A Cross-Country Empirical Analysis of International Reserves*

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Abstract

Using data from more than 100 economies for the period of 1975 to 2004, we conduct an extensive empirical analysis of the determinants of international reserve holdings. Four groups of determinants, namely, traditional macro variables, financial variables, institutional variables, and dummy variables that control for individual economies' characteristics are considered. We find that the relationship between international reserves and their determinants is different between developed and developing economies and is not stable over time. The estimation results indicate that, especially during the recent period, a developed economy tends to hold a lower level of international reserves than a developing one. Furthermore, there is only limited evidence that East Asian economies including China and Japan are hoarding an excessive amount of international reserves.

Keywords: Developed Vs Developing Economies, Excess Hoarding, Macro Determinants, Financial Factors, Institutional Variables

JEL Classification: F31, F34, F36

1. Introduction

The recent Asian financial crisis has rekindled considerable interest in examining the behavior of international reserve hoarding. The fundamental rationale for holding international reserves ranges from transaction demand, precautionary motives, collateral asset argument, and mercantilist behavior. Although numerous studies have attempted to unravel the relevance of these factors, the debate on the determinants of international reserves is far from settled. The difficulty of explicating international reserve holding behavior may be attributed to the anecdotal view that the role and functionality of international reserves have evolved along with developments in global financial markets. For instance, the holding of international reserves is now increasingly susceptible to capital account transactions because of the continuing financial globalization and innovative advancements in international capital markets. The recent financial crisis also signified the importance of expectations, policy credibility, and institutional structures in determining the adequate level of international reserves.[1]

One of the unique features of the Asian financial crisis is that some economies in the region have been accumulating international reserves at an astonishing rate in the aftermath of the event. The first few years of the 21st century have witnessed an unprecedented growth of global international reserves – a growth rate of over 89.2% between 2000 and 2004, which was driven by a handful of economies. During the period, China, Japan, Korea, Malaysia and Taiwan have increased their international reserve holdings by 262%, 133%, 107%, 124% and 126%, respectively.[2] Figure 1 presents the evolution of global international reserves and international reserves held by some selected economies.

The phenomenal build-up by these economies has revived research interest in the determinants of international reserves. Some studies focus on the buffer-stock and precautionary demand motivation and incorporate the crisis-induced costs of output and investment contractions (Aizenman *et al.* 2003; Lee, 2004). Dooley *et al.* (2005), in a series of papers, resurrects the mercantilist view and suggest that international reserve accumulation in East Asia is a consequence of export-oriented growth strategy and the absence of a well-functioning domestic and/or regional financial system. Aizenman and Lee (2005) empirically confirm the

[1] Some recent studies on the recent crisis are Krugman (1999), Corsetti, Pesenti and Roubini (1999), Chang and Velasco (1999) and Dooley (2000).

[2] Japan, China, and Taiwan are the three largest holders of international reserves. During this period, Russia and India increased international reserves by 354% and 219%, respectively. Some developed countries also experienced a sharp increase such as Australia (95.7%) and Denmark (154.4%).

mercantilist motivation, but find that, compared with the precautionary demand, the mercantilist motivation accounts for a relatively small amount of international reserve hoarding. Other determinants for international reserve holding considered in recent studies include short-term external debts, financial development, and political and institutional factors.[3]

The recent developments in the literature on international reserves have raised a few questions. For instance, to what extent do these new factors help us understand the observed holding of international reserves? Are these new factors complements or substitutes for the "old" traditional economic variables? Do these new factors explain observed holdings of international reserves even before they were identified in the literature? Have the determinants of international reserve holding changed over time? Answers to these questions should shed some insight on the evolution of the behavior of demand for international reserves. In addition, an empirical analysis should allow us to assess whether economies are holding deficient or excessive levels of international reserves.

To investigate these questions, we conduct an extensive empirical analysis using data from more than 100 economies during the period of 1975 to 2004. In designing the empirical architecture, we take into account of some known results in the literature. For instance, previous studies have documented that developed and developing economies display different demand for international reserves (Frenkel 1974a). Others have evidenced that the nature of the demand for international reserves has changed in the presence of significant historical events such as the breakdown of the Bretton Woods system and oil crises (Bahmani-Oskooee, 1988; Frenkel, 1980; Lizondo and Mathieson 1987). Most recently, Aizenman *et al.* (2004) also identify structural changes in the Korean international reserve holding after the Asian financial crisis. Hence, in this study, we sort the economies into two groups, the developed and developing economies, and investigate the determinants of the demand for international reserves in non-overlapping sample periods that are partitioned by major crisis episodes.

Following the development in the theoretical literature, we consider four groups of explanatory variables: traditional macro variables, financial variables, institutional variables, and dummy variables that control for individual economies' characteristics. To anticipate the results, we confirm that the demand for international reserves of developed economies is different from that of developing economies. The set of (significant) explanatory variables also changes across

[3] See, for example, Aizenman and Marion (2001, 2003, 2004), Alfaro, *et al.* (2003), and Greenspan (1999).

different sample periods. There is evidence that the holding pattern of international reserves has been affected by the occurrences of the debt crisis in the 1980s, and the Tequila crisis and the Asian crisis in the 1990s.

Among the determinants of international reserves, we find that the propensity to import, a proxy for trade openness, is the only factor that is significant in almost all the specifications and samples under consideration. However, its explanatory power has been declining over time for both developed and developing economies. On the other hand, the explanatory ability of financial variables, especially those related to external financing, has been increasing over time.

Our evidence suggests that, compared with developing economies, the developed economies enjoy a "premium" in accumulating international reserves since the early 1980s – they could afford to hold lower levels of international reserves, *ceteris paribus*, than developing ones if they faced the same economic conditions. Moreover, our estimation results present only limited evidence that East Asian economies including China and Japan are hoarding an excessive amount of international reserves.

A brief review of these determinants of international reserves is given in the next section. Section 3 contains the main regression results. It presents the empirical framework and discusses results from different sample periods and different country groups. Additional analyses are reported in Section 4. Specifically, we compare the patterns of international reserve holdings between developed and developing economies. Also, in view of the recent debate, we assess whether some economies are holding an excessively high level of international reserves in the recent period. Concluding remarks are offered in Section 5.

2. A Brief Review on the Determinants of International reserves

We first group the determinants of international reserves into three categories: traditional macro variables, financial variables, and institutional variables, to trace the theoretical developments and to examine how contributions of the determinants have evolved over time. Readers familiar with the effects of these variables may like to proceed directly to Section 3.

The group of traditional macro variables consists of the propensity to import, volatility of real export receipts, international reserve volatility, the opportunity cost of holding international reserves, real *per capita* GDP, and population. These variables have been commonly considered as determinants since the 1960s. In the early stage of theorization, the demand for international

reserves is mainly attributed to the need for accommodating imbalances arising from trade account transactions, which are the main type of balance of payments transactions before the development of modern international capital markets.

Heller (1966) argues that the demand for international reserves should be negatively related to the marginal propensity to import because a higher propensity to import (m) implies a smaller marginal cost of balance of payments adjustment (i.e., $1/m$), and, thereby, a lower demand for international reserves. However, most empirical exercises – including Heller (1966) himself – use the average, and not the marginal, propensity to import. Frenkel (1974b) argues that the average propensity to import, i.e., the imports-to-GDP ratio, measures trade openness and, therefore, should have a positive effect on the demand for international reserves because of the precautionary holding to accommodate external shocks through trade channels.

The role of international reserve volatility is illustrated by the buffer stock model of international reserves. Extending the model for cash holding, Frenkel and Jovanovic (1981) illustrate the effect of international reserve volatility in a stochastic inventory control setting. In some studies, the volatility of real export receipts is used as an alternative proxy for the uncertainty of balance of payments (Kelly, 1970).

The opportunity cost of holding international reserves, which is commonly measured by the difference between the local interest rate and the US interest rate, has been included in models that compare the costs and benefits of holding international reserves (Heller, 1966; Frenkel and Jovanovic, 1981). The effect of the opportunity cost is quite inconspicuous in the empirical literature, mainly due to the difficulty in assigning a single interest rate for international reserve assets while accounting for their risks.[4]

Following Aizenman and Marion (2003), Edison (2003), and Lane and Burke (2001), real *per capita* GDP and population are included to capture the size effect on international reserve holding. In view of the Baumol (1952) square-root rule for transaction demand, we expect these size variables to have a negative coefficient.

The second group of explanatory variables includes money supply, external debts, and capital flows. The use of money in explaining the hoarding of international reserves can be dated back to the 1950s. Courchene and Youssef (1967), for example, appeal to the monetarist model

[4] The ideal proxy would be the difference in the yield between domestic government bonds and US-dollar denominated bonds. However, due to data availability, we use the differential between domestic lending rates and U.S. Treasury bill rates.

of balance of payments to justify the use of money in their international reserve regression (Johnson, 1958).[5] More recently, de Beaufort Wijnholds and Kapteyn (2001) argue that money stock in an economy is a proxy for potential capital flight by domestic residents and, therefore, can be a measure of the intensity of the "internal drain."[6]

The implications of external debts and capital flows on the holding of international reserves have received considerable attention after the Asian financial crisis. While capital inflows can enhance economic growth by supplementing domestic savings and/or financial intermediaries and improving the efficiency of domestic financial markets, a sudden capital flow reversal can devastate an economy, trigger a crisis, and cause significant output losses.[7] Generally, developing economies with inefficient and immature financial sectors are vulnerable to the adverse effect of capital reversals. Thus, it is conceived that economies with a high level of exposure to external financing, whether they are debts, FDI, or portfolio flows, should hold a high level of international reserves to reduce its vulnerability to financial crises and to boost confidence in their currencies (Aizenman *et al.*, 2004; Feldstein, 1999).[8]

Dooley, *et al.* (2005) offers an alternative view on the link between capital flows and international reserves. These authors argue that in the current international financial framework (the "Bretton Woods II system"), emerging market economies accumulate international reserves to secure FDI inflows from the center country, i.e., the United States. In other words, the economies in the "periphery" hold international reserves to ensure importation of financial intermediaries from abroad. According to this view, capital inflows are positively correlated with holdings of international reserves.

The effect of capital flows on international reserve accumulation, however, is not unambiguous. Besides the insurance motive, international reserves can be viewed as a substitute for external financing. In this case, an economy may hold a lower level of international reserves

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[5] One version of the "global monetarism" argues that an increase in international reserves is driven by an excess demand for money, which implies a balance of payments surplus whereas a fall in international reserve holding is caused by an excess supply of money, which implies a balance of payments deficit.

[6] de Beaufort Wijnholds and Kapteyn (2001) refer to the research on the Early Warning System and argue that the international reserves-to-M2 ratio is a reasonable measure of international reserve adequacy.

[7] Edwards (2004) analyzes the sudden stop of capital inflows and current account performance in the last three decades. Caballero and Panageas (2004) argue that international reserve accumulation is not the best insurance against sudden stops.

[8] In general, it is suggested to cover one year amortized value of various types of liabilities over a wide range of possible outcomes. The role of short-term external debts is brought to the center stage by the popular Greenspan-Guidotti-rule (Greenspan, 1999).

if it has secured access to international capital markets and, thus, the correlation between the two variables is expected to be negative.

Lane and Milesi-Ferretti (2006) note that the types, volumes, and directions of capital flows have changed over time. Hence, the use of an aggregate variable may not capture the differential effects of different types of capital flows. In the following, we examine the individual effects of net external liabilities (i.e., external liabilities minus assets) in debt financing, portfolio equity financing, and FDI, as well as their growth rates.

The third group of explanatory variables is institutional variables. It has been argued that institutional characteristics like corruption, political stability, and capital controls affect the hoarding of international reserves. Aizenman and Marion (2003, 2004) and Alfaro *et al.* (2003), for example, show that holdings of international reserves are influenced by political uncertainty and corruption. Our empirical exercise includes a selected group of institutional variables pertaining to financial openness and political/societal conditions.

In addition to these three groups of explanatory variables, our sample also includes four types of dummy variables to account for other characteristics of the economies. The first type is the exchange rate regime dummy variable.[9] The common wisdom suggests that economies with fixed exchange rates and crawling pegs have incentives to hold international reserves to fight against exchange rate market pressures.[10] The second type is a geographic dummy variable. Its inclusion is motivated by the folklore that economies in certain geographic regions such as East Asia tend to hoard high levels of international reserves especially after the Asian financial crisis. The third type is the crisis dummy variable. The variable is meant to capture the effects of a currency crisis, a banking crisis, or a twin crisis on hoarding of international reserves.[11] The

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[9] Frenkel (1980) and Flood and Marion (2002), for example, report that exchange rate arrangements have effects on the holding of international reserves. Lane and Burke (2001), on the other hand, find no significant association between exchange rate regimes and international reserves.

[10] In this study, the Reinhart-Rogoff (2002) index is used to construct the exchange rate regime dummy variable. Their index ranges from 1 "no separate legal tender," to 14 "Freely falling" (with increasing flexibility of exchange rate movement) and is a "*de facto*" index in contrast to IMF's "*de jure*" exchange rate regime classification. In this paper, we aggregate these categories into three; namely "floating," "Crawling Peg," and "Fixed/Pegged."

[11] The currency crisis dummy variable is derived from the conventional exchange rate market pressure (EMP) index pioneered by Eichengreen *et al.* (1996). The EMP index is defined as a weighted average of monthly changes in the nominal exchange rate, the international reserve loss in percentage, and the nominal interest rate. The weights are inversely related to the pooled variance of changes in each component over the sample countries, and adjustment is made for the countries that experienced hyperinflation following Kaminsky and Reinhart (1999). For countries without data to compute the EMP index, the currency crisis classifications in Glick and Hutchison (2001) and Kaminsky and Reinhart (1999) are used. The banking crisis dummy variable is based on Caprio and Klingebiel

fourth type is an interaction variable that assumes a value of one if the economy is located in a region which is inflicted by a crisis. This dummy variable is included to evaluate the possible contagion effect of crises on international reserve accumulation.

3. Empirical Analysis

3.1 Model Specifications

In the following empirical exercise, we consider a scaled measure of international reserves given by $r_{i,t} = R_{i,t} / GDP_{i,t}$, where $R_{i,t}$ is a generic notation of economy *i*'s holding of international reserves and $GDP_{i,t}$ is economy *i*'s gross domestic product at time *t*. Both variables are measured in U.S. dollars. Scaling international reserves facilitates comparison across countries of different sizes. For brevity, we call the ratio $r_{i,t}$ international reserves. The three types of determinants of international reserves are denoted by $X_{i,t}$ $(=\{x_{i,k,t}; k=1,...,N_x\})$ which contains the traditional macro variables, $Y_{i,t}$ $(=\{y_{i,k,t}; k=1,...,N_y\})$ the financial variables, and $Z_{i,t}$ $(=\{z_{i,k,t}; k=1,...,N_z\})$ the institutional variables. The dummy variables that capture other characteristics of the economies are collected under $D_{i,t}$ $(=\{d_{i,k,t}; k=1,...,N_d\})$. The Appendix provides a complete list of variables, their definitions, their sources, and a description of their period averages.

We consider cross-sectional behavior for three non-overlapping sample periods; namely 1975-1981, 1983-1993, and 1999-2004. The sample periods exclude the years inflicted by the three major financial crises; the Mexican debt crisis of 1982, the 1994 Tequila crisis, and the 1997-8 Asian financial crisis.[12] For each of the three sample periods, we employ the period averages of $r_{i,t}$, X_{it}, $Y_{i,t}$, $Z_{i,t}$, and $D_{i,t}$ and label them r_i, X_i, Y_i, Z_i, and D_i, respectively. The use of period averages allows us to avoid complexity that arises from unknown and, possibly varying dynamics, and focus on the (time-)average behavioral relationship.

The effects of these variables on hoarding of international reserves are studied using the

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(2003). The twin crisis effect is examined by an interaction variable between a currency crisis and a banking crisis (Hutchison and Noy, 2002).

[12] We leave out the two years between the 1994 and the 1997-98 crises since they are too short for a serious investigation. In subsection 3.3, we present robust test results using different time intervals that encompass the left-out period.

following regression equations:

$$r_i = c + X_i' \alpha + \varepsilon_i, \quad (1)$$

$$r_i = c + X_i' \alpha + D_i' \delta + \varepsilon_i, \quad (2)$$

$$r_i = c + X_i' \alpha + Y_i' \beta + D_i' \delta + \varepsilon_i, \text{ and} \quad (3)$$

$$r_i = c + X_i' \alpha + Y_i' \beta + Z_i' \gamma + D_i' \delta + \varepsilon_i. \quad (4)$$

The coefficient vectors α, β, γ, and δ are conformable to the associated explanatory variables. The intercept and disturbance term are given by c and ε_i, respectively.

Specification (1) is an international reserve demand equation of the 1970s vintage. The economy characteristic dummy variables are included in specification (2). Specification (3) includes the financial variables (Y_i) that are often referred to in the recent discussion on the demand for international reserves. The effects of institutional factors (Z_i) are examined in specification (4). These four specifications allow us to gauge the relative contributions of the different groups of explanatory variables.

We divide the sample of 119 economies into two groups: one with 21 developed economies and the other with 98 developing economies. Due to data availability, the actual number of the economies included in the estimation varies across the three sample periods, but for any given sample period, it is set fixed across the four specifications to facilitate comparison.

3.2 Estimation Results

The estimation results for the developed economies are presented in Table 1-1. The estimation results pertaining to the regression equations (1) to (4) are respectively presented under the columns labeled (1) to (4) for each of the three periods; namely 1975-1981, 1983-93, and 1999-2004. Those for the developing economies are presented in the same format in Table 1-2. For brevity, only significant estimates are reported.

3.2.1 The 1975-1981 Period

For the developed economies, two traditional macro variables, real *per capit*a GDP and the propensity to import, are found to be significant in the 1975-81 period. They explain over 40% of variations in international reserves held by the developed economies. The signs of

coefficient estimates are consistent with those predicted in the literature. The transaction demand for international reserves, on a *per capita* basis, falls as the real *per capita* income level rises (Heller 1968). The proxy for trade openness and the degree of external vulnerability given by the (average) propensity to import has the expected positive coefficient (Frenkel, 1974b).

The significant 1982 crisis dummy variable indicates that, in retrospect, the developed economies that experienced a currency crisis in 1982 held lower levels of international reserves than the non-crisis economies before the event.

The significant money effect (M2/GDP) is in accordance with the monetary interpretation of the balance of payments and also with the view that money supply is a proxy for internal drain of international reserves during the crisis period. Nonetheless, we are not sure to what extent the internal drain interpretation is relevant for these economies. In any case, inclusion of M2 leads to a large increase in the adjusted R-square coefficient.

The relevance of financial openness is confirmed by the significance of the Chinn-Ito index reported in column (4).[13] Its positive coefficient underlines the precautionary motive to guard against adverse capital flows under an open capital account regime. This finding appears reasonable because many developed economies, especially those in Europe, implemented capital account liberalization policy in the late 1970s.

For the developing economies (Table 1-2), the propensity to import again enters significantly with the expected sign. In addition, international reserve volatility, a proxy for balance of payments uncertainty, has the expected positive sign – the higher the level of international reserve variability, the stronger the motivation to hold precautionary international reserves. The two variables explain 59% of the variability of international reserve holdings among this group of economies.

Although we do not detect any significant effect of the 1982 crisis, the experience of a currency crisis *during* the period is found to be associated with a fall in the holding of international reserves.[14]

The ratio of net debt liabilities to GDP is the only significant financial variable for

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[13] A larger value of this measure means a higher level of capital account openness. The index is a reciprocal of regulatory restrictions on cross-border financial transactions and is based upon the IMF's categorical enumeration reported in *Annual Report on Exchange Arrangements and Exchange Restrictions* (*AREAER*). See Chinn and Ito (2006) for a detailed discussion. The index is viewed as a *de jure* index on capital account openness.

[14] The "Dummy for crisis during the period" assigns a value of unity to economies that experienced a crisis during the 1975-81 period and, therefore, is different from the 1982 crisis dummy variable.

developing economies in this period. Neither the growth rate of net debt liabilities nor the ratio of short-term external debts to GDP is found to be significant. It appears that the level of external debts, but not its growth rate or its maturity structure, matters. The negative coefficient on net debt liabilities indicates that net borrowers tend to hold lower levels of international reserves.[15] The evidence suggests that international reserves and external debts can be viewed as substitutes. Another possible interpretation is that higher levels of external debts increase the default risk and thus, lead to capital outflow and a drawdown of international reserves. Unfortunately, we are not able to disentangle these two interpretations. We tentatively infer that, during this period, developing economies are not likely to hold international reserves for precautionary reasons.[16]

Two institutional variables, the indexes for corruption and *de facto* financial openness, are found to be significant. The effect of corruption on the holding of international reserves is different from the one reported in Aizenman and Marion (2003, 2004).[17] A higher value of our corruption index means an environment less favorable to corruption. Our results indicate that a less corrupt economy holds a lower level of international reserves. A likely interpretation is that an economy with a good reputation of having less corruption would need fewer international reserves to demonstrate its fundamental soundness.

The effect of the *de facto* financial openness index is quite comparable to the one reported in Table 1-1. Even though the literature on effects of financial and institutional variables on the hoarding of international reserves was limited during the 1970s, their effects are well-evidenced in these regressions.

3.2.2 The 1983-1993 Period

For the developed economies in the 1983-1993 period (Table 1-1), the propensity to import is the only significant macro variable. Its coefficient estimates are generally larger than the ones in the previous sample period. Nevertheless, the variable explains a much smaller proportion of international reserve variation than the two macro variables did in the previous period.

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[15] Positive (Negative) net external financial liabilities correspond to net receivers (provider) of external finances.

[16] The use of the ratio of external debts to GDP from the World Bank/BIS/OECD dataset on external debts gives qualitatively similar results. In the text, we report results pertaining to the Lane and Milesi-Ferretti (2006) dataset because it offers a better coverage than the World Bank/BIS/OECD dataset.

[17] To be exact, Aizenman and Marion focused on political corruption, which may have a different implication for the holding of international reserves.

Interestingly, economies with crawling peg exchange rate regimes tend to hold more international reserves. According to the "unstable middle" hypothesis, crawling peg regimes are more prone to currency crises than flexible or fixed exchange rate regimes (Willett, 2003). Therefore, this coefficient can be interpreted as capturing precautionary holdings.

As it did in the previous sample period, the 1982 crisis dummy variable has a significantly negative estimate. Apparently, these economies tend to hold lower levels of international reserves.

The M2 variable continues to be the only significant financial variable for the developed economies while its coefficient estimates are slightly larger than those in the previous period. More importantly, inclusion of this variable improves the goodness of fit much more substantially in this period.

Although the capital openness variable is no longer significant, two institutional variables on government characteristics enter significantly. Economies with plural electoral parliament systems tend to hold more international reserves, probably because these economies are subject to more stringent scrutiny on international reserve adequacy than those without. Also, developed economies with leftist governments hold more international reserves. This finding is contradictory to the common belief that a leftist government tends to spend more and incur current account deficits, thereby leading to a lower level of international reserves (Roubini and Sachs, 1989). Nonetheless, this argument may possibly be more relevant to developing economies than developed ones since the former has limited access to international financing.

Again, developing economies are also found to be driven by a different set of determinants in this period (Table 1-2). Both the propensity to import and international reserve volatility enter significantly again and continue to account for a large portion (64%) of the goodness of fit.

While there is no sign of a currency crisis effect, the estimates indicate that the experience of a banking crisis in 1982 is associated with an increase in the hoarding of international reserves. Even though there is evidence that a currency or banking crisis may affect the hoarding of international reserves, we do not observe a definite pattern of crisis effects.

For this sample period, the data from developing economies allow us to discriminate the behaviors between net creditors and net debtors.[18] That is, net debtor economies may have an

[18] In the 1975-1981 sample, there is no creditor developing economy.

incentive to hold more or fewer international reserves depending on whether they perceive international reserves an insurance or a substitute to external finances. Net creditor developing economies, on the other hand, would not have such incentives. To this end, we create a dummy variable for net creditor economies (i.e., those with *negative* net debt liabilities) and interact it with the net debt liabilities variable. The effects of these variables are reported in columns (7) and (8).

The results suggest that, for the net debtor developing economies, the level of international reserves is inversely related to the amount of net liabilities; international reserves and external debts are substitutes. The coefficient estimate, however, is much smaller compared to the one from the previous sample period. Net creditor economies, on the other hand, appear to be unresponsive to net debt liabilities; the estimated coefficient on the interaction term is about the same magnitude as that of the level term with an opposite sign, indicating an essentially zero coefficient.

Besides their level, the growth of net debt liabilities is found to be a significant determinant; the faster the net liabilities increase the more international reserves the developing economy would build up.[19] According to the coefficient estimates, the net debt liabilities effect is much weaker than its growth effect. Thus, on the margin, a rise in net debt liabilities will lead to an increase in the holding of international reserves, which can be served as implicit collaterals.

Among the institutional variables, only the *de facto* capital account openness remains to be a significant determinant – however, its magnitude is now much smaller.

3.2.3 The 1999-2004 Period

Population and international reserve volatility are the two significant macro determinants for the developed economies in the post-Asian financial crisis period (Table 1-1). It is worth noting that the propensity to import no longer explains the developed economies' behavior. As was in the case of real GDP *per capita*, larger population captures the size effect, i.e., lower transaction demand. Also, higher volatility in international reserves holding induces developed economies to hold more international reserves.[20] In passing we point out that, compared with the macro variables in the two previous periods, these two macro variables have a fairly low

[19] The variable for the growth of net debt liabilities was also interacted with the creditor dummy variable. However, the interaction term was found to be insignificant.

[20] A dummy variable was constructed for Japan's international reserve volatility, which is an extreme outlier.

explanatory power.

The crawling peg dummy variable is the only significant exchange rate regime dummy variable. Among the financial variables, M2 (relative to GDP) is no longer significant in this period. Instead, two other financial variables, the ratios of net debt liabilities and net portfolio liabilities, are significant determinants. The coefficient estimates of the net debt liabilities variable and its creditor interaction term suggest that, while net debtor economies view international reserves as a substitute to external finances, net creditor economies do not respond much to their net debt liabilities positions. Net receivers of portfolio financing also regard international reserves as a substitute to external finances and, on the other hand, net providers of portfolio financing reduce their holdings of international reserves. For these developed economies, the two types of external financial factors bring down the average of their international reserves because these economies have positive average values for both the net debt and portfolio liabilities ratios. Interestingly, the inclusion of these financial variables boosts the adjusted R-square estimate quite significantly – from 16% to 71%.

Despite the recent discussion of the effect of institutional development on capital flows, no significant institutional variable is found in the international reserve regression for developed economies. Thus, the specification (4) is omitted for this sample period.

For the developing economies (Table 1-2), the coefficient estimates of the propensity to import continue to be significantly positive, but their magnitudes are considerably smaller than those in the two previous periods. The opportunity cost of holding international reserves is now significantly negative; a higher opportunity cost discourages the hoarding of international reserves. The result is contrary to the perception that, in recent years, emerging market economies accumulate international reserves *despite* the rising opportunity costs due to the decline of U.S. interest rates. Interestingly, these two macroeconomic variables explain only 24% of the variations in the holding of international reserves. Indeed, the explanatory power of this specification is the lowest among the 12 cases presented in Table 1-2.

The economies that experienced a currency crisis during the Asian financial crisis and those with crawling peg exchange rate systems tend to hold more international reserves while Latin American economies tend to hold less. These results are broadly in line with those presented earlier. Similar to the estimation results we have so far, the dummy variable capturing the contagious effect of a crisis is found to be insignificant. That is, the economies in a

geographical region where there is a crisis, but are not directly inflicted by it, do not hold a higher level of international reserves, *ceteris paribus*.

Among the financial variables, M2 and the ratio of net portfolio liabilities are significant.[21] It is the first time the regression for developing economies gives a significant M2 effect. The finding is in line with the recent interpretation that money stock can be a measure of internal drain (de Beaufort Wijnholds and Kapteyn, 2001).

As was in the case of developed economies, the specification (4) is omitted for the developing economies because there is no significant institutional variable in this sample period. The result that is not supportive to the recent contention that legal and institutional factors are important determinants of international reserve holding.

3.3 Discussions

The estimation results show that the determinants of international reserve holding are different between developed and developing economies and vary across different periods. The propensity to import is the only variable that is significant in almost all the specifications considered in the three sample periods for both developed and developing economies – the only exception is the case of developed economies in the last sample period. Even for this variable, there is a discernable change in its coefficient estimates across different specifications and sample periods.

The explanatory power of these factors is not stable over time either. Figure 2 presents the marginal contributions of the four groups of explanatory variables to each model's adjusted R-square estimate. That is, the bars in the figure show the "incremental" change in the adjusted R-square estimate when a group of explanatory variables is sequentially added to the estimation. A few observations stand out.

First, in the 30-year span, the group of macro variables displays the most significant drop in explanatory power. Its contributions to the adjusted R-square estimate fall from 44% in the 1975-1981 period to 10% in the 1999-2004 period for the developed economies and from 58% to 24% for the developing economies.

Second, for the developed economies, the incremental explanatory power of the financial variables increases rapidly in the 1983-1993 period and reaches the maximum of 59% in the

[21] The interaction with the dummy variable for creditor countries is found to be insignificant.

1999-2004 period. For the developing economies, after drifting at low levels in the first two periods, the explanatory power of this group jumps up to 36% in the 1999-2004 period.

Apparently, for both groups of economies, the importance of financial variables is growing at the expense of the group of macro variables. The result, nevertheless, may reflect the increasing importance of capital and financial transactions amid the continuing financial liberalization and globalization.

Third, the results do not give a clear trend for the role of the remaining two groups of determinants. In the case of the developed economies, the institutional factors appear gaining importance over the first two periods, whereas the opposite seems to hold for the developing economies. Above all, for both groups, none of the institutional factors is playing a significant role in the most recent sample period.

The role of financial and institutional factors deserves some comments. The literature has not paid much attention to the implications of financial and institutional factors until recently. Nevertheless, we have found the effects of these two types of factors in the 1970s and 1980s samples. The absence of the institutional factor effect in the last sample period is quite unexpected though. Also, the effects of these two types of determinants on international reserve accumulation vary quite substantially over time. The M2 effect, for example, is a significant determinant for the developed economies in the first two sample periods, but not in the third one. For the developing economies, on the other hand, the M2 variable appears significantly only in the most recent period.

The variability of model specifications and coefficient estimates across sample periods and economy groups is quite transparent in Tables 1-1 and 1-2. To formally verify it, we examine parameter stability using the Wald test. Specifically, we pool the data from two sample periods and test whether the parameters are constant over the sample periods, i.e. (1975 – 1981 vs. 1983 – 1993), (1975 – 1981 vs. 1999 –2004), and (1983 – 1993 vs. 1999 – 2004). The procedure is applied to both the developed and developing economies. Also, we test the stability for each of the four groups of explanatory variables.

In general, the results of the Wald tests confirm that the estimates across any two sample periods are significantly different from each other.[22] The results from the developed economies in the 1975 – 1981 and 1983 – 1993 periods give the least dissimilar estimates. Recall that there

[22] For brevity, the Wald test results are not reported here, but are available from the authors.

are major crises separating the three sample periods considered in our exercise. In other words, the evidence lends support to the view that economies alter their international reserve holding behavior before and after major global financial disturbances.

One potential issue with our choice of the sample periods is that there is a five-year gap between the 1983-1993 and 1999-2004 samples. With the current setting, it is not clear whether it is the 1994 Tequila crisis or the 1997-98 Asian financial crisis that causes the change in the international reserve hoarding behavior in the 1990s. To further investigate the underlying reason of coefficient instability, we test parameter constancy over the two periods 1983-1993 and 1995-2004 that are separated by the 1994 Tequila crisis, as well as that over the 1983-1996 and 1999-2004 periods separated by the Asian financial crisis.

The Wald test results show that, for the developed economies, the coefficient estimates are significantly different before and after both the Tequila and Asian financial crises.[23] The coefficient estimates for the developing economies, on the other hand, are significantly affected by the East Asian financial crisis but not by the Tequila crisis.[24] In general, these findings corroborate our choice of the three sample periods.

4. Additional Analyses

4.1 Does it Matter if an Economy Is a Developed or Developing One?

What would happen if a developed economy accumulates international reserves as if it were a developing economy, or *vice versa*? Let the estimated demand for international reserves of developing economies be

$$r_{i,dp} = \hat{c}_{dp} + W_{i,dp}' \hat{\alpha}_{dp} + \hat{\varepsilon}_{i,dp} \equiv \hat{r}_{i,dp} + \hat{\varepsilon}_{i,dp}, \quad (5)$$

and that of developed economies be

$$r_{i,dd} = \hat{c}_{dd} + W_{i,dd}' \hat{\alpha}_{dd} + \hat{\varepsilon}_{i,dd} \equiv \hat{r}_{i,dd} + \hat{\varepsilon}_{i,dd}, \quad (6)$$

where "^" indicates a parameter estimate; the subscripts "*dp*" and "*dd*" denote developing and developed economies; $W_{i,dp}$ contains the significant factors; $\hat{\alpha}_{dp}$ is the vector containing the

[23] Parameter instability is found in all groups of explanatory variables with the exceptions of the financial variable group in the case of the Tequila crisis, and the characteristics dummies and institutional variable group in the case of the Asian financial crisis.

[24] For the 1983 – 1993 and 1995-2004 samples, no parameter instability is detected. For the 1983 – 1996 and 1999 – 2004 samples, parameter instability is detected for the macroeconomic variable group and for the entire set of explanatory variables.

corresponding estimates; and $\hat{r}_{i,dp}$ is the predicted level of international reserves. $W_{i,dd}$, $\hat{\alpha}_{dd}$, and $\hat{r}_{i,dd}$ are similarly defined.

Suppose a developed economy behaves like a developing economy, what would be its predicted level of international reserves? One way to address this question is to generate the "predicted" level of international reserves for this economy by applying its data to equation (5), which is estimated from the data of developing economies. We label this predicted value $\tilde{r}_{i,dd}$. By comparing $\hat{r}_{i,dd}$ with $\tilde{r}_{i,dd}$, one can assess the value (or cost) of being labeled as a developed economy. Similarly, we can generate $\tilde{r}_{i,dp}$ for a developing economy using equation (6) and data from the developing economies. Again, we can infer from $\hat{r}_{i,dp}$ and $\tilde{r}_{i,dp}$ the implications of a developing economy label.

First, we consider the case of a developing economy that behaves like a developed economy and generate $\tilde{r}_{i,dp}$ and $\hat{r}_{i,dp}$ for all four regression specifications (1) to (4). For brevity, the discussion in this and the following subsection are based on results pertaining to specification (4), which includes all four types of explanatory variables. Subsample averages are used in place of missing values.

Figure 3 presents three values of international reserves (as a ratio to GDP) for each economy: actual levels of international reserves ($r_{i,dp}$); predicted values from the fitted equation for the developing economies sample ($\hat{r}_{i,dp}$) – which we call the "simple" predictions for simplicity; and predicted values from the fitted equation for the developed economies ($\tilde{r}_{i,dp}$) – which we call the "cross" predictions. In the figure, the economies are sorted in descending order according to their real *per capita* GDP in U.S. dollars.

As expected, the simple predictions ($\hat{r}_{i,dp}$) match the actual values of international reserves ($r_{i,dp}$) quite well. The distribution of the cross predictions ($\tilde{r}_{i,dp}$), on the other hand, depends on the sample period.

In the 1975 – 1981 sample (Panel A), the cross prediction values ($\tilde{r}_{i,dp}$) appear consistently above the simple prediction values ($\hat{r}_{i,dp}$). Also, the gap between $\hat{r}_{i,dp}$ and $\tilde{r}_{i,dp}$ diverges as the level of real *per capita* income declines. Based on the estimation results in Tables 1-1 and 1-2, we can conjecture that the observed divergence is driven by the negative real output

effect found for developed economies in this period. The negative income effect may reflect the unfavorable conditions faced by low income economies in the international financial market in the 1970s. Thus, if developing economies were viewed as developed economies in the late 1970s, these economies, especially those with low *per capita* income, would have been required to hold higher levels of international reserves.

For the 1983 – 1993 and 1999 – 2004 periods, the cross predictions ($\tilde{r}_{i,dp}$) are quite often lower than the corresponding simple predictions ($\hat{r}_{i,dp}$). During these two sample periods, if developing economies could behave as developed ones, they could afford to hold lower levels of international reserves in these periods. That is, compared with developed economies with similar economic and financial conditions, developing economies tend to hold more international reserves. One possible explanation is that the developing economies have limited access to international financial markets and are more vulnerable to crises.

Admittedly, it is quite difficult to decipher the numerical values of international reserves from Figure 3. Table 2 reports the actual values and the two types of predicted values of international reserves for some Asian economies, the ones that are often perceived to be excessive holders of international reserves, as well as some selected subgroups. In Table 2, positive values in column (3) mean that a developing economy has a level of international reserves higher than the simple predicted value ($r_{i,dp} - \hat{r}_{i,dp} > 0$) whereas those in column (5) mean that the economy has a level of international reserves higher than the one implied by cross prediction ($r_{i,dp} - \tilde{r}_{i,dp} > 0$). Column (6) reports the differences between the two predicted values, $\hat{r}_{i,dp} - \tilde{r}_{i,dp}$. In general, Table 2 confirms the observations we made with Figure 3.

It is worthwhile noting that the relative magnitudes of the differences in the two types of predicted values of international reserves change across sample periods. For example, during the 1983 – 1993 period, the Latin America group gives the largest difference between the two predicted values (column (6)) while the emerging Asian group yields the smallest. However, during the 1999 – 2004 period, the opposite is true for the two groups.

Furthermore, the discrepancies between the two kinds of predictions substantially vary across the economies. In the 1999 – 2004 sample, the actual levels of international reserves held by Hong Kong, Malaysia, Singapore, and Thailand are much higher than the cross predictions. Singapore is an extreme case – the economy's actual level of international reserves is slightly

lower than the simple predicted value, but is higher than the cross prediction by 87.6%! Thus, if the criteria of the developed economies are used to assess adequacy, these developing economies would be deemed to have an excessive level of international reserves.

Another interesting case is China. During the 1999 – 2004 sample period, China's holding of international reserves is 15.4% lower than the simple predicted value. The degree of deficiency increases to 30% when the cross prediction is used as a reference point. That is, both specifications for developing or developed economies suggest that China's holding of international reserves should have been higher between 1999 and 2004.

Next, we repeat the exercise for the group of developed economies and present the results in Figure 4 and Table 3. The panels in Figure 4 show that, generally, the simple prediction values are lower than the cross prediction ones; if a developed economy were treated as a developing economy, it would have to hold a higher level of international reserves – a result consistent with the previous analysis. Comparing the graphs from the three sample periods, the discrepancy between the two kinds of predicted values is the smallest during the second period.

Table 3 confirms that the group of developed economies holds a level of international reserves much lower than what is predicted by the fitted model for developing economies. Again, the degree of under-hoarding is the smallest in the 1983 – 1993 period. Interestingly, Japan, one of the largest holders of international reserves, is deemed to have too few international reserves during the 1999 – 2004 period; its average level of international reserves is 11.6% (of its GDP), but the cross prediction indicates that the ratio should be 27.4%.

4.2 Over- or Under-Hoarding of International Reserves?

As we stated in the introduction, the recent phenomenal buildup of international reserves by some developing economies has triggered a contentious debate about whether these economies are holding an excessive amount of international reserves and, thus, posing a serious threat to the stability of the world economy. One traditional rule of thumb indicator of excessive international reserves holding is whether a country holds international reserves worth more than three months of imports. As of the end of 2005, the amount of international reserves held by China, Japan, Korea, Malaysia and Taiwan is worth 14.93, 19.33, 9.66, 7.36, and 16.65 months of imports, respectively, which is well above the three-month benchmark.

Our analysis, however, has shown that imports are just one of the determinants of the

hoarding behavior. Furthermore, the importance of the propensity to import has been declining over years. Hence, the assessment of the adequacy of international reserves should go beyond the consideration of imports. There are additional complexities. For instance, our results in the previous section suggest that the holding pattern of international reserves has evolved over time. There is also evidence that, under similar conditions, developing economies tend to hold a level of international reserves higher than developed economies.

To shed more light on the issue of excessive hoarding in recent years, we generate the 1999 – 2004 predictions from the empirical equations of international reserves obtained in different sample periods. For example, the predicted values for developed economies are made by applying the 1999 – 2004 data to the fitted equations of developed economies in each of the three sample periods. The results are presented in Table 4. Columns (1) to (3) in the table are the same as the corresponding entries in columns (1) to (3) of Panel 3 in Tables 2 and 3 – they are included for comparison purposes. Columns (4) and (6) list the 1999-2004 predicted values generated from fitted models of the 1983-93 and the 1975-81 periods, respectively. Columns (5) and (7) are the prediction errors for columns (4) and (6), respectively.

When the 1999 – 2004 specifications are used, there is no substantial evidence of over-hoarding of international reserves. Among the selected Asian economies shown in Table 4, Malaysia has the highest level of over-hoarding – the excessive amount is about one half of its predicted value. China, on the other hand, has the highest deficient rate of 15.4%. Compared with developing economies, the developed economies display a lower degree of over-hoarding variability.

The use of the 1975 – 1981 and 1983 – 1993 models presents a different picture. In general, the actual holdings are lower than the values predicted by these two models. For developed economies, Japan in the 1999 – 2004 period is the only case that gives a over-hoarding result. Both the U.K. and Germany are deemed to hold too few international reserves in the period. Indeed, Japan shows a relatively minor change in its estimated over- and under-hoarding positions.

The results for developing economies are quite striking. The predicted values show a high degree of variations. For instance, the 1983 – 1993 specification suggest Singapore holds the most “excessive” amount of international reserves (38.4%) and China’s level of international reserves is 90.9% lower than the model prediction. Under the 1975-1981 model, the Philippines

over-hoards by 4.5% while Hong Kong under-hoards by 310.2%.

According to the 1983 – 1993 specification, the group of developing economies on average has a deficient amount of international reserves; the actual average holding is 20.4% less than the predicted value. The group of oil exporting economies has the highest level of excessive holding (17.6%) among the subgroups.

The 1975 – 1981 specification gives an even more severe under-hoarding scenario. According to this vintage model, developing economies are under-hoarding on average by an amount of 53.5%. All of the three geographical subgroups hold lower levels of international reserves than the model predictions. For individual economies, China, Hong Kong, and Singapore are the three economies that have the largest degrees of under-hoarding – for these economies, the size of international reserves holding is expected to be bigger than their GDPs!

In sum, the evidence for excessive holdings of international reserves in the 2000s is quite limited. Indeed, according to the models of the 1970s and 1980s, these selected economies tend to hold a deficient, instead of an excessive, amount of international reserves. These findings suggest that, in assessing the adequacy of international reserves, one has to take into account of both the changing global environment and the evolving role of international reserves.

5. Concluding Remarks

Against the backdrop of the astonishing growth of global international reserves and the recent advancements in modeling the demand for international reserves, we conduct an extensive cross-country analysis to examine the empirical determinants of international reserve holding. Four groups of determinants, namely, traditional macro variables, financial variables, institutional variables, and dummy variables that control for individual economy characteristics are considered. Also, accounting for the anecdotal evidence that major currency crises affect the demand for international reserves, we examined three sample periods partitioned by three major crisis episodes, the 1982 Mexican debt crisis, the 1994 Tequila crisis, and the 1997 Asian financial crisis.

It is found that the empirical specifications of the demand for international reserves differ between developed and developing economies and across the three sample periods. With the exception of the propensity to import, all the potential determinants do not show up consistently in the estimated equations. Formal Wald statistics confirm parameter non-constancy and

corroborate our choice of sample periods. All in all, the empirical results highlight the difficulty of devising a single empirical model to describe the holding of international reserves. They also represent some challenges for building a unified theory of demand for international reserves.

Besides the changing nature of the estimated relationship, we find the effects of financial and institutional factors in the 1970s and 1980s even though only recently these factors are the subjects of discussions. Our estimation results suggest that developing economies could hold lower levels of international reserves if they were to be perceived as developed ones. One interpretation is that, despite our relatively exhaustive list of explanatory variables, the fitted models do not fully capture the differences between these two groups of economies. Some possible omitted variables are market credibility and the level of sociopolitical governance. Unfortunately we do not have data on these variables.

Furthermore, our results do not lend strong support to the assertion that economies including China, Japan, and Korea are hoarding an excessive amount of international reserves in the 2000s. Specifically, the predicted values generated from various estimated equations of international reserves do not indicate a large over-hoarding phenomenon. Instead, the models of the 1975 – 1981 and 1983 – 1993 vintages suggest that these economies should have higher levels of international reserves than their actual holding levels in the 2000s. We do identify one condition under which some developing economies display signs of excessive hoarding in the 2000s – the use of models fitted to developed economies to generate the predicted level of international reserves.

The continuing process of globalization and the growing importance of capital account transactions are likely to be the reasons for the changing relationship between international reserves and their determinants. Understandably, the changing world economic environment makes the optimal level of international reserves a moving target. A corollary is that the assessment of the adequacy of international reserves is a non-trivial enterprise; especially in the periods that experience significant events in the international arena. Given the occurrence of dramatic events (both economic and geo-political ones) around the new millennium, it is reasonable to expect that the demand for international reserves will not be the same as it was in the past. Hence, the assertions of unusual or excessive hoarding of international reserves must be made with caution and be evaluated with the flexibility of allowing possible behavioral changes.

Appendix

1. Data Appendix

Table A.1 presents the list of the variables considered in the exercise. In the text, only the significant variables are reported in empirical specifications. The table also provides the definitions of these variables and the sources of the primary data used to construct these variables. These are annual data from 1975 to 2004. The sample of economies consists of 21 developed economies and 98 developing economies.

2. Period Averages of Some Selected Variables

The period averages of the variables are reported in Table A.2. There are some obvious variations between developed and developing economies and across the three sample periods. While the two groups of economies have comparable levels of international reserves in the first two sample periods, there is a noticeable change in the 1999-2004 period. Since the Asian financial crisis, developing economies have accumulated a substantial amount of international reserves, averaging more than double that of developed economies.

A few other observations are in order. First, among the developed economies, macroeconomic variables usually remain relatively stable across the three periods. The developing economies, on the other hand, experience variations in some variables. For example, both volatilities of international reserve holdings and export receipts decline over time, a sharp contrast with the developed economies. The opportunity cost of holding international reserves peaks for the developing economies in the 1983-1993 period – reflecting the debt crisis in the period – and reverts back to a lower level in the last period, though still much higher compared to the developed economies.

Second, the financial variables exhibit some discernable differences between the two groups. The developed economies have a higher monetarization ratio, which is consistent with the perception that these economies have a higher degree of financial deepening and more advanced capital markets than the developing ones. The table shows that the group of developing economies is net receivers of external debt and FDI flows.[25] Apparently, for developing economies, FDI flows are gaining importance recently while external debts peak in the 1983-1993 period.

Third, by eyeballing institutional variables, we can confirm that developed economies have already achieved high levels of institutional development and democracy in early years. Developing

[25] Positive (Negative) net external financial liabilities correspond to net receivers (provider) of external finances.

economies are on the catch-up trend, but still lagging behind the developed economies. It is worthwhile noting that the Chinn-Ito (2006) *de jure* index of financial openness suggests that countries have taken different paths of financial liberalization; the developed economies have constantly implemented financial liberalization since the 1970s while the developing economies restricted cross-border capital flows during the 1980s, though they rapidly reopened capital accounts after the mid-1990s (see Ito, 2006).

Table A.1: Definitions and Sources

Variables	Definitions	Sources
1. Dependent variables		
R_GDP	total international reserves (including gold)/current GDP	WDI
2. Variables in "X" – "Macro variables"		
RYPC_US	*per capita* GDP in constant US dollars	WDI
POP	population	WDI
PIMP	propensity to import	IFS
RES_VOL	international reserve volatility	IFS
EXP_VOL	volatility of export receipts	IFS
DIFINT	opportunity cost of holding international reserves	WDI, IFS
3. Variables in "Y" – "Financial variables"		
M2Y	M2 to current GDP	WDI, IFS
NET_DEBT	net debt liabilities / current GDP	LM
NET_FDI	net FDI liabilities / current GDP	LM
NET_PORTFOLIO	net portfolio equity liabilities / current GDP	LM
D_DEBT_LIAB	growth rate of net debt liabilities / current GDP	LM
D_FDI_LIAB	growth rate of net FDI liabilities / current GDP	LM
D_PORTFOLIO_LIAB	growth rate of net portfolio liabilities / current GDP	LM
4. Variables in "Z" – "Institutional variables"		
KAOPEN	capital account openness	Chinn-Ito (2006)
DEFACTO_FININT	*de facto* financial openness = (Total external assets + liabilities) / current GDP	LM
TRADEOPEN	*de jure* trade openness	WDI
CORRUPT	corruption [0, 6]	ICRG
BQ	bureaucratic quality [0, 6]	ICRG
LAO	law and Order [0, 6]	ICRG
LEFT	dummy variable for left-wing government	DPI2004
PLURAL	dummy variable for parliament with Plural electoral system	DPI2004
GOVFRAC	government fractionalization [0, 1]	DPI2004
POLCONV	political constraint (democracy) index	Henisz (2000)
5. Dummies ("D")		
ER_CRAWL	dummy variable for the crawling peg exchange rate regime	RR
ER_FIX	dummy variable for the fixed exchange rate regime	RR
CRISIS	dummy variable for a currency crisis	Authors' calculations
BANKCRISIS	dummy variable for a banking crisis	CK
OIL	dummy variable for oil exporting countries	Authors' calculations

NOTES: The source codes are: BDL: Beck, Demirgüc-Kunt, and Levine (2000, updated in later years); CI: Chinn and Ito (2006); CK: Caprio and Klingebiel (2003); DPI2004: Database of Political Institutions, Beck *et al*. (2001); Henisz: Henisz (2000); ICRG: *International Country Risk Guide*; IFS: IMF's *International Financial Statistics*; IMF: Other IMF databases; LM: Lane and Milesi-Ferretti (2006); Polity IV: Polity IV project (2004); RR: Reinhart and Rogoff (2000); and WDI: *World Development Indicators*.

Table A.2: Summary Statistics

	1975-1981		1983-93		1999-2004	
	Developed	Developing	Developed	Developing	Developed	Developing
International reserves / GDP	0.10	0.11	0.10	0.12	0.07	0.18
X (macro) variables						
Population in millions	35.56	34.18	35.97	35.50	39.83	46.44
International reserve volatility[1]	0.10	0.11	0.05	0.05	0.09	0.01
Real *per capita* GDP (in log US$)	9.56	7.19	9.76	7.15	10.04	7.34
Propensity to Import	0.31	0.40	0.29	0.35	0.33	0.42
Volatility of Export receipts[1]	0.03	0.25	0.03	0.03	0.02	0.01
Opportunity cost	0.04	0.09	0.06	3.26	0.03	0.16
Y (financial) variables						
M2 / GDP	0.56	0.29	0.66	0.39	0.80	0.47
Net portfolio liabilities /GDP[2]	0.00	0.00	0.01	-0.02	0.10	-0.02
Net debt liabilities /GDP[2]	0.11	0.23	0.19	0.47	0.15	0.35
Net FDI liabilities /GDP[2]	0.01	0.12	0.02	0.13	-0.03	0.25
Z (institutional) variables						
Leftist government (0/1)[3]	0.38	0.23	0.33	0.25	0.48	0.23
Parliament/Plural elect. sys. (0/1)[3]	0.52	0.76	0.52	0.84	0.57	0.70
Corruption index [0, 6][4]	5.29	2.75	5.35	3.03	4.48	2.40
Law and order [0, 6][4]	5.41	2.59	5.48	2.81	5.50	3.46
Bureaucratic quality [0, 6][4]	3.68	1.59	3.70	1.80	3.80	1.94
Democracy index [0, 1][5]	0.74	0.15	0.77	0.26	0.76	0.45
Gov't fractionalization [0, 1][6]	0.23	0.11	0.27	0.17	0.28	0.25
De jure KA-openness (Chinn and Ito)[7]	0.36	-0.16	1.21	-0.41	2.48	0.33
De facto KA-openness (Lane and Milesi-Ferretti)	0.79	1.08	1.36	1.83	3.97	1.85

NOTES:

1 – International reserve volatility and export volatility are normalized by the period average of international reserves and exports, respectively.

2 – "Net liabilities" = (liabilities minus assets) of an external financial asset per GDP.

3 – The variables for leftist government and parliament with plural electoral system are zero-one dummy variables.

4 – For political/societal variables: anti-corruption, law and order, and bureaucratic quality, higher values indicate better conditions. For example, a higher value of corruption index indicates an environment with stronger anti-corruption measures and enforcement.

5 – The democracy index is also known as the political constraint index – a higher value means a more democratic system.

6 – A higher value for government fractionalization means a more fractionalized government.

7 – The *de jure* KA openness variable ranges between -1.8 and +2.6 (Chinn and Ito, 2006). A higher value indicates a more open capital account.

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Table 1-1: Estimation Results for Developed economies; 1975 – 1981, 1983 – 1993, 1999 – 2004

	1975 – 1981				**1983 – 1993**				**1999 - 2004**		
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)
Real *per capita* GDP	-0.105	-0.129	-0.096	-0.118							
	[0.052]*	[0.050]**	[0.032]***	[0.036]***							
Propensity to import	0.203	0.139	0.363	0.394	0.361	0.283	0.314	0.443			
	[0.067]**	[0.072]*	[0.073]***	[0.070]***	[0.111]***	[0.092]***	[0.102]***	[0.106]**			
Population (in log)									-0.022	-0.02	-0.047
									[0.011]*	[0.010]*	[0.006]**
International reserve volatility									0.004	0.004	0.004
									[0.003]	[0.003]	[0.002]**
Crisis in 1982		-0.061	-0.044	-0.050		-0.047	-0.04	-0.093			
		[0.036]*	[0.028]	[0.021]**		[0.041]	[0.021]*	[0.016]**			
Crawling peg regime						0.043	0.058	0.101		0.018	0.036
						[0.035]	[0.021]**	[0.015]**		[0.050]	[0.017]*
M2 / GDP			0.200	0.200			0.268	0.265			
			[0.053]***	[0.051]***			[0.071]***	[0.054]**			
Net debt liabilities											-0.206
											[0.033]**
Creditor x Net debt liabilities											0.215
											[0.037]**
Net portfolio liabilities											-0.106
											[0.027]**
Creditor x Net portfolio liabilities											0.33
											[0.127]**
De jure capital acct. openness				0.012*							
				[0.007]							
Pluralist parliament								0.068			
								[0.018]**			
Leftist government								0.036			
								[0.014]**			
Constant	1.022	1.285	0.796	1.000	0	0.004	-0.191	-0.29	0.41	0.378	0.921
	[0.505]*	[0.501]**	[0.311]**	[0.347]**	[0.023]	[0.023]	[0.055]***	[0.038]**	[0.179]**	[0.165]**	[0.108]**
# Observations	19	19	19	19	21	21	21	21	21	21	21
Adj. R-square	0.44	0.51	0.76	0.80	0.21	0.19	0.70	0.79	0.19	0.16	0.71

NOTES: Robust standard errors are given in brackets. *, **, and *** indicate significance at the 10%; 5%; and 1% levels, respectively. The column headings (1), (2), (3), and (4) correspond to the model specifications (1), (2), (3), and (4) in the text. (4) is absent under the 1999-2004 sample period because there is no significant institutional variables.

Table 1-2: Estimation Results for Developing economies, 1975 – 1981, 1983 – 1993, 1999 – 2004

	1975 – 1981				**1983 – 1993**				**1999 – 2004**		
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)
Propensity to import	0.327	0.345	0.348	0.136	0.322	0.326	0.34	0.325	0.266	0.24	0.085
	[0.028]**	[0.027]***	[0.020]***	[0.060]**	[0.040]***	[0.037]***	[0.034]***	[0.036]***	[0.119]**	[0.116]**	[0.049]*
International reserve volatility	0.032	0.026	0.015	0.010	0.012	0.009	0.007	0.007			
	[0.007]**	[0.008]***	[0.008]*	[0.005]*	[0.003]***	[0.003]***	[0.002]***	[0.002]***			
Opportunity cost									-0.330	-0.307	-0.135
									[0.118]***	[0.102]***	[0.066]**
Crisis during period		-0.054	-0.046	-0.054							
		[0.017]***	[0.015]***	[0.014]***							
Banking crisis in 1982						0.047	0.045	0.046			
						[0.018]***	[0.017]***	[0.017]***			
Crisis in 1997-98										0.073	0.04
										[0.041]*	[0.023]*
Latin America										-0.06	-0.068
										[0.036]	[0.031]**
Crawling peg regime										0.05	0.071
										[0.041]	[0.036]**
M2 / GDP											0.179
											[0.036]***
Net debt liabilities			-0.163	-0.392			-0.064	-0.064			
			[0.057]***	[0.061]***			[0.021]***	[0.020]***			
Creditor x Net debt liabilities							0.058	0.062			
							[0.027]**	[0.027]**			
Growth in net debt liabilities							0.362	0.361			
							[0.187]*	[0.188]*			
Net portfolio liabilities											-0.672
											[0.070]***
Anti-corruption				-0.016							
				[0.005]***							
De facto capital acct. openness				0.242				0.002			
				[0.058]***				[0.001]**			
Constant	-0.035	-0.021	0.033	0.055	-0.025	-0.033	-0.006	-0.005	0.136	0.127	0.076
	[0.012]**	[0.014]	[0.025]	[0.017]***	[0.013]*	[0.012]***	[0.014]	[0.014]	[0.066]**	[0.075]*	[0.035]**
# Observations	53	53	53	53	78	78	78	78	74	74	74
Adj. R-square	0.59	0.63	0.70	0.86	0.64	0.66	0.72	0.72	0.24	0.25	0.61

NOTES: Robust standard errors are given in brackets. *, **, and *** indicate significance at the 10%; 5%; and 1% levels, respectively. The column headings (1), (2), (3), and (4) correspond to the model specifications (1), (2), (3), and (4) in the text. (4) is absent under the 1999-2004 sample period because there is no significant institutional variables.

Table 2: *Developing* Economies Behave as if They were *Developed* Economies

	Actual	Estimates based on developing economy equations, $\hat{r}_{i,dp}$	Errors (1) - (2)	Estimates based on developed economy equations, $\tilde{r}_{i,dp}$	Errors (1) - (4)	Differences (2) - (4)
	(1)	(2)	(3)	(4)	(5)	(6)
1. 1975 - 1981						
Indonesia	5.6%	8.5%	-2.9%	43.6%	-38.0%	-35.2%
Korea	4.9%	7.5%	-2.6%	24.6%	-19.8%	-17.2%
Malaysia	20.7%	18.8%	1.9%	36.0%	-15.3%	-17.2%
Philippines	10.0%	12.4%	-2.5%	32.8%	-22.8%	-20.3%
Singapore	57.8%	56.1%	1.7%	75.5%	-17.7%	-19.4%
Thailand	11.3%	7.5%	3.7%	39.7%	-28.4%	-32.1%
The whole group	7.6%	8.0%	-0.5%	23.8%	-16.2%	-15.8%
Emerging Asia	10.7%	11.9%	-1.2%	37.5%	-26.8%	-25.6%
Latin America	7.3%	7.2%	0.1%	9.8%	-2.5%	-2.6%
Oil Countries	18.0%	17.8%	0.1%	27.4%	-9.4%	-9.6%
2. 1983-1993						
China	7.8%	11.1%	-3.2%	5.3%	2.5%	5.8%
Indonesia	7.3%	7.0%	0.3%	-0.5%	7.8%	7.5%
Korea	4.5%	11.5%	-7.0%	10.7%	-6.2%	0.8%
Malaysia	23.8%	20.8%	3.0%	23.8%	-0.1%	-3.0%
Philippines	6.4%	10.9%	-4.5%	9.3%	-2.9%	1.6%
Singapore	70.8%	64.2%	6.5%	78.7%	-7.9%	-14.4%
Thailand	12.8%	14.2%	-1.4%	9.7%	3.1%	4.5%
The whole group	8.5%	9.5%	-1.0%	1.1%	7.4%	8.4%
Emerging Asia	12.2%	14.8%	-2.6%	13.2%	-1.0%	1.7%
Latin America	6.7%	7.3%	-0.6%	-12.7%	19.3%	19.9%
Oil Countries	15.9%	12.8%	3.1%	4.1%	11.8%	8.7%
3. 1999 - 2004						
China	23.5%	38.9%	-15.4%	53.6%	-30.1%	-14.7%
Hong Kong	69.2%	68.6%	0.6%	20.4%	48.9%	48.3%
Indonesia	16.6%	16.0%	0.6%	-13.3%	29.9%	29.3%
Korea	22.3%	17.9%	4.5%	20.7%	1.6%	-2.9%
Malaysia	40.6%	26.7%	13.9%	9.4%	31.1%	17.2%
Philippines	20.2%	23.0%	-2.7%	-6.4%	26.6%	29.4%
Singapore	95.3%	98.1%	-2.8%	7.7%	87.6%	90.4%
Thailand	29.0%	25.9%	3.1%	0.0%	29.0%	25.9%
The whole group	19.8%	21.8%	-2.0%	16.9%	2.9%	4.9%
Emerging Asia	34.7%	31.7%	3.1%	10.5%	24.2%	21.2%
Latin America	9.6%	2.7%	6.9%	3.5%	6.1%	-0.8%
Oil Countries	27.0%	21.5%	5.5%	9.9%	17.1%	11.6%

NOTES: Due to data availability, China is not included in the 1975-81 sample, and Hong Kong is not in the 1975-81 and 1983-93 samples. The "Emerging Asia" group does not include China. The subsample average is a real US dollar GDP weighted average. Therefore, the prediction errors for "The whole group" in columns (3) are not necessarily zero. A positive (negative) error in columns (3) and (5) indicates over(under)-hoarding of international reserves relative to model predictions.

Table 3: *Developed* Economies Behave as if they were *Developing* Economies

	Actual	Estimates based on *developed* economy equations, $\hat{r}_{i,dd}$	Errors (1) - (2)	Estimates based on *developing* economy equations, $\tilde{r}_{i,dd}$	Errors (1) - (4)	Differences (2) - (4)
	(1)	(2)	(3)	(4)	(5)	(6)
1. 1975 - 1981						
U.K.	5.4%	4.4%	1.0%	47.4%	-42.0%	-43.0%
Germany	10.3%	9.8%	0.5%	38.0%	-27.7%	-28.2%
Japan	3.4%	5.5%	-2.1%	14.1%	-10.7%	-8.7%
Average of developed economies	5.5%	5.0%	0.5%	35.1%	-29.6%	-30.1%
2. 1983 - 1993						
U.K.	4.8%	7.2%	-2.4%	18.4%	-13.6%	-11.2%
Germany	8.2%	5.2%	3.0%	20.1%	-11.9%	-14.9%
Japan	2.8%	9.2%	-6.4%	22.2%	-19.3%	-12.9%
Average of developed economies	5.3%	5.2%	0.1%	17.3%	-12.0%	-12.1%
3. 1999 – 2004						
U.K.	2.8%	2.7%	0.1%	22.4%	-19.7%	-19.8%
Germany	4.2%	3.0%	1.2%	29.6%	-25.4%	-26.6%
Japan	11.6%	11.6%	0.0%	27.4%	-15.8%	-15.8%
Average of developed economies	4.8%	5.6%	-0.9%	23.1%	-18.3%	-17.5%

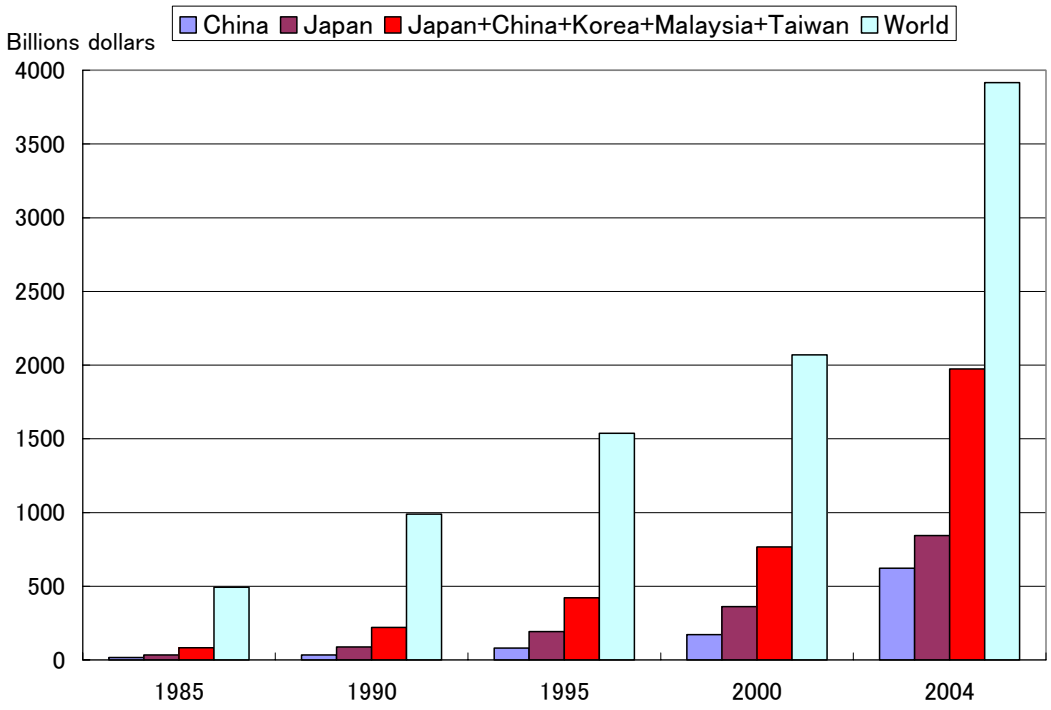
NOTES: The average is a real US dollar GDP weighted average. Therefore, the prediction errors for "Average of developed economies" in columns (3) are not necessarily zero. A positive (negative) error in columns (3) and (5) indicates over- (under-) hoarding of international reserves relative to model predictions.

Table 4: Predicted Values of the 1999 – 2004 International reserves from Different Model Vintages

	Actual	Estimates based on the 1999-04 Model	Errors (1) - (2)	Estimates based on the 1983-93 Model	Errors (1) - (4)	Estimates based on the 1975-81 Model	Errors (1)-(6)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Developed Economies							
U.K.	2.8%	2.7%	0.1%	24.3%	-21.6%	17.4%	-14.6%
Germany	4.2%	3.0%	1.2%	15.1%	-10.9%	11.7%	-7.6%
Japan	11.6%	11.6%	0.0%	16.5%	-4.9%	8.1%	3.5%
Average of developed economies	4.8%	5.6%	-0.9%	9.5%	-4.7%	5.9%	-1.2%
2. Developing Economies							
China	23.5%	38.9%	-15.4%	114.5%	-90.9%	164.9%	-141.4%
Hong Kong	69.2%	68.6%	0.6%	55.8%	13.4%	379.5%	-310.2%
Indonesia	16.6%	16.0%	0.6%	6.3%	10.3%	7.0%	9.5%
Korea	22.3%	17.9%	4.5%	41.9%	-19.5%	54.7%	-32.4%
Malaysia	40.6%	26.7%	13.9%	40.9%	-0.4%	59.5%	-18.9%
Philippines	20.2%	23.0%	-2.7%	17.7%	2.5%	15.7%	4.5%
Singapore	95.3%	98.1%	-2.8%	56.9%	38.4%	269.3%	-174.0%
Thailand	29.0%	25.9%	3.1%	20.2%	8.8%	28.2%	0.8%
Average of developing economies	19.8%	21.8%	-2.0%	40.3%	-20.4%	73.4%	-53.5%
Emerging Asia	34.7%	31.7%	3.1%	36.2%	-1.4%	100.6%	-65.9%
Latin America	9.6%	2.7%	6.9%	13.2%	-3.6%	27.7%	-18.1%
Oil Countries	27.0%	21.5%	5.5%	9.3%	17.6%	39.6%	-12.6%

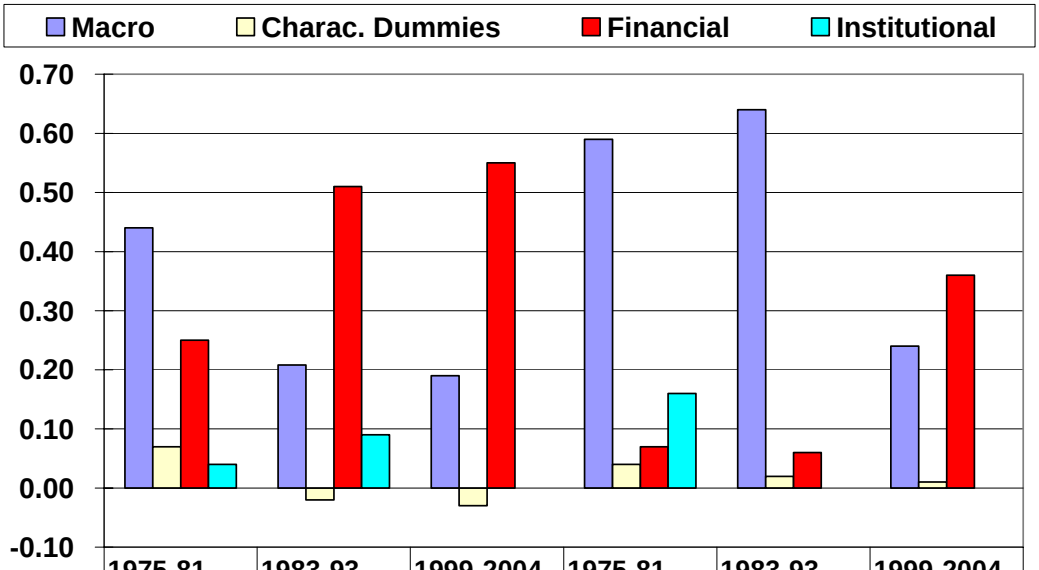
NOTES: The (subsample) averages real US dollar GDP weighted averages and thus are not necessarily zeros. A positive (negative) error in columns (3), (5), and (7) indicates over- (under-) hoarding of international reserves. The “Emerging Asia” group does not include China.

Figure 1: International Reserves – the World and Selected Economies



Source: World Development Indicator and IFS

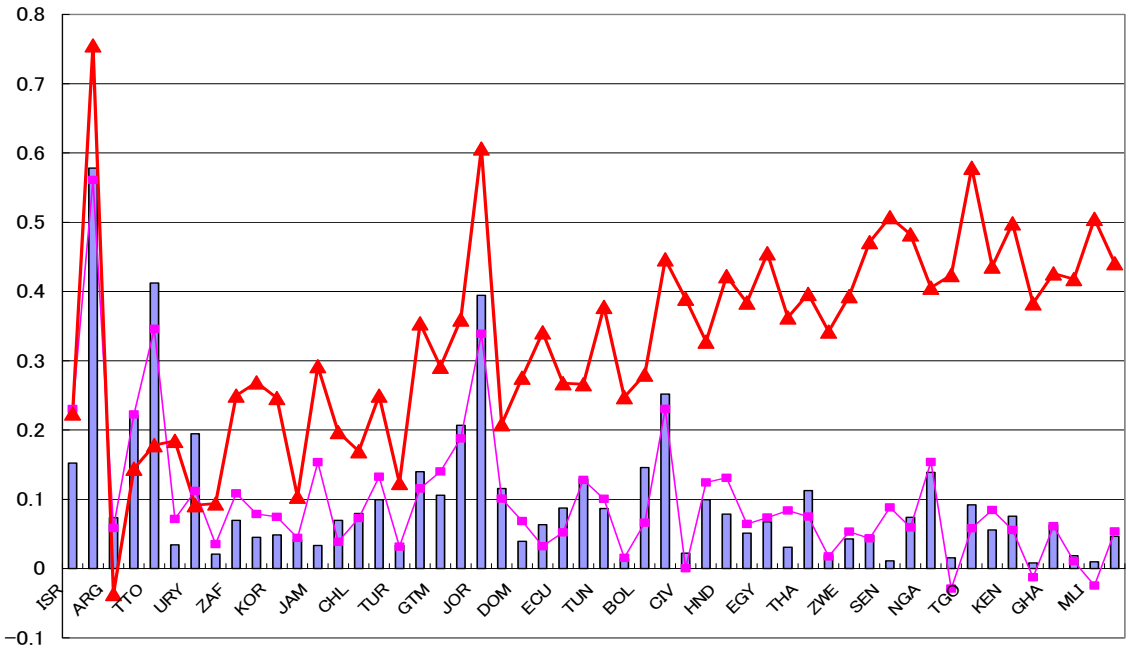
Figure 2: Incremental Explanatory Power of the Determinants



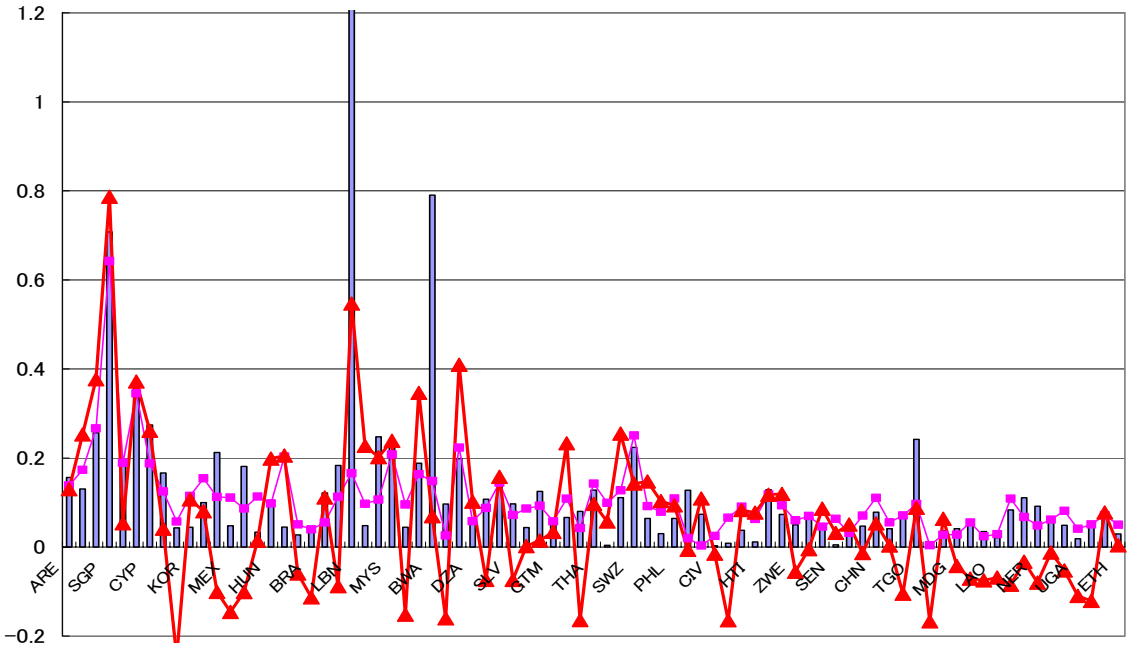
	Developed Economies			Developing Economies		
	1975-81	1983-93	1999-2004	1975-81	1983-93	1999-2004
Macro	0.44	0.21	0.19	0.59	0.64	0.24
Charac. Dummies	0.07	-0.02	-0.03	0.04	0.02	0.01
Financial	0.25	0.51	0.55	0.07	0.06	0.36
Institutional	0.04	0.09	0.00	0.16	0.00	0.00

Figure 3: *Developing* Economies Behave as if They were *Developed* Economies

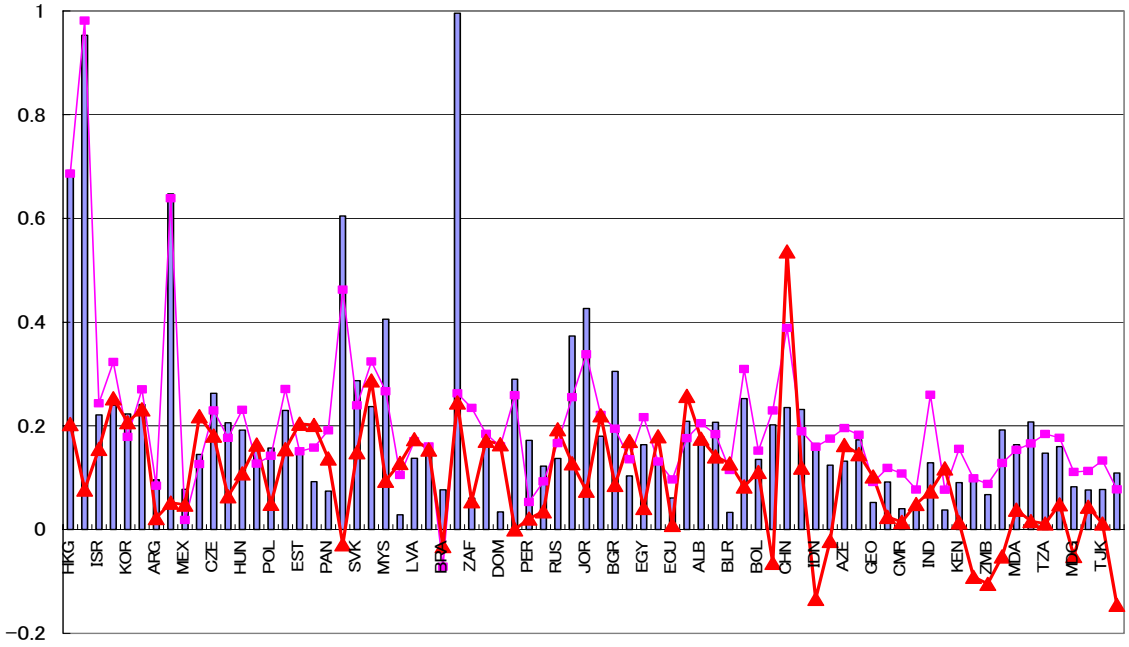
A: 1975 - 1981



B: 1983 – 1993



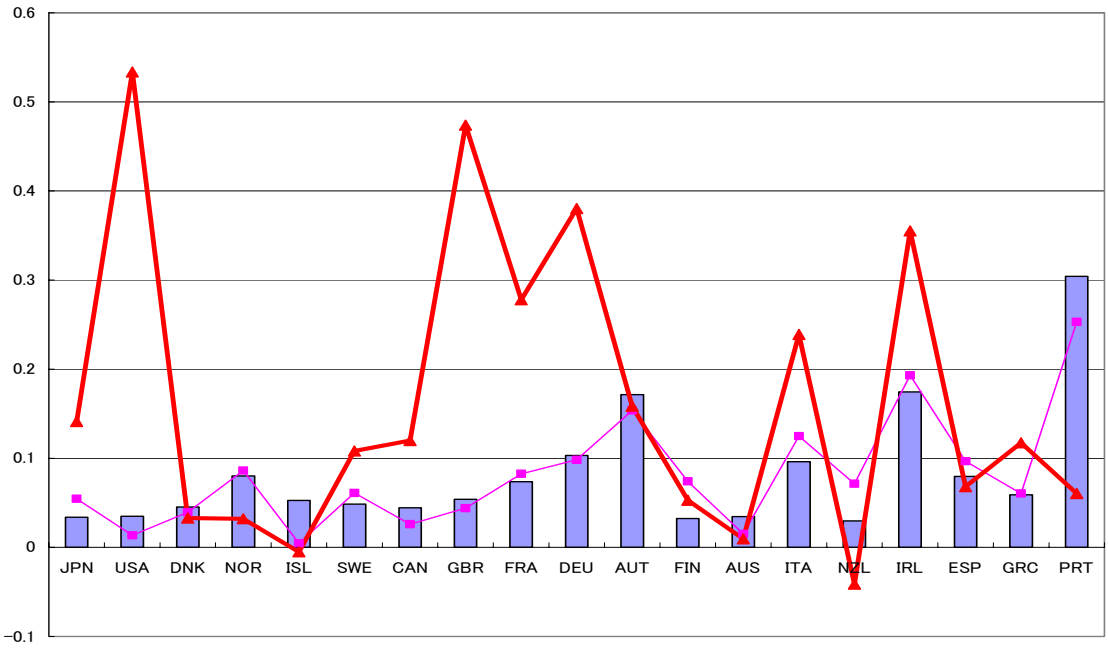
C: 1999 - 2004



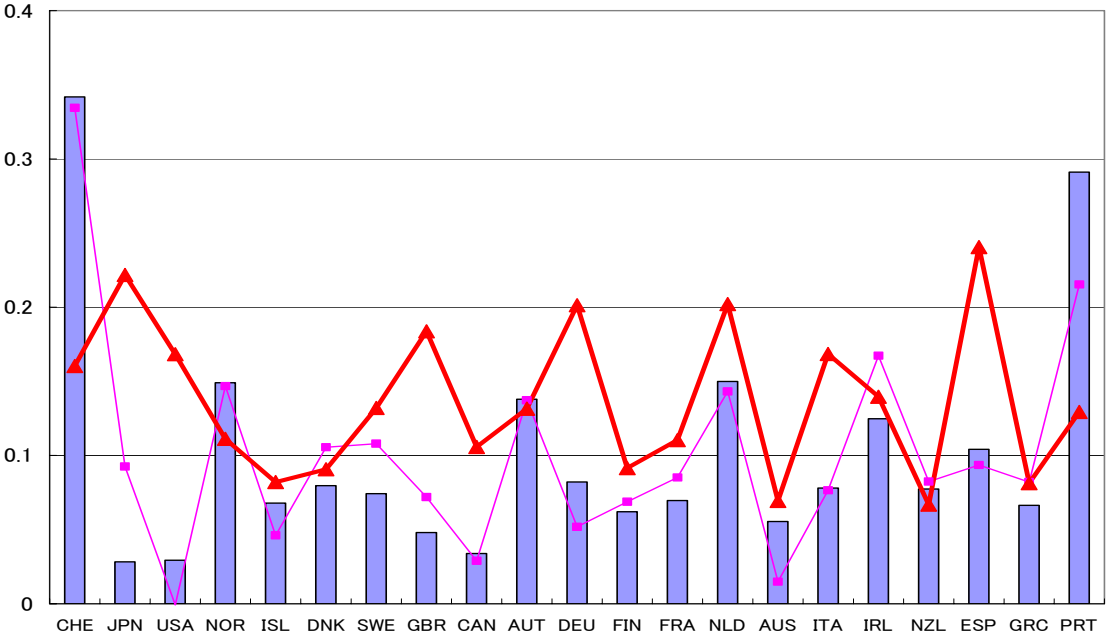
Actual levels of international reserves
Simple predicted values from the models of *developing* economies
Cross predicted values from the models of *developed* economies

Figure 4: *Developed* Economies Behave as if They were *Developing* Economies

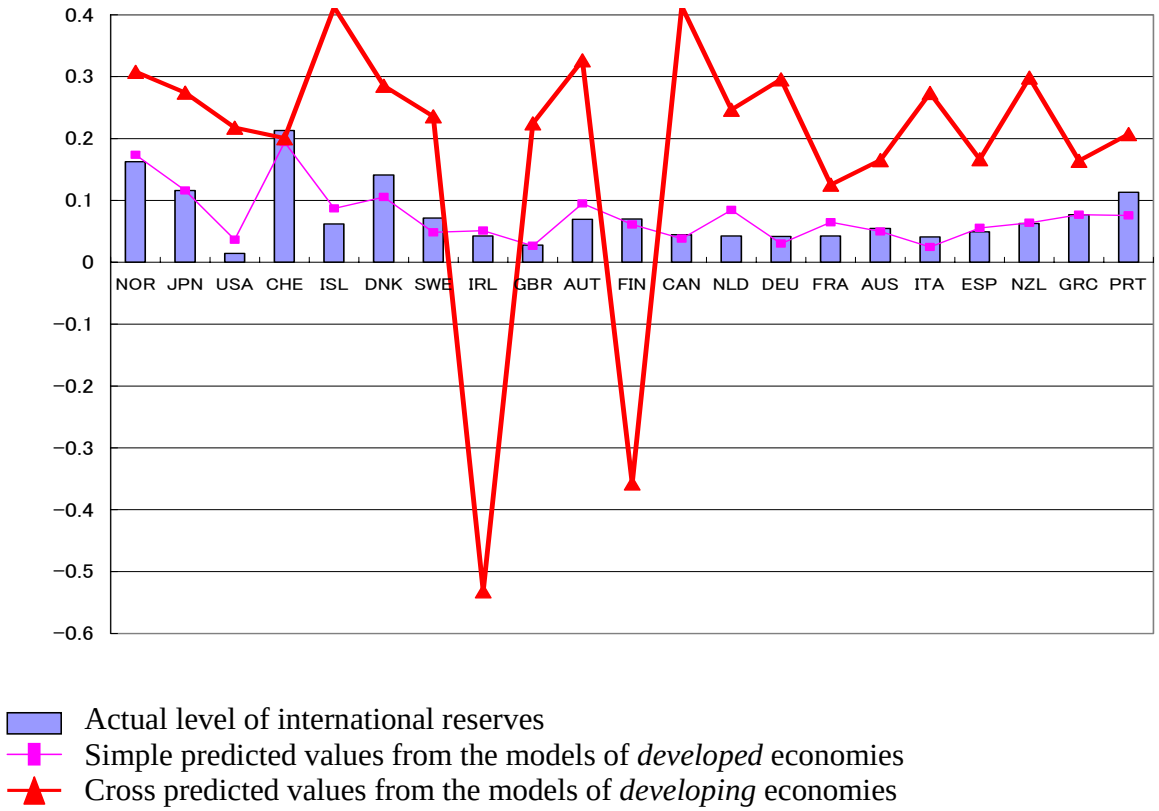
A: 1975 – 81



B: 1983 – 1993



C: 1999 - 2004



Actual level of international reserves
Simple predicted values from the models of *developed* economies
Cross predicted values from the models of *developing* economies