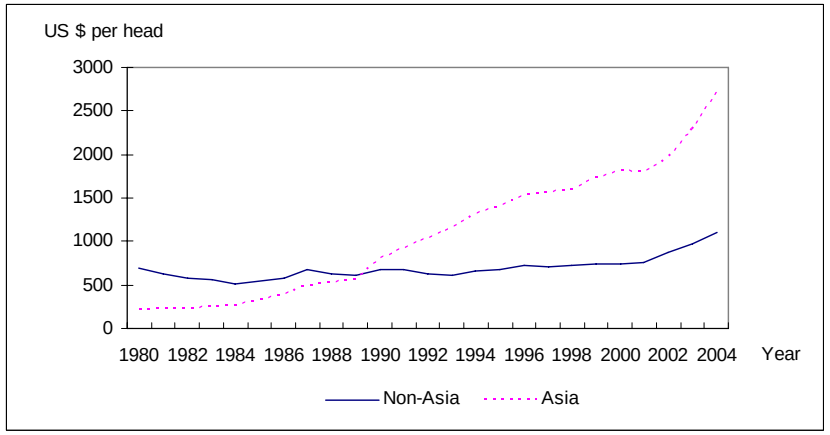
d. International Reserves to Cumulative FDI Inflows



e. International Reserves to M2



f. International Reserves to Population



g. International Reserves to GDP

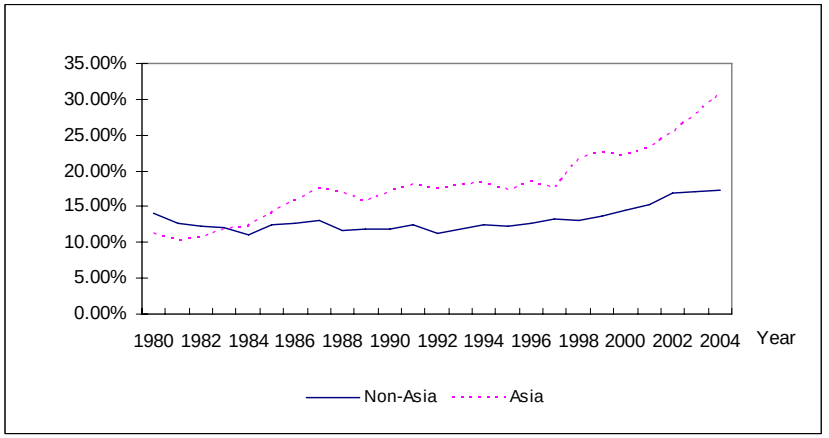
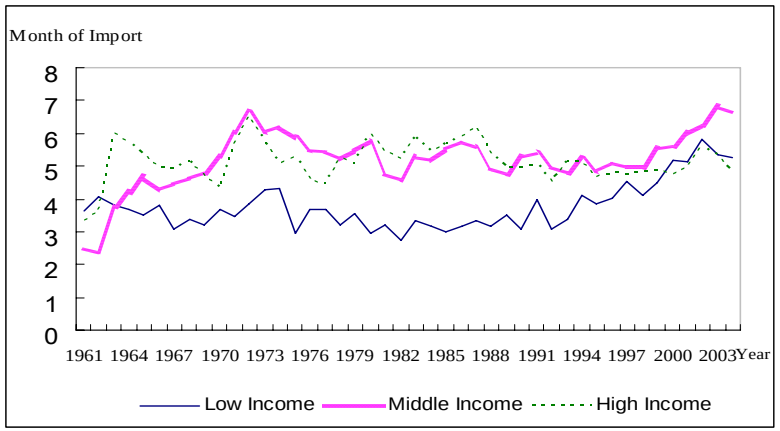
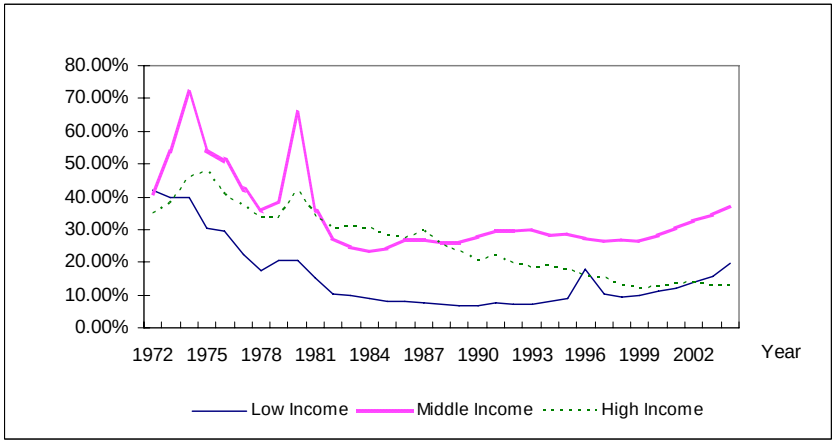


Figure A2.3: International Reserve Ratios By Income Levels

a. International Reserves to Imports



b. International Reserves to Total Foreign Liabilities



c.1 International Reserves to Short-Term External Debts

c.2 International Reserves to Short-Term External Debts

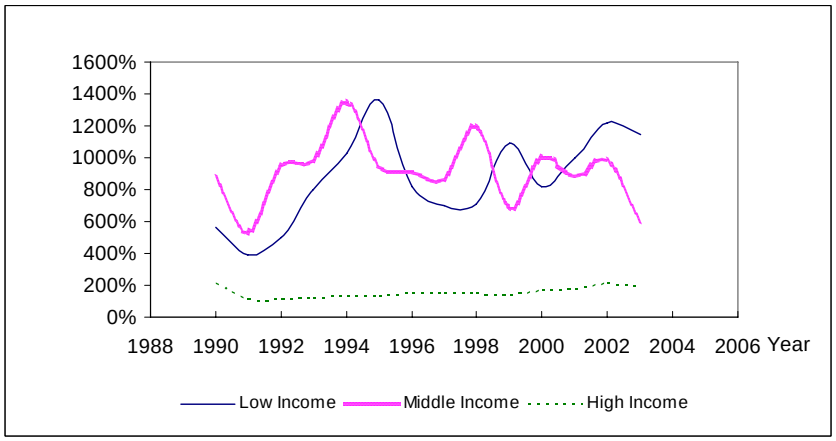
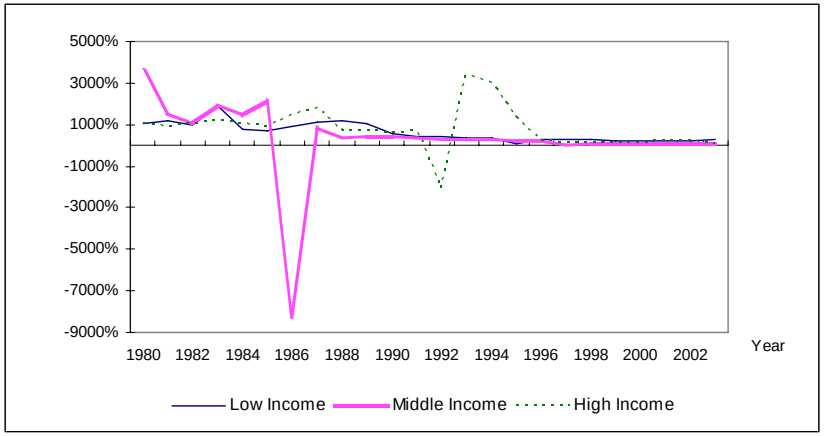
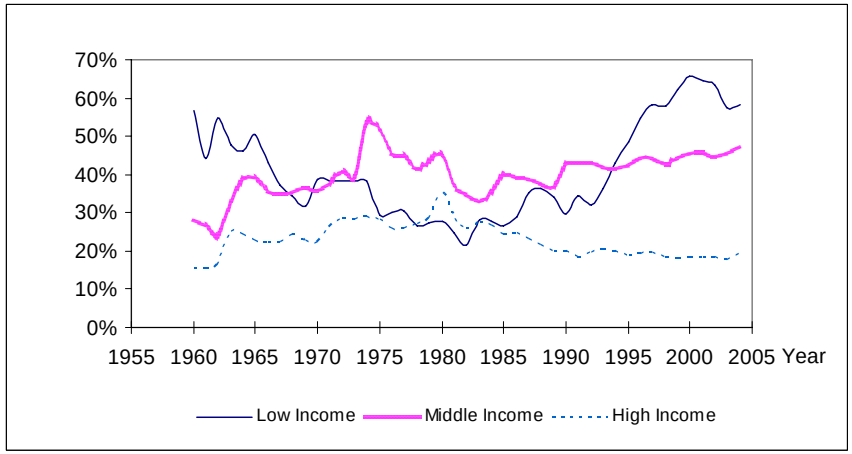


Figure A2.3 continued

d. International Reserves to Cumulative FDI Inflows



e. International Reserves to M2



f. International Reserves to Population

g. International Reserves to GDP

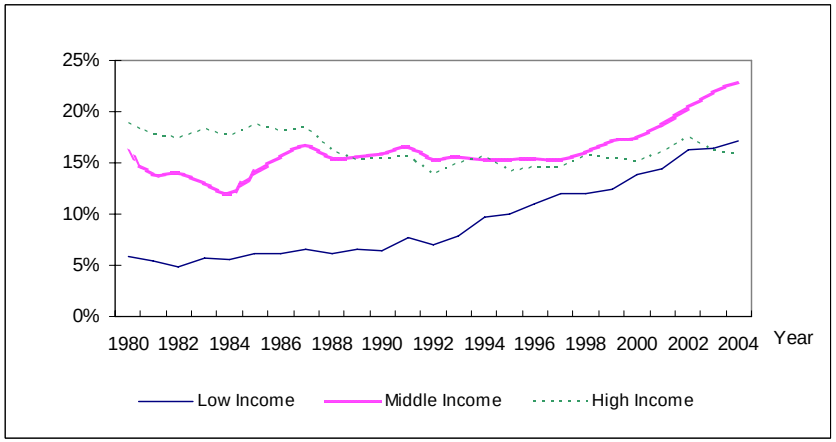
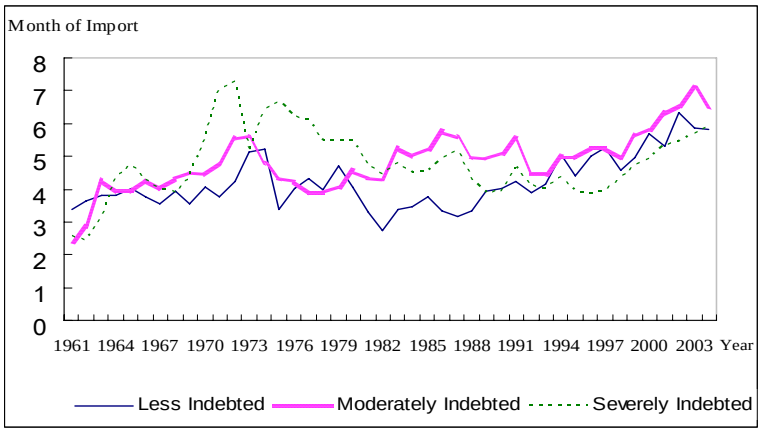
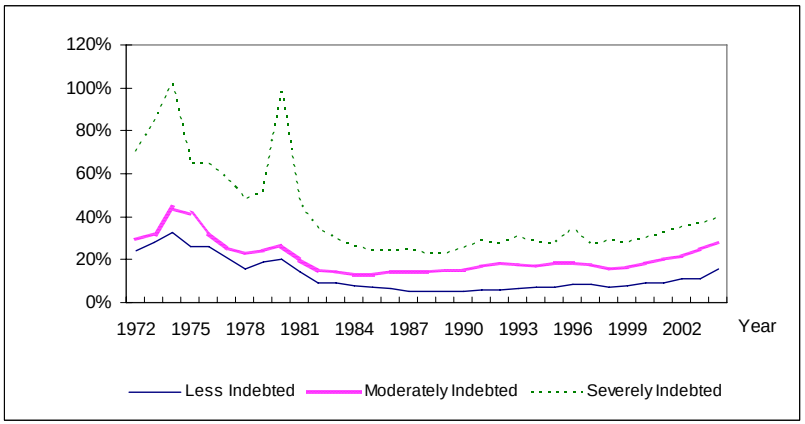


Figure A2.4: International Reserve Ratios by Indebtedness Levels

a. International Reserves to Imports



b. International Reserves to Total Foreign Liabilities



c.1 International Reserves to Short-Term External Debts

c.2 International Reserves to Short-Term External Debts

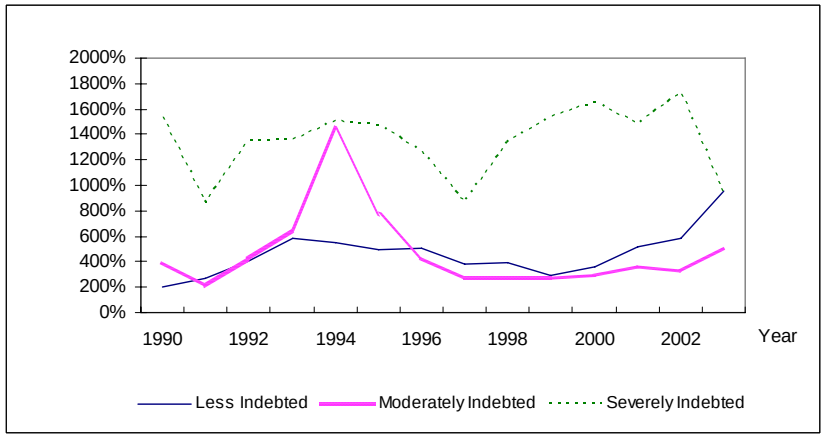
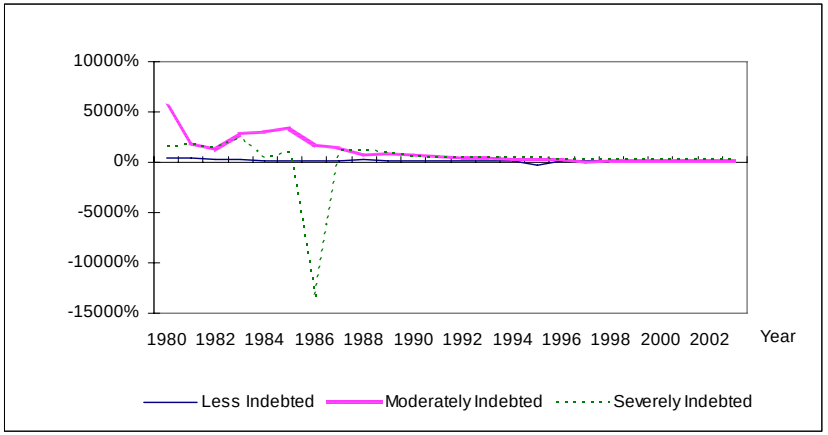
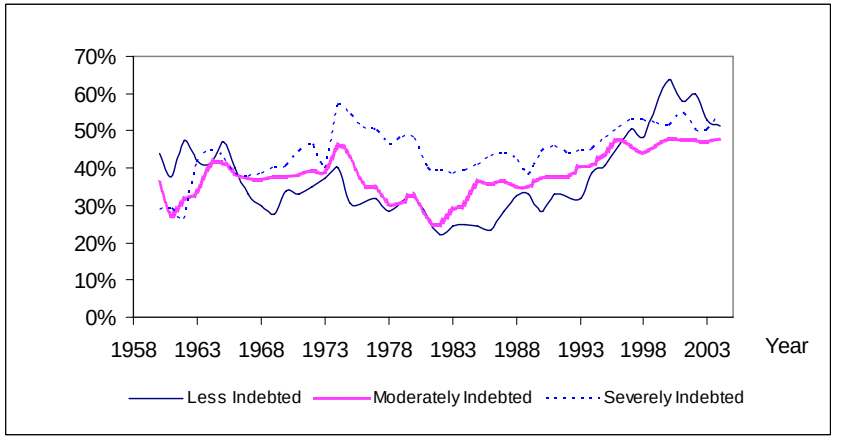


Figure A2.4 continued

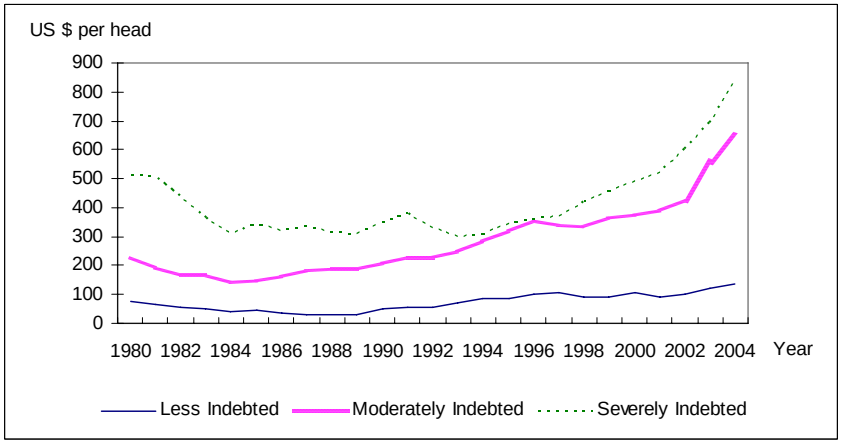
d. International Reserves to Cumulative FDI Inflows



e. International Reserves to M2



f. International Reserves to Population



g. International Reserves to GDP

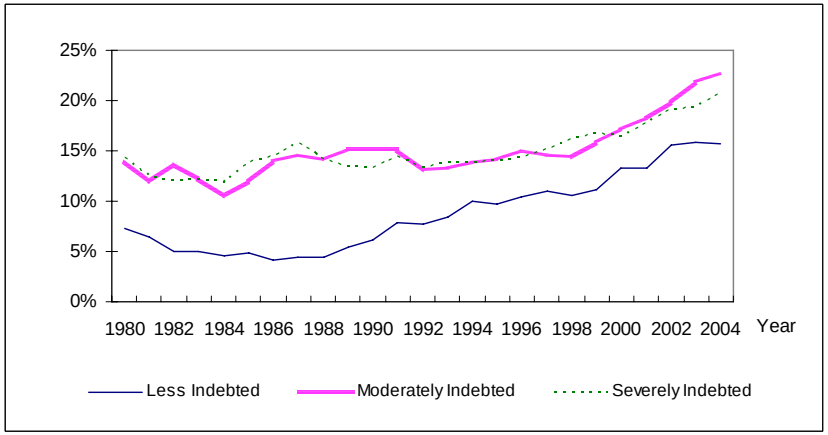
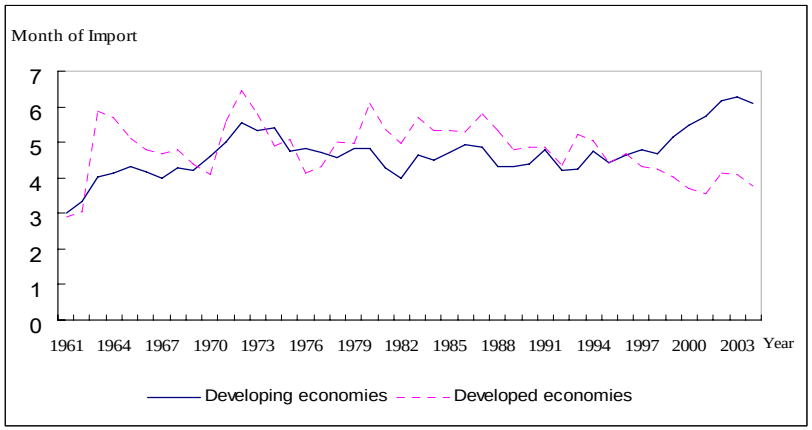
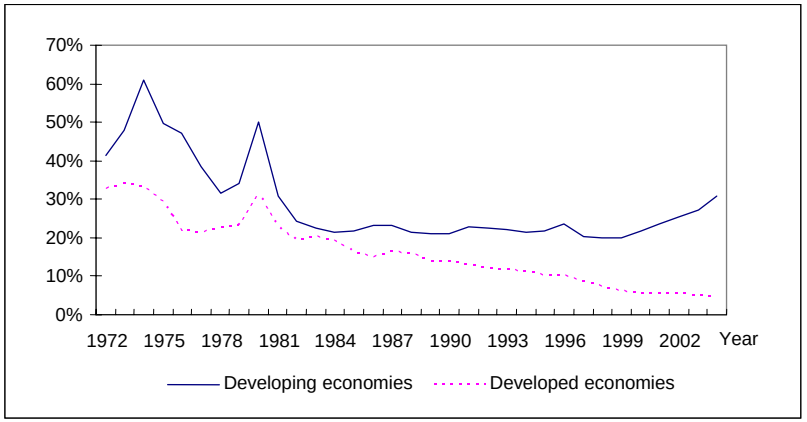


Figure A2.5: International Reserve Ratios by Stages of Development

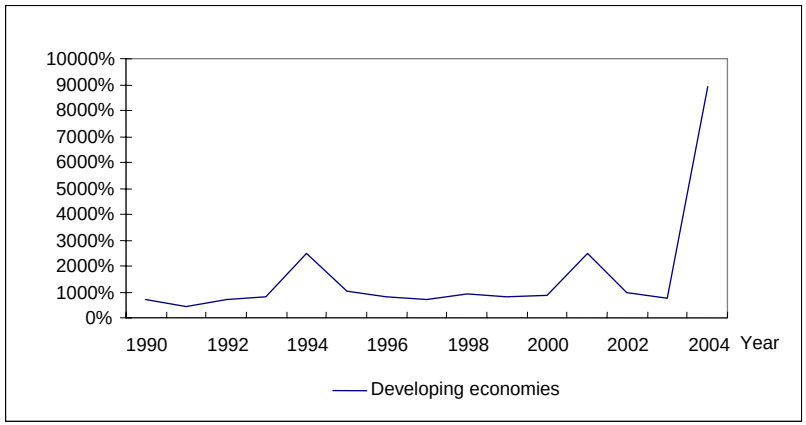
a. International Reserves to Imports



b. International Reserves to Total Foreign Liabilities



c.1 International Reserves to Short-Term External Debts (for developing economies only)



c.2 International Reserves to Short-Term External Debts (for developing economies only)

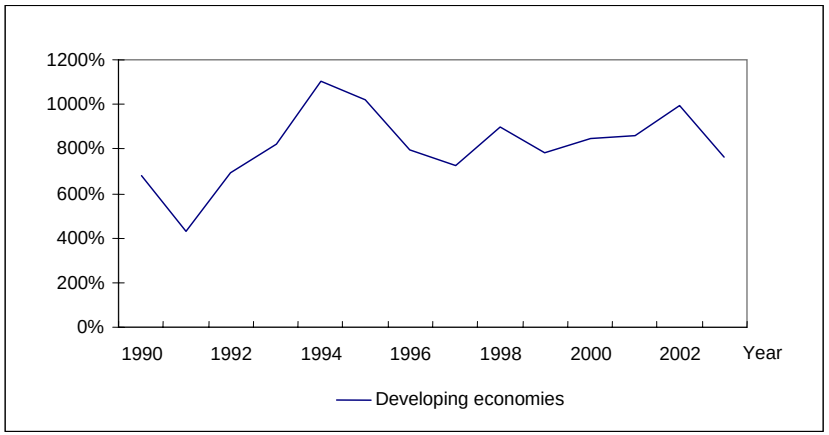
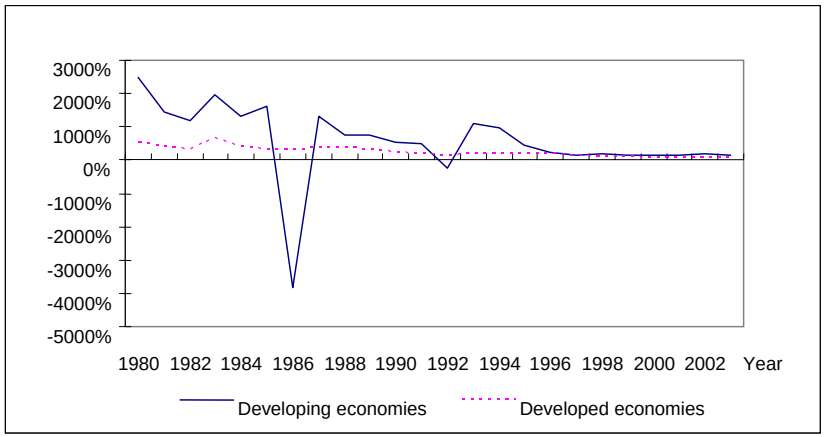
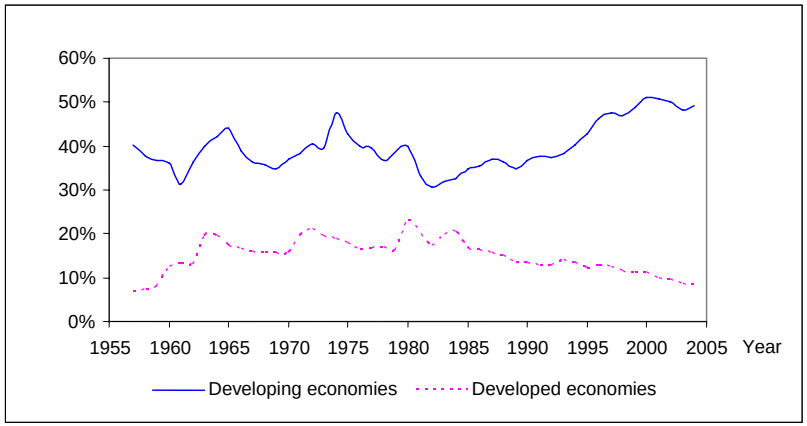


Figure A2.5 continued

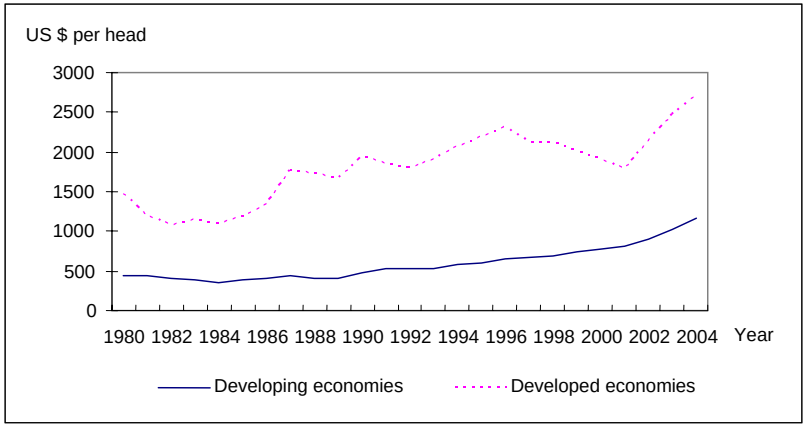
d. International Reserves to Cumulative FDI Inflows



e. International Reserves to M2



f. International Reserves to Population



g. International Reserves to GDP

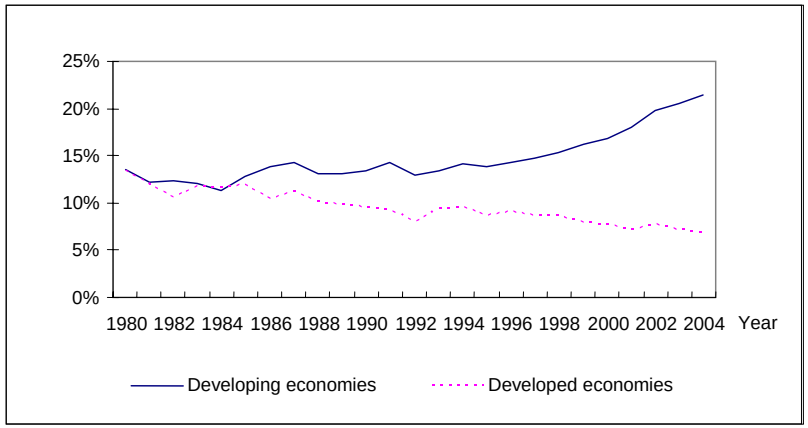
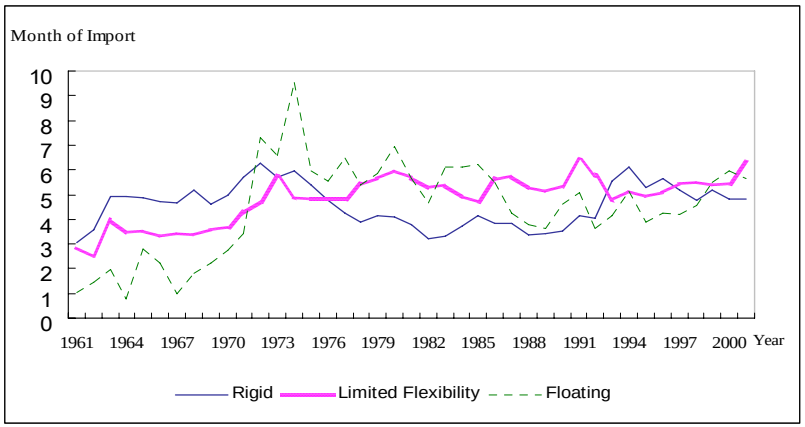
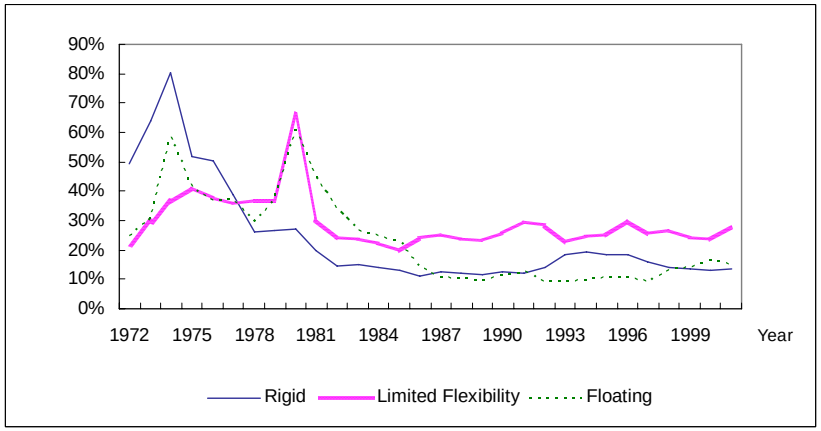


Figure A2.6: International Reserve Ratios by Exchange Rate Regimes

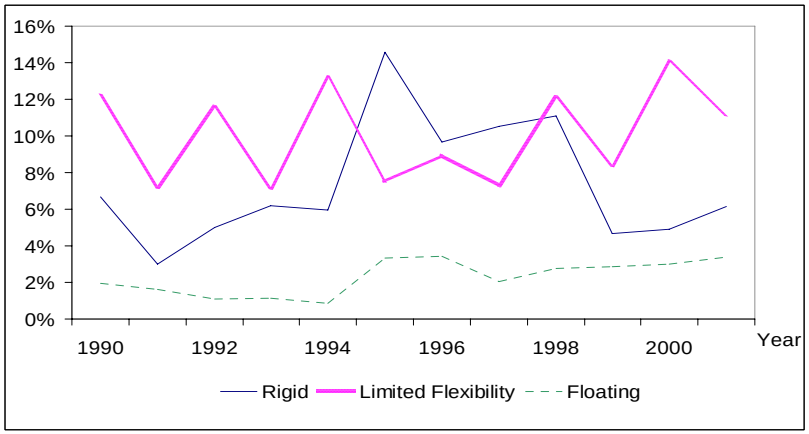
a. International Reserves to Imports



b. International Reserves to Total Foreign Liabilities



c. International Reserves to Short-Term External Debts



d. International Reserves to Cumulative FDI Inflows

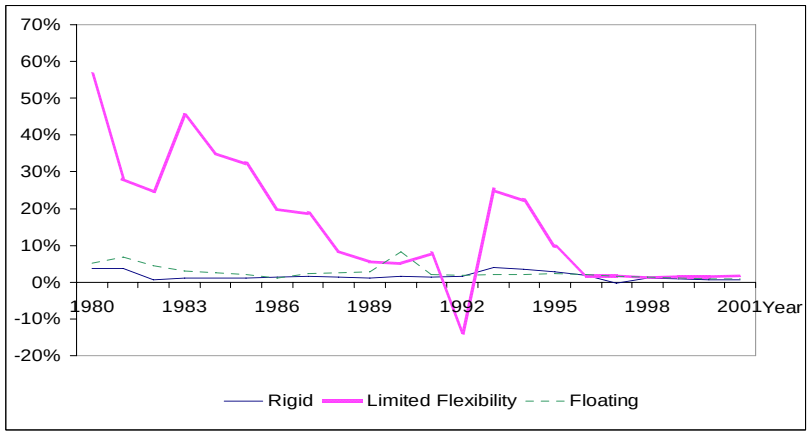
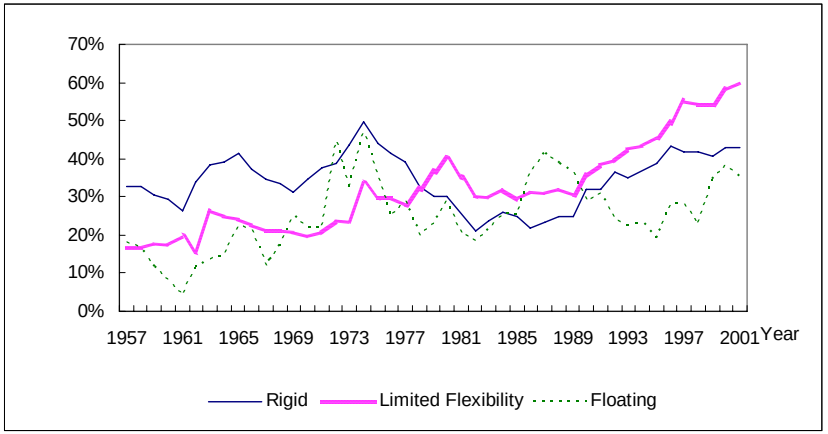
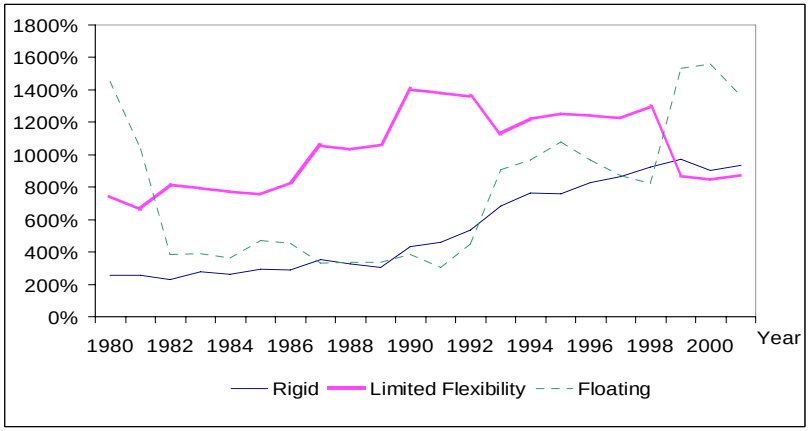


Figure A2.6 continued

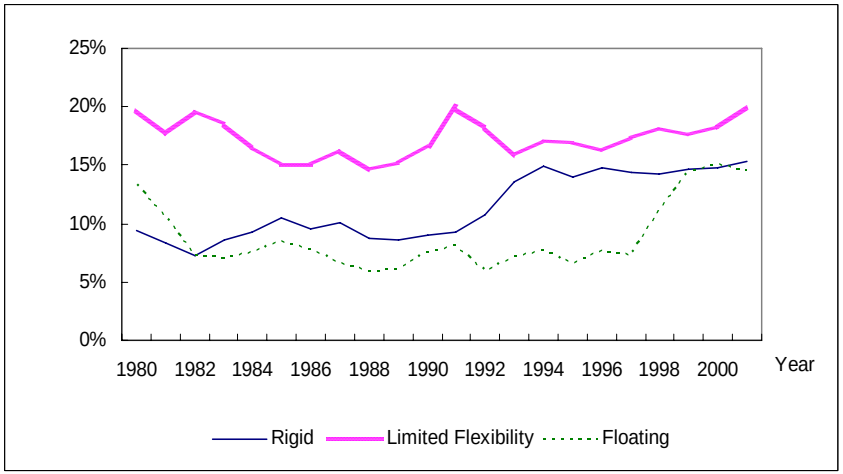
e. International Reserves to M2



f. International Reserves to Population



g. International Reserves to GDP



Appendix 3: Frequency Distributions of International Reserve Ratios

The appendix contains frequency distributions of $\{r_{i,j,.}\}_{i=1,\ldots,N}$, where N is the number of economies and j indicates the variable used to normalize international reserves. $r_{i,j,}$ is the time average of international reserve ratios given by $r_{i,j,.} = \Sigma_{t=1}^{T} r_{i,j,t} / T$.

Figure A3.1: International Reserves to Imports

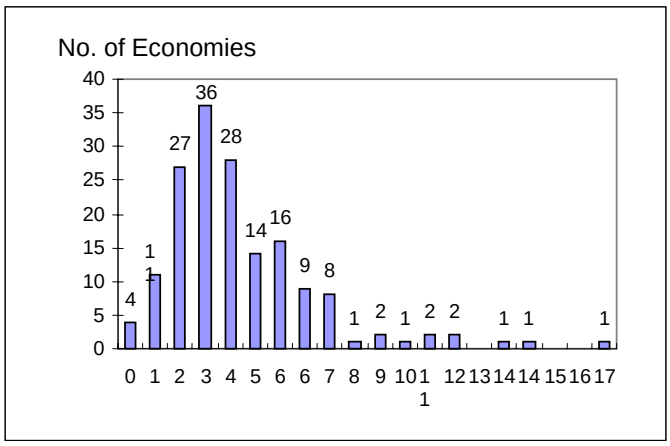


Figure A3.2(I): International Reserves to Total Foreign Liabilities

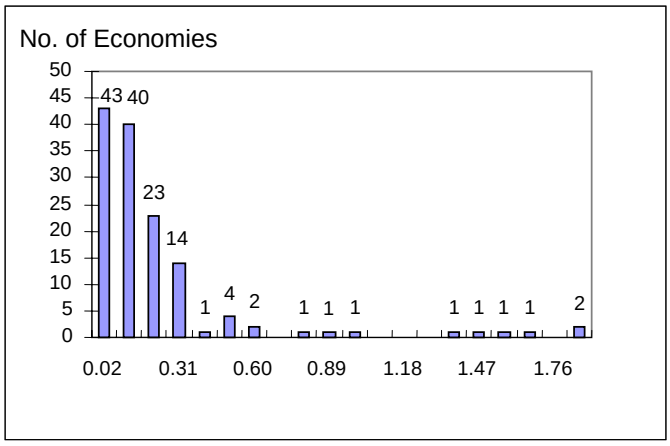


Figure A3.2(II) International Reserves to Total Foreign Liabilities

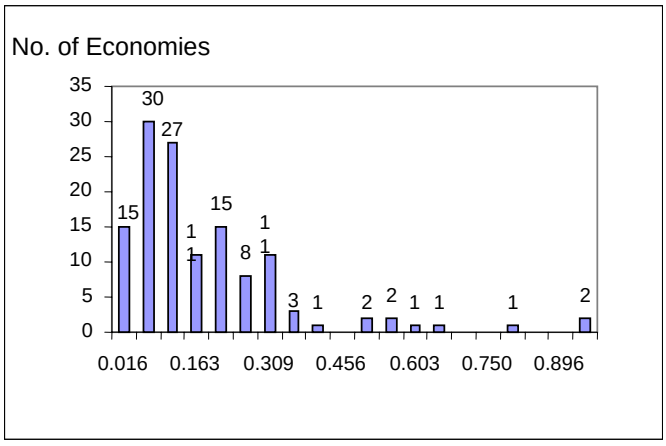


Figure A3.3(I): International Reserves to Short-Term External Debts

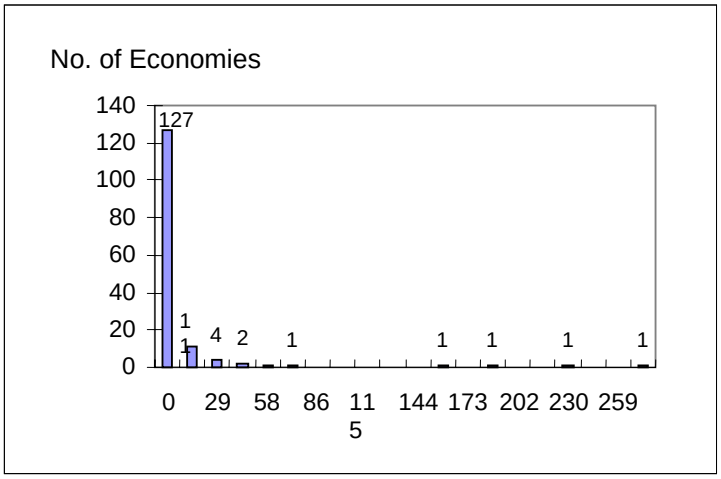


Figure A3.3(II): International Reserves to Short-Term External Debts

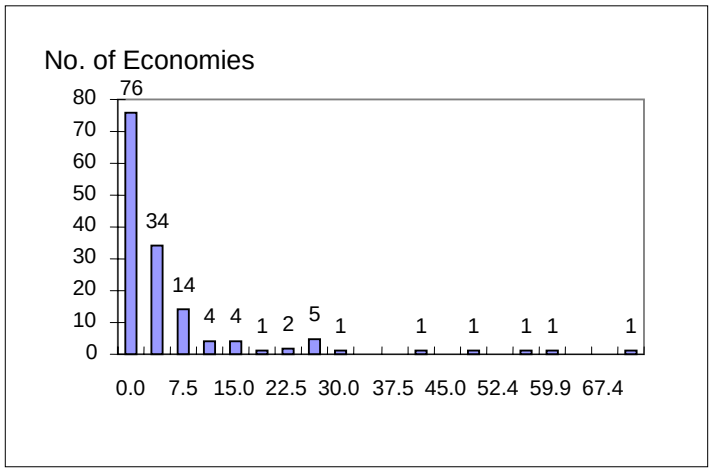


Figure A3.4(I): International Reserves to Cumulative FDI Inflows

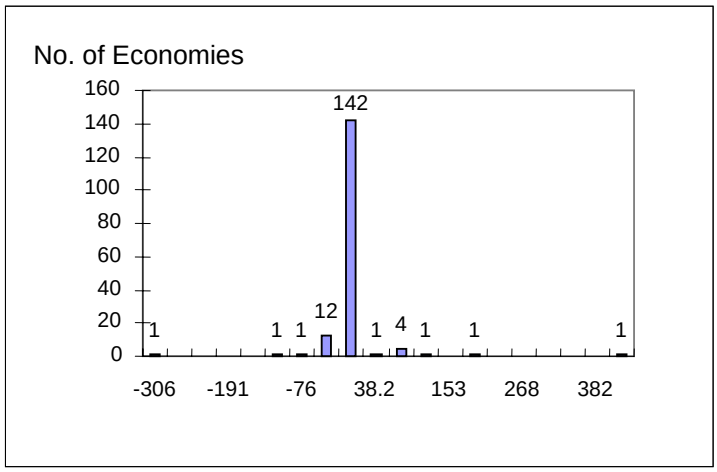


Figure A3.4(II): International Reserves to Cumulative FDI Inflows

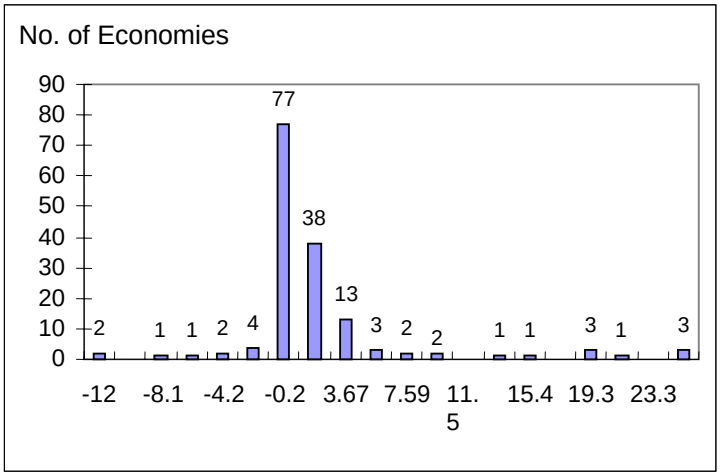


Figure A3.5(I): International Reserves to M2

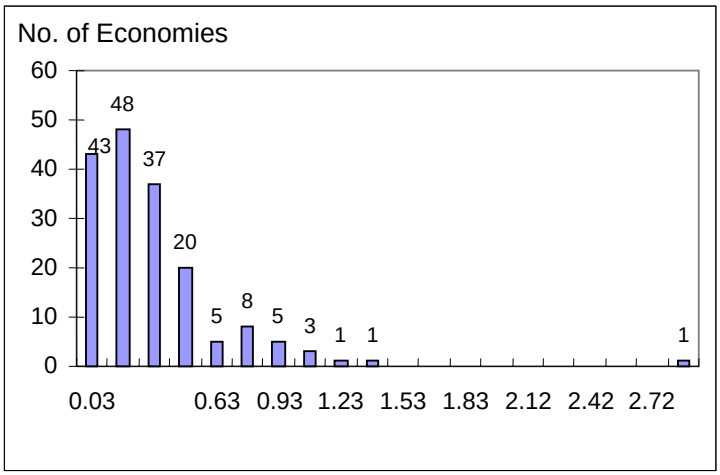


Figure A3.5(II): International Reserves to M2

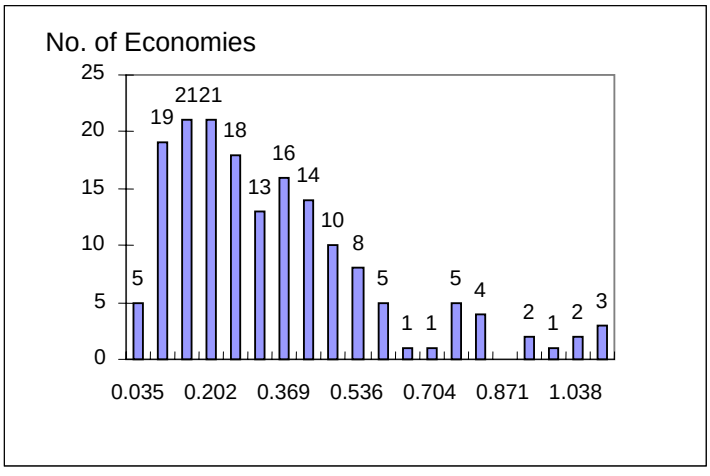


Figure A3.6(I): International Reserves to Population

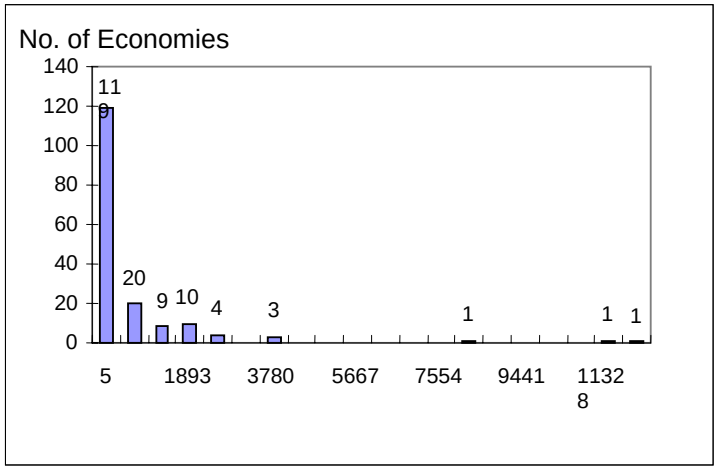


Figure A3.6(II): International Reserves to Population

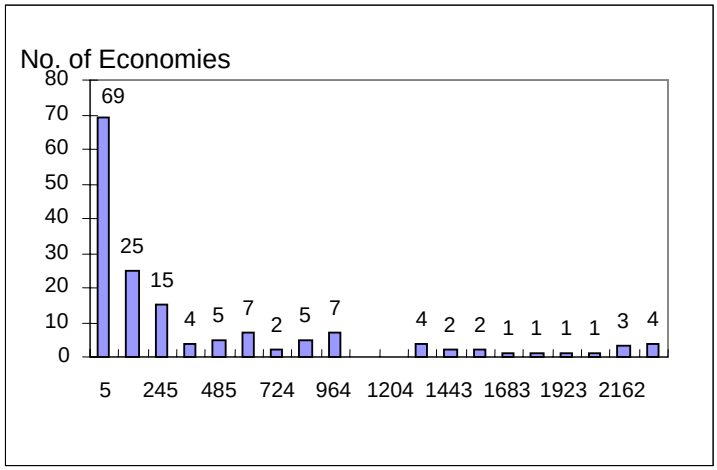
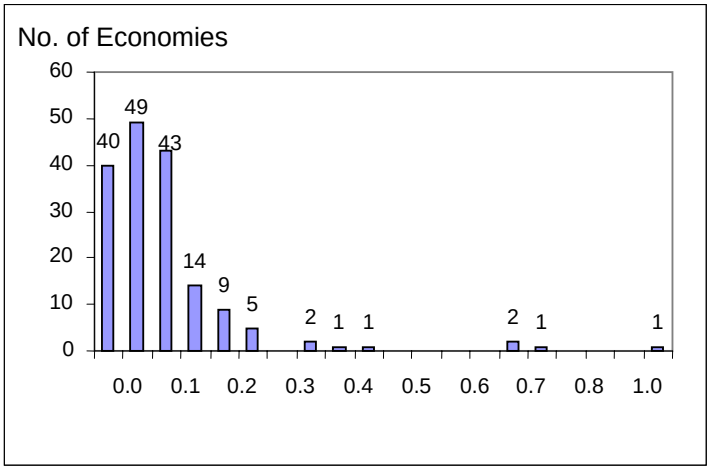


Figure A3.7: International Reserves to GDP



Appendix 4: Statistical Procedures

A Contingency Table Analysis and Contingency Coefficient

The contingency table analysis is based on the statistic defined by

$$Q = \sum_r \sum_c \frac{(O_{rc} - E_{rc})^2}{E_{rc}} .$$

In our exercise, r is ranking (LOW and HIGH) attribute and c is an index of a given structural characteristic. Under the null hypothesis that the attributes "r" and "c" are independent, the test statistic Q has a chi-square distribution with (R-1)(C-1) degrees of freedom, where C is the number of categories of the structural characteristic and R is 2, the number of rankings. For example, when the income structural characteristic is under consideration, c = low-income, middle-income and high-income, and C =3. O_{rc} is the number of economies that have attributes "r" and "c" and E_{rc} is the corresponding expected number of economies under the null hypothesis. The expected quantity is given by $E_{rc} = O_r O_c / N$, where O_r is the number of economies defined by "r," O_c is number of economies defined by "c," and N is the total number of economies under consideration.

The degree of association between the two attributes is measured by a non-parametric contingency coefficient defined as follows:

$$\text{Contingency coefficient} = \sqrt{\frac{Q}{N+Q}}$$

The contingency coefficient equals zero when the two attributes are independent, and approaches one as the degree of association between them increases. The statistical significance of a contingency coefficient follows from that of the Q statistic.

B Rank Correlation

To assess the degree of association between the type *j* and type *j** international reserve ratios, we consider two ranked series $\{ r_{|i|,j,.} \}$ and $\{ r_{|i|,j^*,.} \}$; $i = 1,\ldots,N$, where $r_{|i|,j,.}$ is the rank of $r_{i,j,.}$ among the N economies and $r_{|i|,j^*,.}$ is the rank of $r_{i,j^*,.}$. Specifically, we compute the Spearman rank correlation coefficient

$$S = 1 - \sum_{i=1}^{N} (r_{|i|,j,.} - r_{|i|,j^*,.})^2 / (N^3 - N) .$$

Under the null hypothesis that the rankings $r_{|i|,j,.}$ and $r_{|i|,j^*,.}$ are independent and for sample size, say, larger 30, the statistically significance of S can be tested using the t-statistic

$$T_{N-2} = S[(N-2)/(1-S^2)]^{1/2}.$$

The rank correlation coefficient is between 1 and –1. A rank correlation close to one indicates that the two ratios tend to give similar rankings: that is, a relatively large international reserve ratio $r_{i,j,.}$ will tend to imply a relatively large ratio $r_{i,j^*,.}$. A rank correlation close to zero suggests that the ranking of an economy's international reserve

ratio $r_{i,j,\cdot}$ bears no implication for the ranking of its other ratio $r_{i,j^*,\cdot}$. If the rank correlation is negative, then a large $r_{i,j,\cdot}$ implies a small $r_{i,j^*,\cdot}$.

C Augmented Dickey-Fuller Test

For a time series of international reserve ratios, $\{r_{i,j,t}\}_{t=1,\ldots,T}$, the augmented Dickey-Fuller test is based on the regression equation

$$\Delta r_{i,j,t} = \omega_i + \tau_i t + \delta_i r_{i,j,t-1} + \sum_{k=1}^{p-1} \varphi_{ij} \Delta r_{i,j,t-k} + \varepsilon_{i,j,t},$$

where Δ is the differencing operator. Under the unit-root null hypothesis, $\delta_i = 0$. The null hypothesis is rejected when the ADF test statistic, which is given by the usual *t*-statistic for $\delta_i = 0$ against the alternative of $\delta_i < 0$, is significant. Finite sample critical values for the test are given in Cheung and Lai (1995).

Appendix 5: The High and Low Breakdowns of International Reserve Ratios

For each type of international reserve ratios, we rank the time averages $\{ r_{i,j,.}\}_{i=1,...,N}$. Then we assign a LOW or HIGH label to each time average $r_{i,j,.}$ depending on whether it is below or above the median of $\{ r_{i,j,.}\}$. The appendix presents the proportions of economies with a LOW or HIGH label under each category of a given structural characteristic.

Table A5.1: The Observed Frequencies of High and Low International Reserve Ratios, 1957–2004

	% low	% high	% low	% high	% low	% high	% low	% high	% low	% high	% low	% high	% low	% high
I. Region categories	AR/IM**		AR/TFL***		AR/STED***		AR/CFDI_in***		AR/M2		AR/POP***		AR/GDP***	
1) Asia, Pacific & South Asia	48	52	57	43	38	62	46	54	56	44	50	50	47	53
2) Europe & Central Asia	48	52	38	62	31	69	29	71	49	51	29	71	48	52
3) Latin America & Caribbean	61	39	62	38	78	22	75	25	61	39	38	62	50	50
4) Middle East & North Africa	12	88	19	81	47	53	18	82	41	59	29	71	6	94
5) Sub-Sahara Africa	59	41	68	32	50	50	64	36	39	61	91	9	67	33
I.a Asian Vs Non-Asian	AR/IM		AR/TFL		AR/STED		AR/CFDI in		AR/M2		AR/POP		AR/GDP	
1) Asian	50	50	50	50	53	47	51	49	49	51	49	51	51	49
2) Non-Asian	48	52	48	52	38	62	42	58	53	47	54	46	43	57
II. Income categories	AR/IM**		AR/TFL***		AR/STED**		AR/CFDI_in***		AR/M2***		AR/POP***		AR/GDP***	
1) Low	61	39	72	28	39	61	59	41	36	64	98	2	68	32
2) Middle	49	51	37	63	53	47	53	47	49	51	36	64	35	65
3) High	31	69	43	57	79	21	24	76	74	26	0	100	52	48
III. Indebtedness	AR/IM		AR/TFL**		AR/STED**		AR/CFDI_in		AR/M2		AR/POP***		AR/GDP***	
1) Less	51	49	74	26	54	46	63	37	47	53	83	17	72	28
2) Moderate	49	51	42	58	63	37	41	59	41	59	44	56	41	59
3) Severe	48	52	40	60	37	63	46	54	57	43	33	67	40	60
IV. Stage of Development	AR/IM		AR/TFL		AR/STED		AR/CFDI_in**		AR/M2***		AR/POP***		AR/GDP**	
1) Developing Economies	52	48	49	51	50	50	54	46	44	56	57	43	46	54
2) Developed Economies	38	62	57	43	n.a.	n.a.	24	76	90	10	0	100	76	24

Note: See the note to Table 1 and the text for definitions of the ratios. "***," "**," and "*" in the column headings indicate significance of the corresponding contingency coefficients reported in Table 2 in the text at, respectively, the 1%, 5%, and 10% levels.

Table A5.2: The Observed Frequencies of High and Low International Reserve Ratios, 1957–1989

	% low	% high	% low	% high	% low	% high	% low	% high	% low	% high	% low	% high	% low	% high
I. Region categories	AR/IM*		AR/TFL**		AR/STED		AR/CFDI_in***		AR/M2**		AR/POP***		AR/GDP***	
1) Asia, Pacific & South Asia	42	58	45	55	n.a	n.a	42	58	50	50	52	48	56	44
2) Europe & Central Asia	43	57	37	63	n.a	n.a	5	95	80	20	14	86	43	57
3) Latin America & Caribbean	56	44	67	33	n.a	n.a	75	25	56	44	47	53	44	56
4) Middle East & North Africa	25	75	20	80	n.a	n.a	25	75	31	69	25	75	19	81
5) Sub-Sahara Africa	64	36	66	34	n.a	n.a	66	34	38	62	82	18	69	31
I.a Asian Vs Non-Asian	AR/IM		AR/TFL		AR/STED		AR/CFDI in		AR/M2		AR/POP		AR/GDP	
1) Asia	52	48	53	47	n.a	n.a	53	47	51	49	49	51	50	50
2) Non-Asia	42	58	39	61	n.a	n.a	38	62	46	54	56	44	52	48
II. Income categories	AR/IM		AR/TFL**		AR/STED		AR/CFDI_in***		AR/M2		AR/POP***		AR/GDP***	
1) Low	60	40	69	31	n.a	n.a	57	43	44	56	97	3	74	26
2) Middle	49	51	49	51	n.a	n.a	59	41	47	53	43	57	41	59
3) High	38	62	30	70	n.a	n.a	20	80	64	36	0	100	35	65
III. Indebtedness	AR/IM		AR/TFL*		AR/STED		AR/CFDI_in		AR/M2		AR/POP***		AR/GDP**	
1) Less	48	52	68	32	n.a	n.a	61	39	45	55	84	16	72	28
2) Moderate	48	52	39	61	n.a	n.a	45	55	52	48	42	58	45	55
3) Severe	54	46	44	56	n.a	n.a	44	56	53	47	30	70	38	62
IV. Stage of Development	AR/IM		AR/TFL		AR/STED		AR/CFDI_in***		AR/M2***		AR/POP***		AR/GDP	
1) Developing Economies	52	48	52	48	n.a	n.a	55	45	44	56	59	41	50	50
2) Developed Economies	38	62	40	60	n.a	n.a	20	80	86	14	0	100	48	52

Note: See the note to Table 1 and the text for definitions of the ratios. "***," "**," and "*" in the column headings indicate significance of the corresponding contingency coefficients reported in Table 2 in the text at the 1%, 5%, and 10% levels, respectively.

Table A5.3: The Observed Frequencies of High and Low International Reserve Ratios, 1990–2004

	% low	% high	% low	% high	% low	% high	% low	% high	% low	% high	% low	% high	% low	% high
I. Region categories	AR/IM**		AR/TFL***		AR/STED***		AR/CFDI_in***		AR/M2		AR/POP***		AR/GDP**	
1) Asia, Pacific & South Asia	48	52	43	57	38	62	45	55	59	41	50	50	40	60
2) Europe & Central Asia	60	40	43	57	31	69	33	67	49	51	29	71	55	45
3) Latin America & Caribbean	55	45	57	43	78	22	81	19	61	39	34	66	47	53
4) Middle East & North Africa	12	88	13	87	47	53	18	82	53	47	29	71	18	82
5) Sub-Sahara Africa	51	49	77	23	50	50	57	43	34	66	91	9	65	35
I.a Asian Vs Non-Asian	AR/IM		AR/TFL		AR/STED		AR/CFDI in		AR/M2		AR/POP		AR/GDP*	
1) Asian	51	49	52	48	53	47	52	48	49	51	49	51	53	47
2) Non-Asian	44	56	38	62	38	62	41	59	57	43	54	46	38	62
II. Income categories	AR/IM		AR/TFL***		AR/STED**		AR/CFDI_in		AR/M2***		AR/POP***		AR/GDP***	
1) Low	59	41	74	26	39	61	53	47	32	68	98	2	63	37
2) Middle	45	55	25	75	53	47	51	49	45	55	36	64	35	65
3) High	43	57	63	37	79	21	41	59	89	11	0	100	60	40
III. Indebtedness	AR/IM		AR/TFL***		AR/STED**		AR/CFDI_in		AR/M2		AR/POP***		AR/GDP	
1) Less	46	54	86	14	54	46	63	37	42	58	83	17	64	36
2) Moderate	41	59	44	56	63	37	46	54	43	57	43	57	41	59
3) Severe	58	42	28	72	37	63	43	57	60	40	33	67	45	55
IV. Stage of Development	AR/IM		AR/TFL***		AR/STED		AR/CFDI_in		AR/M2***		AR/POP***		AR/GDP***	
1) Developing Economies	48	52	44	56	n.a	n.a	49	51	43	57	57	43	45	55
2) Developed Economies	62	38	81	19	n.a	n.a	52	48	100	0	0	100	85	15

Note: See the note to Table 1 and the text for definitions of the ratios. "***," "**," and "*" in the column headings indicate significance of the corresponding contingency coefficients reported in Table 2 in the text at the 1%, 5%, and 10% levels, respectively.

Table A5.4: The Observed Frequencies of High and Low International Reserve Ratios: Exchange Rate Regimes

	% low	% high	% low	% high	% low	% high	% low	% high	% low	% high	% low	% high	% low	% high
I. 1957–72; Bretton Woods period	AR/IM*		AR/TFL*		AR/STED		AR/CFDI_in*		AR/M2**		AR/POP		AR/GDP	
1) Rigid	48	52	47	53	n.a.	n.a.	47	53	46	54	n.a.	n.a.	n.a.	n.a.
2) Managed	60	40	53	47	n.a.	n.a.	43	57	71	29	n.a.	n.a.	n.a.	n.a.
3) Floating	100	0	100	0	n.a.	n.a.	100	0	100	0	n.a.	n.a.	n.a.	n.a.
II. 1973–89; post Bretton Woods	AR/IM		AR/TFL		AR/STED		AR/CFDI in**		AR/M2**		AR/POP***		AR/GDP**	
1) Rigid	59	41	60	40	n.a.	n.a.	64	36	57	43	69	31	60	40
2) Limited flexibility	41	59	45	55	n.a.	n.a.	34	66	51	49	31	69	42	58
3) Floating	44	56	53	47	n.a.	n.a.	50	50	63	37	65	35	76	24
III. 1990–2001; post-Bretton Woods	AR/IM*		AR/TFL***		AR/STED		AR/CFDI_in*		AR/M2*		AR/POP		AR/GDP***	
1) Rigid	48	52	46	54	49	51	60	40	53	47	42	58	46	54
2) Limited flexibility	41	59	33	67	52	48	39	61	36	64	53	47	42	58
3) Floating	70	30	85	15	67	33	60	40	70	30	55	45	85	15

Note: See the note to Table 1 and the text for definitions of the ratios. "***," "**," and "*" in the column headings indicate significance of the corresponding contingency coefficients reported in Table 2 in the text at the 1%, 5%, and 10% levels, respectively.

Appendix 6: The top 10 and bottom 10 economies, 1957–1989 and 1990–2004

In this appendix, we list the top 10 and bottom 10 economies for each of the seven international reserve ratios. The rankings are based on the averages over the 1957–1989 and 1990–2004 periods, respectively.

Table A6.1: International Reserve Ratios: Lists of Top 10 and Bottom 10 Economies, 1957–1989

	Economies	**AR/IM**	**Economies**	**AR/TFL**	**Economies**	**AR/CFDI_in**
Top 10	Saudi Arabia	19.9941	Portugal	3.3128	Nepal	802.3614
	Malta	14.6229	Saudi Arabia	2.5829	Hungary	461.6483
	Libya	14.5127	Nepal	2.3759	Bangladesh	185.8859
	Uruguay	12.4048	China	1.8225	Bhutan	158.3361
	Switzerland	12.3439	Libya	1.8121	Myanmar	142.9182
	Lebanon	11.9937	Taiwan	1.689	Kuwait	142.4785
	Portugal	11.2925	Kuwait	1.2622	Uruguay	137.9242
	Venezuela	10.4964	Malta	1.0846	Tonga	135.0059
	Cape Verde	8.8072	Jordan	0.7976	Mongolia	89.9425
	Jordan	8.4126	Mauritius	0.7656	Jordan	44.4746
Bottom 10	Laos	0.2725	Laos	0.002	Cape Verde	–1390.45
	Liberia	0.3871	Panama	0.0062	Lebanon	–151.524
	Bahamas	0.6949	Equatorial Guinea	0.0173	Sudan	–145.235
	Mali	0.7203	Mali	0.0199	Venezuela	–20.1267
	Equatorial Guinea	0.7736	Congo	0.0247	Bolivia	–9.5636
	Panama	0.8584	Sudan	0.0248	Philippines	–7.1871
	Poland	1.1439	Senegal	0.026	Niger	–4.1633
	Senegal	1.1652	Mozambique	0.0316	Grenada	–1.9919
	Haiti	1.1695	Jamaica	0.0319	Zambia	–1.4845
	Maldives	1.1864	Poland	0.0322	Chile	–1.1477
	Economies	**AR/M2**	**Economies**	**AR/POP**	**Economies**	**AR/GDP**
Top 10	Botswana	1.8465	Switzerland	8256.118	Lebanon	1.5032
	Bhutan	1.5978	Singapore	4402.968	Malta	1.0492
	Saudi Arabia	1.4651	Malta	3932.643	Singapore	0.624
	Madagascar	1.119	Bahrain	3431.53	Botswana	0.5772
	Tonga	1.0797	Kuwait	3317.622	Switzerland	0.4308
	Libya	0.9117	Norway	2590.205	Bahrain	0.4002
	Singapore	0.8546	United Arab Emirates	2534.862	Taiwan	0.3694
	Samoa	0.8152	Qatar	2525.156	Portugal	0.3233
	Solomon Islands	0.8038	Libya	2249.245	Tonga	0.3183
	Cape Verde	0.7405	Netherlands Antilles	2223.302	Cape Verde	0.3139
Bottom 10	United States	0.036	Laos	0.7186	Sudan	0.0028
	Japan	0.0377	Sudan	1.0978	Côte d'Ivoire	0.0036
	Poland	0.0572	Tanzania	1.4796	Laos	0.004
	Panama	0.0786	Uganda	3.1056	Tanzania	0.0054
	Mali	0.0799	Côte d'Ivoire	3.2288	Mongolia	0.0059
	Macao	0.0838	Senegal	3.4734	Senegal	0.0067
	Egypt	0.0854	Sierra Leone	3.4824	Uganda	0.0084
	Finland	0.0897	Haiti	3.5222	Sierra Leone	0.0105
	Sweden	0.09	Benin	3.7593	Haiti	0.0118
	Haiti	0.0903	Equatorial Guinea	3.9185	Benin	0.0121

Note: No data on reserves to short-term external debts are available from the 1957–1989 period. See the note to Table 1 and the text for definitions of the ratios

Table A6.2: International Reserve Ratios: Lists of Top 10 and Bottom 10 Economies, 1990–2004

	Economies	**AR/IM**	**Economies**	**AR/TFL**	**Economies**	**AR/STED**	**Economies**	**AR/CFDI_in**
Top 10	Libya	29.4921	Botswana	2.1814	Bhutan	287.941	Kuwait	144.449
	Lebanon	16.9645	Libya	2.1574	Botswana	238.808	Bhutan	58.1295
	Venezuela	14.5903	Taiwan	1.8148	Cambodia	197.222	Lebanon	39.3943
	Macao	13.482	Kuwait	0.708	Micronesia	162.747	Bangladesh	17.5112
	Peru	13.1844	United Arab Emirates	0.6279	China	74.9268	Nepal	16.8282
	Algeria	12.7643	Mauritius	0.5982	India	61.6449	Japan	13.3673
	Egypt	12.6941	Armenia	0.5718	Grenada	56.7141	Mongolia	9.2559
	Central African Rep	11.8575	Lebanon	0.5115	Eritrea	51.1339	Tonga	7.6829
	Argentina	11.1219	Malta	0.4469	Moldova	41.7143	United Arab Emirates	6.8218
	Chile	10.7366	Algeria	0.4224	Swaziland	30.3089	Botswana	6.0246
Bottom 10	Liberia	0.0114	Congo	0.0099	Liberia	0.0009	Bosnia & Herzegovina	–12.003
	Belarus	0.6801	Sudan	0.0131	Netherlands Antilles	0.0282	São Tomé & Príncipe	–6.9795
	Congo	0.7713	Equatorial Guinea	0.0152	Bahamas	0.0692	Libya	–2.6689
	Bahamas	1.0358	United Kingdom	0.0155	Congo	0.1038	Suriname	–0.1589
	Dominican Republic	1.0643	Bahrain	0.0211	Cameroon	0.2185	Gabon	–0.0466
	Cameroon	1.2653	Cameroon	0.025	Gabon	0.3826	Congo	0.0378
	Tajikistan	1.3447	Zambia	0.0285	St. Vincent & Grenadines	0.4533	Equatorial Guinea	0.0381
	Seychelles	1.3483	United States	0.0324	Zimbabwe	0.5562	Angola	0.0869
	Sudan	1.3628	Angola	0.0334	Angola	0.6024	Seychelles	0.0877
	Canada	1.4563	Panama	0.0335	Côte d'Ivoire	0.6063	Papua new Guinea	0.1052

	Economies	AR/M2	Economies	AR/POP	Economies	AR/GDP
Top 10	Botswana	4.1126	Singapore	18041.4	Botswana	0.997
	El Salvador	2.6396	Hong Kong	11693.7	Singapore	0.8668
	Bhutan	1.4832	Switzerland	8899.21	Lebanon	0.7602
	Lesotho	1.3755	Norway	5466.88	Bhutan	0.5272
	Mauritania	1.152	Taiwan	5281.94	Malta	0.5196
	Kyrgyz Republic	1.1496	Malta	4327.48	Hong Kong	0.5168
	Madagascar	1.1236	United Arab Emirates	3463.88	Libya	0.4892
	Armenia	1.1031	Denmark	3456.73	Taiwan	0.4449
	Libya	1.0899	Botswana	3378.73	Lesotho	0.4125
	Tajikistan	1.0441	Kuwait	2979.6	Guyana	0.4011
Bottom 10	Myanmar	0.0151	Sudan	8.3281	Cameroon	0.0174
	United States	0.0315	Sierra Leone	9.2475	Sudan	0.0185
	Liberia	0.0343	Myanmar	9.5067	United States	0.0195
	United Kingdom	0.0417	Ethiopia	10.0433	Congo	0.0202
	Japan	0.0536	Cameroon	11.9169	Gabon	0.0312
	Canada	0.0608	Niger	13.0546	Belarus	0.0324
	France	0.0639	Tajikistan	14.4081	United Kingdom	0.0351
	Germany	0.0716	Bangladesh	15.061	Dominican Republic	0.0356
	South Africa	0.0769	Madagascar	15.1234	Canada	0.0363
	Australia	0.0785	Malawi	15.9946	Haiti	0.0396

Note: See the note to Table 1 and the text for definitions of the ratios.

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