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Macroeconomic Impacts of Foreign Exchange Reserve Accumulation: Theory and International Evidence

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Abstract

Recently, a dramatic accumulation in foreign exchange reserves has been widely observed in developing countries. This paper explores the possible long-run impacts of this trend on macroeconomic variables in developing countries. We analyze a simple open economy model where increased foreign exchange reserves reduce the costs of liquidity risk. Given the amount of foreign exchange reserves, utility-maximizing representative agents decide consumption, capital stock, and labor input, as well as the amounts of liquid and illiquid external debt. The equilibrium values of these variables depend on the amount of foreign exchange reserves. A rise in foreign exchange reserves increases both liquid and total debt, while shortening debt maturity. To the extent that interest rates of foreign exchange reserves are low, an increase in foreign reserves also leads to a permanent decline in consumption. However, when the tradable sector is capital intensive, the increase may enhance investment and economic growth. We provide empirical support for our theoretical analysis using panel data from the Penn World Table. The cross-country evidence shows that an increase in foreign exchange reserves raises external debt outstanding and shortens debt maturity. The results also imply that increased foreign exchange reserves may lead to a decline in consumption, but can also enhance investment and economic growth. The positive impact on economic growth, however, disappears when we control the impact through investment.

JEL Classification: F21, F32, F34

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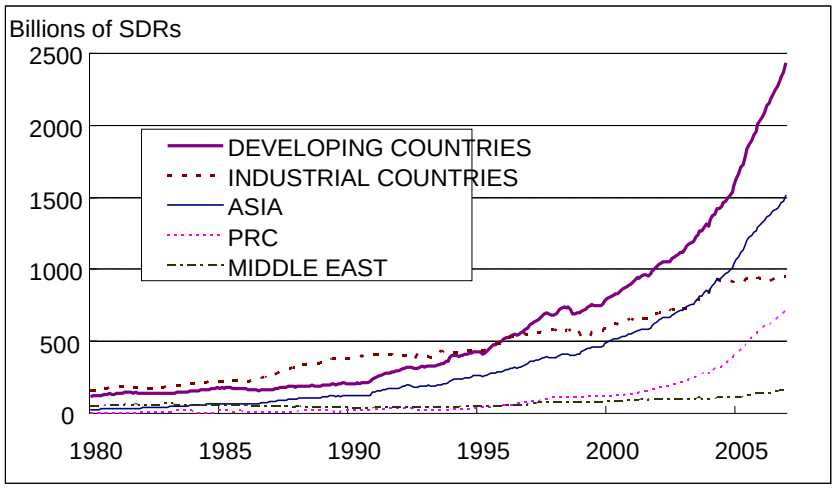
1. INTRODUCTION

Recently, a dramatic accumulation in foreign exchange reserves has been widely observed in developing countries. Foreign exchange reserves grew at a slow but steady pace between 1980 and 1995; beginning in the late 1990s, however, there was a dramatic rise in the accumulation of reserves. Foreign exchange reserves have now reached record-breaking levels in many developing countries, especially in Asia and the Middle East (Figure 1).

During the Asian financial crisis, less developed economies with smaller liquid foreign assets had difficulty averting panic in the financial markets and preventing sudden reversals in capital flows (see, for example, Corsetti, Pesenti, and Roubini 1999 and Sachs and Radelet 1998). Many developing countries thus came to recognize the importance of increased liquidity as a form of self-protection against crises. Replacing liquid, short-term debt with illiquid, long-term debt was a popular policy recommendation, at least initially. Ultimately, however, the course of action that most developing economies took more seriously was raising foreign reserves. The acceleration in the accumulation of reserves was abetted by policymakers' desire to prevent currency appreciation and maintain the competitiveness of the tradable sector.

To the extent that government's decision is exogenous, foreign exchange reserve accumulation will also influence and change the behavior of private agents. These changes in behavior may have various macroeconomic consequences that will be particularly important in the long-run, when the temporary impacts of an accumulation in foreign exchange reserves disappear.

Figure 1: Total Reserves Minus Gold in Developing Countries, 1980–2005



Notes: Developing countries include the People's Republic of China (PRC). Asia includes PRC, but not Japan. Monthly, end of period.

Source: IMF International Financial Statistics (2006).

In this paper, we explore the potential long-run impacts of foreign exchange reserve accumulation on macroeconomic variables in developing countries. In the first part of the paper, we analyze a simple open economy model where increased foreign reserves reduce the costs of liquidity risk. In the model, each representative agent maximizes the utility function from the consumption of tradable and non-tradable goods over time; the relative size of net foreign liquid debt to foreign exchange reserves reduces both the costs of liquidity risk and the liquidity premium. Given the amount of foreign exchange reserves, utility-maximizing representative agents decide consumption, capital stock, and labor input, as well as the amounts of liquid and illiquid foreign debt. The equilibrium values of these macroeconomic variables thus depend on the amount of foreign exchange reserves.

An increase in foreign exchange reserves raises both liquid and total debt, while shortening debt maturity. To the extent that foreign exchange reserve interest rates are low, increased foreign reserves will cause a permanent decline in consumption, as well as move labor from the non-tradable to the tradable sector. However, if the tradable sector is capital intensive, increased foreign exchange reserves may enhance investment and economic growth.

The second part of the paper provides empirical support for this theory using unbalanced panel data from the Penn World Table Version 6.2 (Heston, Summers, and Aten 2006). The data covers 134 countries for the period 1980–2004. To allow a structural break after the Asian financial crisis, we included the post-crisis dummy in some regressions. The evidence on external debt shows that an increase in foreign reserves raises total external debt outstanding and shortens debt maturity. The evidence also reveals that increased foreign exchange reserves may cause a decline in consumption, but can also enhance investment and economic growth. These results are consistent with those predicted by theory, when the interest rates of foreign exchange reserve are low and the tradable sector is capital intensive. The positive impact on economic growth, however, disappears when we control the impact through investment.

One may argue that an increase in foreign exchange reserves improves the current account, and consequently enhances aggregate output. In the short-run, aggressive intervention could help maintain the competitiveness of the tradable sector, and manifest itself in a massive accumulation in foreign exchange reserves by the central bank. The argument may be particularly relevant in explaining reserve accumulation in the People's Republic of China (PRC), where the *de facto* dollar peg has been maintained. However, this is a Keynesian type, demand-side outcome that will not be relevant in the long-run. Even though the intervention may be effective in changing nominal exchange rates, the current account needs to be balanced in the long-run, such that real exchange rates are fully adjusted to the equilibrium values. The results of our analysis are therefore instructive in determining the long-run, macroeconomic impacts of an exogenous accumulation in foreign exchange reserves.

In a previous study, Aizenman and Lee (2005) compared the relative importance of precautionary and mercantilist motives in explaining the hoarding of international reserves by developing countries. Their empirical results suggest that precautionary motives have played a more prominent role in reserve accumulation. Meanwhile, a study by Rodrik (2006) revealed that reasonable spreads between the yield on reserve assets and the cost of foreign borrowing led to an income loss of nearly one percent of GDP in developing countries that have rapidly increased foreign exchange reserves. In contrast, Levy Yeyati (2006) pointed out that the costs of foreign exchange reserves may have been considerably overstated in previous studies. He argued that, to the extent that reserves lower the probability of a run-induced default, they reduce the spread paid on the stock of sovereign debt.

This paper builds on these previous studies by investigating the macroeconomic effects of exogenous foreign exchange reserve accumulation---an issue which has not been well discussed in the literature. In particular, we distinguish liquid from illiquid debt and investigate how the maturity structure of external debt changes when foreign exchange reserves are accumulated. The model allows costs and benefits from foreign exchange reserve accumulation, as reported in the literature. It also incorporates both the tradable and non-tradable sectors, with different capital intensities. The different capital intensities are crucial in determining the long-run effects of foreign exchange reserve accumulation on capital accumulation and economic growth.

The rest of the paper proceeds as follows. Section 2 sets up our small open economy model, while Section 3 discusses the impacts of increased foreign exchange reserves. Section 4 provides supporting empirical evidence using panel data from the Penn World Table.

Section 5 provides various robustness tests for our empirical results. Section 6 summarizes our main results and discusses their implications.

2. A SMALL OPEN ECONOMY

The main purpose of our theoretical model is to investigate the long-run impacts of accumulated foreign exchange reserves on macroeconomic variables in developing countries. We consider a small open economy that produces two composite goods, tradables and nontradables, relying on external debt. Each representative agent in the economy maximizes the following utility function:

(1) $\sum_{j=0}^{\infty} \beta^j U(c^T_{t+j}, c^N_{t+j})$,

where c^T_t = consumption of the tradable good, and c^N_t = consumption of the non-tradable good. The parameter β is a discount factor, such that $0 < \beta < 1$. The subscript *t* denotes time period. The utility function $U(c^T_{t+j}, c^N_{t+j})$ is increasing and strictly concave in c^T_{t+j} and c^N_{t+j}.

The representative agent is a net debtor in the international market. The budget constraint is

(2) $b^A_{t+1} + b^B_{t+1} - k_{t+1} = (1+r)\, b^A_t + (1+r+\rho(b^A_t/R_t))\, b^B_t - k_t - [y_t^T + p^N_t\, y_t^N - \phi(b^A_t/R_t) - c^T_t - p^N_t\, c^N_t - T_t]$.

where b^A_t = net liquid debt outstanding; b^B_t = net illiquid debt outstanding; k_t = domestic capital stock; T_t = lump-sum tax; p^N_t = the price of the nontradable good; r = real interest rate of liquid debt; and R_t = foreign exchange reserves. For simplicity, we assume that capital stock is tradable and that there is no capital depreciation. We also assume that $1+r < 1/\beta$, to assure the existence of the steady state. Since the numeraire is the traded good, the real interest rate and the price of the non-tradable good are defined in terms of tradables.

Our model has two salient features that have not been commonly used in previous studies. One is a liquidity premium $\rho(b^A_t/R_t)$, which makes the real interest rate of illiquid debt higher than that of liquid debt. The other is an insurance premium $\phi(b^A_t/R_t)$. which increases as potential liquidity risk increases. In developing countries, sudden reversals in capital flows are less likely when the borrower shifts its external debt from liquid to illiquid debt. The lender thus requires an interest rate premium when issuing illiquid debt. The liquidity premium $\rho(b^A_t/R_t)$ in the budget constraint reflects this premium. Unlike the liquidity premium $\rho(b^A_t/R_t)$, the insurance premium $\phi(b^A_t/R_t)$ is included as an independent cost in the budget constraint because it is a direct cost of holding liquid foreign debt. In our model, the net supply of domestic debt is always zero, such that b^A_t denotes net liquid ***foreign*** debt. As b^A_t becomes larger relative to R_t, the borrowing agent needs to pay larger costs to prevent a potential liquidity crisis. We assume that both of the premiums are increasing and convex in b^A_t/R_t; that is, $\rho'(b^A_t/R_t) > 0$, $\rho''(b^A_t/R_t) > 0$, $\phi'(b^A_t/R_t) > 0$, and $\phi''(b^A_t/R_t) > 0$. This reflects the fact that a panic in the financial market is more likely when a country has higher (net) levels of liquid foreign debt, and less likely when it has higher levels of foreign exchange reserves. The relative size of net liquid foreign debt to foreign exchange reserve is thus a good proxy for the premiums.

In the following analysis, we assumed that each production function has constant returns to scale in capital stock and labor input. Denoting the labor input for tradable good by n_t and the total constant labor supply by N, our production functions are written as

(3) $y^T_t = f(k^T_t/n_t)n_t$ and $y^N_t = g(k^N_t/(N - n_t))(N - n_t)$,

where $f' > 0$, $g' > 0$, $f'' < 0$, and $g'' < 0$. We defined capital stock held in the tradable and nontradable sectors by k^T_t and k^N_t respectively. By definition, the total domestic capital stock is the sum of the two capital stocks, that is, $k_t = k^T_t + k^N_t$.

The amount of foreign exchange reserves R_t and the lump-sum tax T_t are exogenously given for the representative agent. The first-order conditions are thus derived by maximizing the following Lagrangian:

(4) $L = \sum_{j=0}^{\infty} \beta^j U(c^T_{t+j}, c^N_{t+j})$

$+ \sum_{j=0}^{\infty} \beta^j \mu_{t+j} [b^A_{t+1+j} + b^B_{t+1+j} - (k^T_{t+1+j} + k^N_{t+1+j}) - (1+r) b^A_{t+j} - (1+r+\rho(b^A_{t+j}/R_{t+j})) b^B_{t+j} + (k^T_{t+j} + k^N_{t+j})$

$+ f(k^T_{t+j}/n_{t+j})n_{t+j} + p^N_{t+j} g(k^N_t/(N- n_t))(N- n_{t+j}) - \phi(b^A_{t+j}/R_{t+j}) - c^T_{t+j} - p^N_{t+j} c^N_{t+j} - T_{t+j}]$.

Assuming interior solutions, the first-order conditions thus lead to

(5a) $U_2 \equiv \partial U(c^T_t, c^N_t)/\partial c^N_t = \mu_t p^N_t$,
(5b) $U_1 \equiv \partial U(c^T_t, c^N_t)/\partial c^T_t = \mu_t$,
(5c) $f(k^T_t/n_t) - f'(k^T_t/n_t)(k^T_t/n_t) = p^N_t [g(k^N_t/(N- n_t)) – g'(k^N_t/(N- n_t)) k^N_t/(N- n_{t+j})]$,
(5d) $\mu_t = \beta \{(1+r) +\rho'(b^A_{t+1}/R_{t+1})(b^B_{t+1}/R_{t+1}) + \phi'(b^A_{t+1}/R_{t+1})/R_{t+1}\}\mu_{t+1}$,
(5e) $\mu_t = \beta \{(1+r) +\rho(b^A_{t+1}/R_{t+1})\}\mu_{t+1}$,
(5f) $\mu_t = \beta \{1 + f'(k^T_{t+1}/n_{t+1})\}\mu_{t+1}$,
(5g) $\mu_t = \beta \{1 + p^N_{t+1} g'(k^N_t/(N- n_t))\}\mu_{t+1}$.

Under the assumption of perishable goods, it holds that $c^N_t = y^N_t$ in equilibrium. Since the numeraire is the traded good, the price of the nontradable good p^N_t denotes the real exchange rate of this small open economy at time t, where a decline in p^N_t implies a depreciation of the real exchange rate. Equation (5a) implies that the real exchange rate is determined by U_2/U_1. Given the Lagrange multiplier, equation (5b) determines the amount of tradable good consumption. Equation (5c) shows that the amount of liquid foreign debt b^A_t is positively related to the amount of foreign exchange reserves R_t. This is because foreign reserves, which reduce liquidity risk, allow the representative agent to hold more liquid foreign debt.

At the steady state, the Lagrange multiplier μ_t is constant and equal to $\mu > 0$. This implies that all of the macro variables c^T_t, p^N_t, b^A_t, and $b^A_t + b^B_t$ are constant over time, in the absence of unanticipated external shocks. An unanticipated change in foreign exchange reserves affects the equilibrium values of these variables. However, at the steady state, it holds that $\mu_t = \mu_{t+1}$, so that equations (5d), (5e), (5f), and (5g) lead to

(6) $\rho(b^A/R) = \rho'(b^A/R)(b^B/R) + \phi'(b^A/R)/R = (1/\beta) – (1+ r)$,
(7) $f'(k^T/n) = p^N g'(k^N/(N- n)) = (1/\beta) – 1$.

Equations (5c), (6), and (7) imply that b^A/R, k^T/n, $k^N/(N- n)$, and p^N remain unchanged at the steady state for alternative values of foreign exchange reserves.

3. THE IMPACTS OF INCREASED FOREIGN EXCHANGE RESERVES ON MACROECONOMIC VARIABLES

To determine the long-run impacts of increased foreign exchange reserves on macroeconomic variables, we explore the impacts of an unanticipated change in R_t on various macroeconomic variables at the steady state. The government has several alternatives for financing an increase in the amount of foreign exchange reserves. However, because of Ricardian equivalence, the method of finance will not affect resource allocation. We thus focus on the case where increases in foreign exchange reserves are solely financed by increases in the lump-sum tax T_t. In this case, the government budget constraint at period t is written as

(8) Tt = G* + Rt+1 – (1+rR) Rt,

where G^* is exogenous government expenditure and r_R is the real interest rate of foreign exchange reserves. It is natural to assume that the rate of returns from foreign exchange reserves is very low in the international capital market.

Assuming that there is an unanticipated increase in foreign reserves, we first consider the impacts of this increase on external debt and its components at the steady state. We denote the steady-state value of variable x_t by x and its change by Δx. Since equation (6) holds at the steady state for any R_t, we obtain

(9a) Δ bA /ΔR = bA/R > 0,
(9b) Δ bB /ΔR = ρ(bA/R)/ρ'(bA/R) > 0.

Since there is no net supply of domestic debt, two types of debt b^A_t and b^B_t denote net liquid foreign debt and net illiquid foreign debt, respectively. Equations (9a) and (9b) imply that an unexpected rise in foreign exchange reserves increases not only liquid foreign debt but also the sum of liquid and illiquid foreign debt. Equations (9a) and (9b) also lead to

$$(10)\quad \frac{\Delta\left(b^A - b^B\right)}{\Delta R} = \frac{b^A / R}{\rho'(b^A / R)}\left\{\rho'(b^A / R) - \frac{\rho(b^A / R)}{b^A / R}\right\}.$$

Equation (10) indicates that an unexpected rise in foreign exchange reserves always increases the share of liquid foreign debt to total foreign debt. This happens because foreign exchange reserves reduce liquidity risk, so that the value of holding illiquid debt declines. An unexpected rise in foreign exchange reserves not only has an income effect that increases total foreign debt, it also has a substitution effect that replaces illiquid foreign debt with liquid debt.

We next consider the impacts of increased foreign exchange reserves on macroeconomic variables. Recall that each of p^N, k^T/n, and $k^N/(N- n)$ relies solely on the rate of time preference, that is, $1/\beta$, and is independent of the amount of foreign exchange reserves at the steady state. This implies that an unanticipated increase in the foreign reserve has no impact on the real exchange rate or the capital-labor ratios of the two sectors, even in the long-run. However, the change in foreign reserves affects the steady state values of other macroeconomic variables such as consumption, capital stock, labor, and total output.

At the steady state, all the macroeconomic variables are constant over time. Since $y^T = f(k^T/n)n$, $T = G^* - r_R R$, and $c^N = y^N$, the budget constraint at the steady state implies that $rb^A + \{r+\rho(b^A/R)\}b^B = f(k^T/n)n - c^T - \phi'(b^A/R) - G^* + r_R R$. Since b^A/R, k^T/n, and $k^N/(N- n)$ remain unchanged, we thus obtain

(11) rΔbA + {r+ρ(bA/R)}ΔbB = rR ΔR + f(kT/n)Δn - ΔcT.

In addition, noting that $c^N = y^N = g(k^N/(N- n))(N- n)$, equations (5a), (5b), and (7) imply that

(12a) ΔcT = B ΔcN,
(12b) ΔcN = - g(kN/(N- n) Δn,
(12c) pN = U2/U1 = f'(kT/n)/g'(kN/(N- n)),

where $B \equiv \{(U_2/U_1)U_{12} - U_{22}\}/\{U_{12} - (U_2/U_1)U_{11}\}$. Since $B > 0$, equations (12a) and (12b) imply that consumption declines in both the tradable and non-tradable sectors when labor input increases in the tradable sector. Equation (12c) indicates that the real exchange rate is equal not only to the substitution rate of marginal utility, but also to the substitution rate of marginal transformation between the two sectors. The latter is the supply side determinant of the real exchange rate in our model.

Since $(1/\beta) - 1 = \rho(b^A/R) + r$, combining (12a) and (12b) with (9a), (9b), and (11) leads to

$$(13a)\quad \frac{\Delta(c^T + c^N)}{\Delta R} = -(1+B)g(k^N/(N-n))]\frac{\Delta n}{\Delta R},$$

$$\text{(13b)}\quad \frac{\Delta n}{\Delta R} = -\frac{\{(1/\beta)-1\}\dfrac{\rho(b^A/R)}{\rho'(b^A/R)} + \left\{(b^A/R)r - r_R\right\}}{f(k^T/n) + Bg(k^N/(N-n))}$$

Equations (13a) and (13b) determine the impacts of increased foreign reserves on total consumption and labor input in the tradable sector, respectively. In general, we cannot see whether the derivatives are positive or negative in these equations; while a low rate of return on foreign exchange reserves and increased total foreign debt reduce permanent income, a shift from illiquid to liquid debt may relieve the interest rate burden of foreign debt. However, we can show that $\Delta(c^T + c^N)/\Delta R < 0$ and $\Delta n/\Delta R > 0$, if and only if

$$\text{(14)}\quad r_R < [(1/\beta)-1][\rho(b^A/R)/\rho'(b^A/R)] + (b^A/R)\, r.$$

The right-hand side of (14) is increasing in b^A/R. This implies that when b^A/R is large enough, an increase in foreign exchange reserves has a positive impact on consumption and shifts labor from the tradable to the non-tradable sector. This happens because increasing foreign exchange reserves reduces risk premiums when liquidity risk is high enough. In contrast, the left-hand side of (14) is increasing in r_R. Therefore, when the interest rate of foreign exchange reserves r_R is low enough, an unanticipated increase in foreign exchange reserves has a negative impact on consumption and shifts labor from the non-tradable to the tradable sector. When the interest rate of foreign exchange reserves is low, holding foreign reserves is costly and leads to a decline in permanent income in terms of tradable goods. Consequently, while the tradable sector expands to supplement this decline of permanent income, consumption declines in both sectors simultaneously.

Note that $\Delta k^T/\Delta R > 0$ and $\Delta k^N/\Delta R < 0$ when (14) holds, because capital-labor ratios k^T/n and $k^N/(N-n)$ are independent of the amount of foreign reserves at the steady state. Shifting labor from the non-tradable to the tradable sector increases capital stock in the tradable sector, but decreases the same in the non-tradable sector. We also obtain

$$\text{(15a)}\quad \frac{\Delta k}{\Delta R} = \frac{\Delta k^T}{\Delta R} + \frac{\Delta k^N}{\Delta R} = \left(\frac{k^T}{n} - \frac{k^N}{N-n}\right)\frac{\Delta n}{\Delta R},$$

$$\text{(15b)}\quad \frac{\Delta y}{\Delta R} = \frac{\Delta y^T}{\Delta R} + p^N \frac{\Delta y^N}{\Delta R}$$

$$= [f(k^T/n) - p^N g(k^N/(N-n))]\frac{\Delta n}{\Delta R},$$

$$= f'(k^T/n)\,[\{f(k^T/n)/f'(k^T/n)\} - \{g(k^N/(N-n))/g'(k^N/(N-n))\}]\frac{\Delta n}{\Delta R}.$$

Equations (15a) and (15b) determine the impacts of increased foreign exchange reserves on total capital stock and total output, respectively. The impacts depend not only on the sign of $\Delta n/\Delta R$, but also on the relative capital intensity of each sector. When $\Delta n/\Delta R > 0$, increased foreign exchange reserves lead to an expansion in the tradable sector, but a contraction in the non-tradable sector. Consequently, when $\Delta n/\Delta R > 0$, total capital stock increases as foreign exchange reserves increase, if and only if the tradable sector is more capital intensive than the non-tradable sector; that is, $(k^T/n) > (k^N/(N-n))$. When $\Delta n/\Delta R > 0$, total output also increases as foreign exchange reserves increase, if and only if the tradable sector is more capital intensive than the non-tradable sector; that is, $f(k^T/n)/f'(k^T/n) > g(k^N/(N-n))/g'(k^N/(N-n))$. The relative capital intensities between the two sectors are crucial in determining the impacts of increased foreign reserves on aggregate capital stock and aggregate output.

4. SOME INTERNATIONAL EVIDENCE

4.1 The Impacts on External Debt

The main implication of our theoretical analysis is that an increase in foreign reserves has significant long-run impacts on several macroeconomic variables in developing countries. The impacts, however, depend on the parameter values as well as on the interest rates. The purpose of this section is to test this theory using panel data on a large number of developing countries. We first examine the relationship between foreign reserves and total external debt outstanding and their average maturity. In terms of liquidity, short-term debt is more liquid than long-term debt, because sudden reversals in capital flows are more likely when debt maturity is short. Shorter average foreign debt maturity can therefore proxy for the degree of foreign debt. Our theoretical analysis suggests that a rise in foreign exchange reserves not only increases foreign debt, but also causes a shift from illiquid to liquid debt. In the following estimation, we can therefore expect foreign exchange reserves to have a positive impact on total external debt outstanding and a negative impact on average maturity.

We estimated the following two equations:

(16) $\Delta(Debt_{j,t}/\ GNI_{j,t}) = a_1 \cdot \Delta(Foreign\ Reserve_{j,t}\ /\ GNI_{j,t}) + a_2 \cdot log\ GNI_{j,t}$,

(17) $Maturity_{j,t} = b_1 \cdot Foreign\ Reserve_{j,t}/\ GNI_{j,t} + b_2 \cdot log\ GNI_{j,t}$,

where *Debt* = total external debt outstanding; *Maturity* = average maturity of new commitments (years); *GNI* = gross national income; and *Foreign Reserve* = the amount of foreign exchange reserves. Subscript j denotes country j, while subscript t denotes year. The variable $\Delta x_{j,t}$ denotes the first difference of $x_{j,t}$. To avoid heteroscedasticity, foreign exchange reserve was divided by *GNI* in equation (17). To allow income differences and scale effects, we included *log GNI* as an explanatory variable in both equations. We also included auxiliary variables such as the import ratio, degree of openness, and an Asia dummy in (16).

Data on foreign exchange reserves was taken from the International Monetary Fund's *International Financial Statistics*, while data on total external debt outstanding, average maturity of new commitments, and *GNI* were derived from the World Bank's *Global Development Finance.* The data is unbalanced panel data on 134 developing countries, following the World Bank's classification (see Appendix 1 for the list of countries). The sample period is from 1980 to 2004.

The method of estimation was OLS with a constant term. To allow a structural break after the crisis, we included a post-crisis dummy in some regressions. The post-crisis dummy is a time dummy that takes on a value of one from 1998 to 2004, and zero otherwise.

Tables 1-(1) and 1-(2) report the estimation results of (16) and (17), with and without the post-crisis dummy. Total external debt outstanding has a significantly positive correlation with foreign exchange reserves, and is negatively correlated with log *GNI*. The increase in foreign exchange reserves is financed by issuing new external debt when income differences are adjusted. The results are robust even if we include auxiliary variables. This supports the view that increased foreign exchange reserves increase external debt outstanding. In contrast, debt maturity is negatively correlated with foreign exchange reserves as well as with log *GNI*. This negative correlation implies that an increase in foreign exchange reserves shortens debt maturity. Our theoretical analysis implied that foreign exchange reserves reduce liquidity risk, so that their increase will cause a shift from illiquid to liquid debt. To the extent that short-term debt is more liquid than long-term debt, the empirical results support this implication. The negative correlation with log *GNI* implies that debt maturity is shorter in smaller countries.

Table 1: International Evidence on the Impacts on External Debt

(1) $\Delta Debt_{i,t}$ = constant term + $a_1 \cdot \Delta Foreign\ Reserve_{i,t}$ + $a_2 \cdot log\ GNI_{i,t}$,

Regression	1		2		3		4		5	
Constant	7.0888	**	7.6568	**	7.0881	**	7.0816	*	6.9725	
	(2.47)		(2.54)		(2.47)		(1.68)		(1.64)	
△(R/GNI)	0.8547	***	0.8525	***	0.8580	***	0.8542	***	0.8552	***
	(5.10)		(5.09)		(5.12)		(5.11)		(5.11)	
log(GNI)	-0.6975	**	-0.7755	**	-0.6770	**	-0.6225	*	-0.6082	
	(-2.18)		(-2.25)		(-2.09)		(-1.67)		(-1.59)	
Asia-dummy			1.7918							
			(0.63)							
After98-dummy					-0.6220				0.1053	**
					(-0.43)				(2.50)	
Import/GNI							0.1049	**	-0.0758	***
							(2.49)		(-2.99)	
Openness							-0.0763	***	-0.2429	
							(-3.03)		(-0.16)	
adj.R squared	0.0153		0.0150		0.0149		0.0192		0.0187	

Notes:

1) Number of observations = 1835 (134 countries, 1980–2004, unbalanced panel). The sample includes developing countries only.

2) The method of estimation is pooled-OLS; t-statistics are in parentheses.

3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).

4) Openness is (Export+Import)/GDP (variable "openk" of PWT 6.2).

(2) $Maturity_{i,t}$ = constant term + $b_1 \cdot Foreign\ Reserve_{i,t}/ GNI_{i,t}$ + $b_2 \cdot log\ GNI_{i,t}$

Regression	1		2		3		4	
Constant	44.6099	***	44.8509	***	44.7498	***	45.1080	***
	(41.25)		(39.60)		(41.46)		(39.86)	
R/GNI	-0.0536	***	-0.0549	***	-0.0706	***	-0.0729	***
	(-2.90)		(-2.95)		(-3.72)		(-3.81)	
log(GNI)	-2.4161	***	-2.4472	***	-2.4807	***	-2.5280	***
	(-20.43)		(-19.42)		(-20.81)		(-19.84)	
Asia-dummy			0.8480				1.2485	
			(0.72)				(1.05)	
After98-dummy					1.9947	***	2.0435	***
					(3.78)		(3.86)	
adj.R squared	0.1390		0.1388		0.1434		0.1434	

Notes:

1) Number of observations = 2411 (134 countries and 25 periods, unbalanced panel). The sample includes developing countries only.

2) The method of estimation is pooled-OLS; t-statistics are in parentheses.

3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).

4.2 The Impacts on Macroeconomic Variables

Using the same panel data, we next examined the long-run impacts of foreign exchange reserves on consumption, capital investment, export share, and GDP growth rate. These are important variables to measure macroeconomic performance. Our theoretical model suggests that, when interest rates on foreign exchange reserves are low, an increase in foreign exchange reserves will have: (i) a negative impact on consumption; (ii) a positive impact on export share; and (iii) a positive impact on capital investment and output, if the tradable sector is more capital intensive than the non-tradable sector.

We estimated the following three equations:

(18) $Consumption_{j,t}/GDP_{j,t} = c_1$ (*Foreign Reserve*$_{j,t}$/ $GNI_{j,t}$) + $c_2 \cdot$ *log* $GNI_{j,t}$,
(19) $Export_{j,t}/GNI_{j,t} = d_1$ (*Foreign Reserve*$_{j,t}$/ $GNI_{j,t}$) + $d_2 \cdot$ *log* $GNI_{j,t}$,
(20) $Investment_{j,t}/GDP_{j,t} = e_1$ (*Foreign Reserve*$_{j,t}$/ $GNI_{j,t}$) + $e_2 \cdot$ *log* $GNI_{j,t}$,
(21) $\Delta GDP_{j,t}/GDP_{j,t} = f_1$ (*Foreign Reserve*$_{j,t}$/ $GNI_{j,t}$) + $f_2 \cdot$ *log* $GNI_{j,t}$,

where *Consumption* = domestic consumption; *GDP* = gross domestic product; *Export* = the amount of export; and *Investment* = domestic capital investment. Subscript j denotes country j, while subscript t denotes year. To avoid heteroscedasticity, foreign exchange reserves and export were divided by *GNI*, while consumption and investment were divided by *GDP*.

Equations (18) and (19) explore the impacts of foreign exchange reserves on consumption and the export ratio respectively, while equations (20) and (21) investigate the impacts on capital stock and aggregate output. In equations (20) and (21), we used investment rate and GDP growth rate as dependent variables. If we strictly follow our theoretical discussions, we may use capital stock and the level of GDP as dependent variables in these equations. However, while consumption responds to a shock instantaneously, it usually takes a long time for capital stock to reach the steady state. In the estimations, we therefore explored whether investment and GDP growth are on the right transition path to the steady state, as predicted by our theory. To allow income differences and scale effects, we included *log GNI* in all equations. One may be concerned that the accumulation of foreign exchange reserves might be endogenous; however, the accumulation is a consequence of repeated changes in previous years. As such, reverse causality from the dependent variables to the level of foreign exchange reserves is less likely in our estimations.

The data on consumption, investment, and *GDP* were taken from the Penn World Table Version 6.2 (Heston, Summers, and Aten 2006). The data is unbalanced panel data on 134 countries and the sample period is 1980–2004. The method of estimation is OLS with a constant term. To allow a structural break after the crisis, we included the post-crisis dummy in some regressions. The post-crisis dummy is a time dummy that takes on a value of one from 1998 to 2004 and zero otherwise.

Tables 2-(1), 2-(2), 2-(3), and 2-(4) report the results of our regressions with and without the post-crisis dummy. The coefficients of foreign exchange reserves are statistically significant in all cases. Foreign exchange reserve is negatively correlated with consumption in Table 2-(1) and positively correlated with export ratio in Table 2-(2). The results imply that an increase in foreign exchange reserves decreases consumption and expands the share of the tradable sector. To the extent that interest rate revenues from foreign exchange reserves are low, this is consistent with our theoretical results. Foreign exchange reserves are positively correlated with investment rate and GDP growth rate in Tables 2-(3) and 2-(4). This implies that the accumulation of foreign exchange reserves enhances capital accumulation and promotes sustainable growth in developing countries. Our theory suggests that this happens when the tradable sector is more capital intensive than the non-tradable sector.

Table 2: Impacts of Increased Foreign Exchange Reserves on Macroeconomic Variables: International Evidence

(1) $Consumption_{i,t}/GNI_{i,t}$ = constant term + c_1 $Foreign\ Reserve_{i,t}/\ GNI_{i,t}$ + $c_2 \cdot\ log\ GNI_{i,t}$

Regression	1		2		3	
Constant	95.6620	***	82.7353	***	82.7034	***
	(62.26)		(50.04)		(49.90)	
R/GNI	-0.2537	***	-0.1965	***	-0.1948	***
	(-9.05)		(-7.34)		(-7.09)	
log(GNI)	-2.2701	***	-1.2512	***	-1.2425	***
	(-13.64)		(-7.26)		(-7.10)	
Asia-dummy			-9.0239	***	-9.0628	***
			(-5.88)		(-5.88)	
Africa-dummy			10.1350	***	10.1254	***
			(14.90)		(14.87)	
After98-dummy					-0.2070	
					(-0.28)	
adj.R squared	0.0985		0.1944		0.1941	

Notes:
1) Number of observations = 2297 (134 countries, 1980–2004, unbalanced panel). The sample includes developing countries only.
2) The method of estimation is pooled-OLS; t-statistics are in parentheses.
3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).
4) Africa-dummy takes on a value of 1 for African countries listed in the appendix.

(2) $Export_{i,t}/GNI_{i,t}$ = d_1 ($Foreign\ Reserve_{i,t}/\ GNI_{i,t}$) + $d_2 \cdot\ log\ GNI_{i,t}$,

Regression	1		2		3		4	
Constant	57.7109	***	72.2412	***	73.3367	***	74.5535	***
	(28.37)		(32.45)		(33.24)		(34.46)	
R/GNI	0.6687	***	0.6031	***	0.5441	***	0.4822	***
	(18.02)		(16.72)		(14.89)		(13.28)	
log(GNI)	-3.0394	***	-4.2169	***	-4.5163	***	-4.5371	***
	(-13.80)		(-18.17)		(-19.38)		(-19.89)	
Asia-dummy			11.9238	***	13.2619	***	-17.0032	***
			(5.77)		(6.47)		(-4.69)	
Africa-dummy			-10.8637	***	-10.5310	***	-10.7252	***
			(-11.86)		(-11.62)		(-12.08)	
After98-dummy					7.1217	***	6.3296	***
					(7.33)		(6.63)	
Asia*(R/GNI)							1.8677	***
							(10.02)	
adj.R squared	0.1928		0.2534		0.2702		0.3005	

Notes:

1) Number of observations = 2297 (134 countries, 1980–2004, unbalanced panel). The sample includes developing countries only.
2) The method of estimation is pooled-OLS; t-statistics are in parentheses.
3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).
4) Africa-dummy takes on a value of 1 for African countries listed in the appendix.

(3) $Investment_{j,t}/GDP_{j,t}$ = constant term + e_1 ($Foreign\ Reserve_{j,t}/\ GNI_{j,t}$) + $e_2 \cdot\ log\ GNI_{j,t}$,

Regression	1		2		3		4	
Constant	3.8187	***	9.7789	***	3.6617	***	9.6381	***
	(6.14)		(14.93)		(5.89)		(14.71)	
R/GNI	0.1423	***	0.1127	***	0.1511	***	0.1203	***
	(12.55)		(10.63)		(13.04)		(11.09)	
log(GNI)	0.7476	***	0.2035	***	0.7889	***	0.2420	***
	(11.11)		(2.98)		(11.57)		(3.50)	
Asia-dummy			8.2814	***			8.1094	***
			(13.63)				(13.32)	
Africa-dummy			-3.4497	***			-3.4925	***
			(-12.81)				(-12.97)	
After98-dummy					-1.0852	***	-0.9155	***
					(-3.50)		(-3.17)	
adj.R squared	0.1022		0.2307		0.1066		0.2337	

Notes:

1) Number of observations = 2297 (134 countries, 1980–2004, unbalanced panel). The sample includes developing countries only.

2) The method of estimation is pooled-OLS; t-statistics are in parentheses.

3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).

4) Africa-dummy takes on a value of 1 for African countries listed in the appendix.

(4) $\Delta GDP_{j,t}/GDP_{j,t}$ = constant term + f_1 ($Foreign\ Reserve_{j,t}/\ GNI_{j,t}$) + $f_2 \cdot\ log\ GNI_{j,t}$,

Regression	1		2		3		4	
Constant	-0.8413		0.5695		-0.8428		0.5825	
	(-1.41)		(0.84)		(-1.41)		(0.86)	
R/GNI	0.0422	***	0.0347	***	0.0422	***	0.0341	***
	(3.83)		(3.13)		(3.76)		(3.01)	
log(GNI)	0.1884	***	0.0485		0.1888	***	0.0455	
	(2.91)		(0.68)		(2.87)		(0.63)	
Asia-dummy	(0.00)		2.4535	***			2.4632	***
	(0.00)		(3.94)				(3.95)	
Africa-dummy			-0.6193	**			-0.6194	**
			(-2.19)				(-2.19)	
After98-dummy			(0.00)		-0.0118		0.0771	
			(0.00)		(-0.04)		(0.24)	
adj.R squared	0.0037		0.0057		0.0113		0.0132	

Notes:

1) Number of observations = 2411 (134 countries and 25 periods, unbalanced panel). The sample includes developing countries only.

2) The method of estimation is pooled-OLS; t-statistics are in parentheses.

3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).

5. ROBUSTNESS CHECKS

5.1 The impact of a change in foreign exchange reserves

The purpose of this sub-section is to estimate equations (18), (19), (20), and (21) with the change in foreign exchange reserves as an additional explanatory variable, to distinguish temporary and persistent impacts of foreign exchange reserve accumulation. The resource constraint suggests that a change in foreign exchange reserves, rather than the level of foreign exchange reserves, will have a dominant impact on consumption, investment, and aggregate output. The impacts of a temporary change will be reflected in the coefficient of the change in foreign exchange reserves, while the impacts of a permanent change will be reflected in the coefficient of the level of foreign exchange reserves. Comparing the coefficients will reveal how different the temporary and the persistent impacts are.

Tables 3-(1), 3-(2), 3-(3), and 3-(4) report the results of our regressions with and without the post-crisis dummy. Even after including the change in foreign exchange reserves, the coefficients of the level of foreign exchange reserves take the same signs and remain statistically significant in all cases. However, the coefficients of the change in foreign exchange reserves either become statistically insignificant or take different signs.

Table 3: The Impacts when Including ΔR as an Independent Variable

(1) dependent variable = $Consumption_{i,t}/GNI_{i,t}$

Regression	1		2		3	
Constant	95.6744	***	82.7426	***	82.7106	***
	(62.23)		(50.02)		(49.87)	
R/GNI	-0.2554	***	-0.1974	***	-0.1957	***
	(-8.94)		(-7.24)		(-7.01)	
△R/GNI	0.0282		0.0141		0.0148	
	(0.32)		(0.17)		(0.17)	
log(GNI)	-2.2704	***	-1.2514	***	-1.2425	***
	(-13.64)		(-7.26)		(-7.10)	
Asia-dummy			-9.0242	***	-9.0638	***
			(-5.88)		(-5.88)	
Africa-dummy			10.1338	***	10.1239	***
			(14.90)		(14.86)	
After98-dummy					-0.2107	
					(-0.29)	
adj.R squared	0.0981		0.1941		0.1937	

Notes:

1) Number of observations = 2297 (134 countries, 1980–2004, unbalanced panel). The sample includes developing countries only.

2) The method of estimation is pooled-OLS; t-statistics are in parentheses.

3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).

4) Africa-dummy takes on a value of 1 for African countries listed in the appendix.

(2) dependent variable = $Export_{i,t}/GNI_{i,t}$,

Regression	1		2		3		4	
Constant	57.7797	***	72.3313	***	73.4087	***	74.6030	***
	(28.40)		(32.48)		(33.27)		(34.47)	
R/GNI	0.6592	***	0.5926	***	0.5354	***	0.4759	***
	(17.44)		(16.14)		(14.41)		(12.91)	
△R/GNI	0.1573		0.1724		0.1488		0.1109	
	(1.33)		(1.51)		(1.32)		(1.01)	
log(GNI)	-3.0409	***	-4.2194	***	-4.5169	***	-4.5375	***
	(-13.81)		(-18.19)		(-19.38)		(-19.89)	
Asia-dummy			11.9202	***	13.2518	***	-16.9062	***
			(5.77)		(6.46)		(-4.66)	
Africa-dummy			-10.8793	***	-10.5462	***	-10.7359	***
			(-11.88)		(-11.63)		(-12.09)	
After98-dummy					7.0846	***	6.3047	***
					(7.29)		(6.60)	
Asia*(R/GNI)							1.8612	***
							(9.98)	
adj.R squared	0.1930		0.2538		0.2704		0.3005	

Notes:

1) Number of observations = 2297 (134 countries, 1980–2004, unbalanced panel). The sample includes developing countries only.

2) The method of estimation is pooled-OLS; t-statistics are in parentheses.

3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).

4) Africa-dummy takes on a value of 1 for African countries listed in the appendix.

(3) dependent variable = $Investment_{j,t}/GDP_{j,t}$,

Regression	1		2		3		4	
Constant	3.7253	***	9.6699	***	3.5771	***	9.5385	***
	(6.04)		(14.88)		(5.79)		(14.67)	
R/GNI	0.1553	***	0.1255	***	0.1634	***	0.1325	***
	(13.54)		(11.71)		(13.97)		(12.11)	
△R/GNI	-0.2134	***	-0.2087	***	-0.2100	***	-0.2058	***
	(-5.94)		(-6.28)		(-5.86)		(-6.20)	
log(GNI)	0.7496	***	0.2066	***	0.7889	***	0.2428	***
	(11.22)		(3.05)		(11.66)		(3.54)	
Asia-dummy			8.2858	***			8.1234	***
			(13.75)				(13.45)	
Africa-dummy			-3.4308	***			-3.4715	***
			(-12.84)				(-13.00)	
After98-dummy					-1.0344	***	-0.8642	***
					(-3.36)		(-3.02)	
adj.R squared	0.1155		0.2434		0.1194		0.2460	

Notes:

1) Number of observations = 2297 (134 countries, 1980–2004, unbalanced panel). The sample includes developing countries only.
2) The method of estimation is pooled-OLS; t-statistics are in parentheses.
3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).
4) Africa-dummy takes on a value of 1 for African countries listed in the appendix.

(4) dependent variable = $\Delta GDP_{j,t}/GDP_{j,t}$,

Regression	1		2		3		4	
Constant	-0.8701		0.5297		-0.8698		0.5450	
	(-1.46)		(0.78)		(-1.45)		(0.80)	
R/GNI	0.0461	***	0.0386	***	0.0461	***	0.0379	***
	(4.12)		(3.43)		(4.04)		(3.30)	
△R/GNI	-0.0695	*	-0.0687	*	-0.0695	*	-0.0689	*
	(-1.96)		(-1.95)		(-1.96)		(-1.95)	
log(GNI)	0.1886	***	0.0490		0.1885	***	0.0455	
	(2.91)		(0.69)		(2.87)		(0.63)	
Asia-dummy			2.4694	***			2.4810	***
			(3.97)				(3.98)	
Africa-dummy			-0.6031	**			-0.6032	**
			(-2.14)				(-2.14)	
After98-dummy					0.0023		0.0916	
					(0.01)		(0.29)	
adj.R squared	0.0105		0.0201		0.0100		0.0197	

Notes:

1) Number of observations = 2108 (134 countries, 1980–2004, unbalanced panel). The sample includes developing countries only.
2) The method of estimation is pooled-OLS; t-statistics are in parentheses.
3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).
4) Africa-dummy takes on a value of 1 for African countries listed in the appendix.
5) Dependent variable is growth rate of real GDP per capita (variable "grgdpch" of PWT 6.2).

The change in foreign exchange reserves is positively correlated with consumption in Table 3-(1) and with the export ratio in Table 3-(2). However, neither of the correlations is statistically significant. The short-run impacts of increased foreign exchange reserve on consumption and export share are, if any, very small. In contrast, the change in foreign exchange reserves is negatively correlated with investment and GDP growth rates in Tables 3-(3) and 3-(4). The correlations are statistically significant but take opposite signs. This implies that increased foreign exchange reserves may reduce investment and GDP growth rates in the short-run, but increase them in the long-run.

When increased foreign reserves are persistent, consumption declines along with a fall in permanent income. But when increased foreign reserves are temporary, consumption does not decline, because of the permanent income hypothesis. Temporary increases in foreign exchange reserves therefore reduce domestic savings and have a negative impact on domestic investment and economic growth. Since the main purpose of our analysis is to explore the long-run impacts of exogenous accumulation in foreign exchange reserves on various macroeconomic variables, the impacts of temporary increases in foreign exchange reserves are not our main concern. However, it is in itself noteworthy that the accumulation of foreign exchange reserves may have different impacts in the short-run.

It is also noteworthy that the inclusion of the change of foreign exchange reserves might be useful in avoiding possible simultaneous bias in the coefficient of the level of foreign exchange reserves. Foreign exchange reserves may respond endogenously to several macroeconomic shocks. However, the response will only be reflected in the change in foreign exchange reserves. Reverse causality from the dependent variables to the level of foreign exchange reserves will be less likely when we include both the level of foreign exchange reserves and the change in foreign exchange reserves in the estimations.

5.2 Impacts through the current account surplus

Thus far, our empirical analysis has not investigated the impacts of foreign exchange reserve accumulation on the current account surplus. This is because we have focused on the long-run, where the current account will be balanced. To the extent that the rate of time preference is equal to world interest rate, the current account needs to be balanced in the long-run, where real exchange rates are fully adjusted. However, our sample period may not be long enough to smooth out short-run impacts. In the short-run, aggressive intervention could maintain competitiveness of the tradable sector and manifest itself in the massive accumulation of foreign exchange reserves by the central bank. One may argue that an increase in foreign exchange reserves improves the current account, and consequently has a positive impact on investment and aggregate output in our sample period.

The purpose of this sub-section is to estimate equations (18), (19), and (21) with the current account surplus as an additional explanatory variable, to isolate the impacts of foreign exchange reserve accumulation on the current account surplus in our regressions. Tables 4-(1), 4-(2), and 4-(3) report the results of our regressions with and without the post-crisis dummy. The current account surplus has a significantly positive impact on consumption, but has significantly negative impacts on investment and economic growth. The current account surplus may benefit consumption, but it may not enhance investment and economic growth in our long-run data.

More importantly, even after including the current account surplus, the coefficients of the level of foreign exchange reserves still take the same signs and remain statistically significant in all cases. Neglecting the impacts through current account surplus is not essential in discussing our main results in our long-run data set.

Table 4: The Impacts through the Current Account Surplus

(1) dependent variable = $Consumption_{i,t}/GNI_{i,t}$

Regression	1		2		3	
Constant	93.4117	***	80.5921	***	81.0855	***
	(42.51)		(34.21)		(34.04)	
R/GNI	-0.1431	***	-0.1266	***	-0.1328	***
	(-5.10)		(-4.66)		(-4.83)	
△R/GNI	0.0013		-0.0065		-0.0099	
	(0.02)		(-0.08)		(-0.13)	
log(GNI)	-1.6558	***	-0.6998	***	-0.7628	***
	(-8.39)		(-3.36)		(-3.58)	
CA/GNI	0.8510	***	0.7861	***	0.7879	***
	(12.56)		(11.92)		(11.94)	
Export/GNI	-1.0001	***	-0.9188	***	-0.9204	***
	(-17.98)		(-16.87)		(-16.90)	
Import/GNI	0.8138	***	0.7824	***	0.7806	***
	(14.06)		(13.89)		(13.85)	
Asia-dummy			-8.3645	***	-8.1390	***
			(-5.80)		(-5.61)	
Africa-dummy			7.1984	***	7.2077	***
			(10.98)		(11.00)	
After98-dummy					0.9580	
					(1.39)	
adj.R squared	0.2552		0.3041		0.3044	

Notes:

1) Number of observations = 2297 (134 countries, 1980–2004, unbalanced panel). The sample includes developing countries only.

2) The method of estimation is pooled-OLS; t-statistics are in parentheses.

3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).

4) Africa-dummy takes on a value of 1 for African countries listed in the appendix.

(2) dependent variable = $Investment_{i,t}/GDP_{i,t}$,

Regression	1		2		3		4	
Constant	-5.5362	***	1.6163	*	-6.2786	***	0.8956	
	(-6.08)		(1.71)		(-6.89)		(0.94)	
R/GNI	0.1402	***	0.1293	***	0.1513	***	0.1384	***
	(12.07)		(11.85)		(12.97)		(12.58)	
△R/GNI	-0.1707	***	-0.1668	***	-0.1644	***	-0.1618	***
	(-5.03)		(-5.24)		(-4.88)		(-5.11)	
log(GNI)	1.3842	***	0.7912	***	1.4819	***	0.8833	***
	(16.93)		(9.45)		(17.92)		(10.37)	
CA/GNI	-0.1835	***	-0.1651	***	-0.1878	***	-0.1677	***
	(-6.54)		(-6.23)		(-6.75)		(-6.36)	
Export/GNI	0.0218		-0.0059		0.0255		-0.0036	
	(0.95)		(-0.27)		(1.12)		(-0.17)	
Import/GNI	0.0440	*	0.0447	**	0.0460	*	0.0473	**
	(1.84)		(1.97)		(1.93)		(2.10)	
Asia-dummy			7.5720	***			7.2426	***
			(13.07)				(12.49)	
Africa-dummy			-2.9392	***			-2.9529	***
			(-11.16)				(-11.27)	
After98-dummy					-1.7735	***	-1.3993	***
					(-6.10)		(-5.08)	
adj.R squared	0.2227		0.3163		0.2348		0.3237	

Notes:

1) Number of observations = 2297 (134 countries, 1980–2004, unbalanced panel). The sample includes developing countries only.

2) The method of estimation is pooled-OLS; t-statistics are in parentheses.

3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).

4) Africa-dummy takes on a value of 1 for African countries listed in the appendix.

(3) dependent variable = $\Delta GDP_{j,t}/GDP_{j,t}$,

Regression	1		2		3		4	
Constant	-3.5278	***	-1.9842	*	-3.5896	***	-2.0269	*
	(-3.70)		(-1.88)		(-3.75)		(-1.90)	
R/GNI	0.0366	***	0.0341	***	0.0379	***	0.0348	***
	(3.06)		(2.85)		(3.12)		(2.86)	
△R/GNI	-0.0578		-0.0578		-0.0571		-0.0574	
	(-1.63)		(-1.63)		(-1.61)		(-1.62)	
log(GNI)	0.3592	***	0.2170	**	0.3684	***	0.2226	**
	(4.20)		(2.31)		(4.25)		(2.33)	
CA/GNI	-0.0640	**	-0.0651	**	-0.0649	**	-0.0656	**
	(-2.19)		(-2.22)		(-2.22)		(-2.23)	
Export/GNI	0.0339		0.0326		0.0346		0.0330	
	(1.41)		(1.34)		(1.44)		(1.36)	
Import/GNI	-0.0069		-0.0116		-0.0072		-0.0117	
	(-0.28)		(-0.46)		(-0.29)		(-0.47)	
Asia-dummy			2.1291	***			2.1120	***
			(3.38)				(3.34)	
Africa-dummy			-0.3510				-0.3478	
			(-1.21)				(-1.20)	
After98-dummy					-0.2131		-0.1030	
					(-0.66)		(-0.32)	
adj.R squared	0.0231		0.0285		0.0228		0.0281	

Notes:

1) Number of observations = 2108 (134 countries, 1980–2004, unbalanced panel). The sample includes developing countries only.

2) The method of estimation is pooled-OLS; t-statistics are in parentheses.

3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).

4) Africa-dummy takes on a value of 1 for African countries listed in the appendix.

5) Dependent variable is growth rate of real GDP per capita (variable "rgdpch" of PWT 6.2).

5.3 Neoclassical growth regression

In our basic regression, we found that foreign exchange reserves are positively correlated with GDP growth rate. The regression is, however, not standard in literature. Following seminal papers by Barro (1991) and Mankiw, Romer, and Weil (1992), a number of studies have confirmed that the rate of economic growth is well explained by the initial income level, the investment rate, and other auxiliary variables. The purpose of this sub-section is to examine how robust our results are when we follow the traditional growth literature. We estimate the following equation:

(22) $\Delta GDP_{j,t}/GDP_{j,t} = g_1$ (*initial* $GDP_{j,t}$) + g_2 (*Investment*$_{j,t}/GDP_{j,t}$) + g_3· (*Foreign Reserve*$_{j,t}/GNI_{j,t}$).

We estimate equation (22) with and without the investment rate as an explanatory variable. Table 5 summarizes the estimation results. When we estimate (22) without the investment rate, foreign exchange reserves still have a significantly positive correlation with GDP growth rate. However, this is no longer the case when we add the investment rate as an explanatory variable. This implies that once we add the investment rate as an explanatory variable, foreign exchange reserve accumulation is irrelevant for the economic growth rate. In other

words, foreign exchange reserve accumulation can enhance economic growth rate, but only by enhancing investment.

Table 5: The Impacts in Neoclassical Growth Regressions

$\Delta GDP_{i,t}/GDP_{i,t}$ = constant term + f_1 (*Foreign Reserve*$_{i,t}$/ $GNI_{i,t}$) + f_2· *log* $GNI_{i,t}$,

Regression	1		2		3		4		3		4	
Constant	0.6187	***	0.9849	***	0.9035	***	-0.2345		0.2774		0.1704	
	(2.62)		(3.11)		(2.79)		(-0.78)		(0.70)		(0.42)	
R/GNI	0.0244	**	0.0222	*	0.0192	*	0.0136		0.0153		0.0118	
	(2.14)		(1.96)		(1.65)		(1.18)		(1.32)		(0.99)	
△R/GNI	-0.0495		-0.0522		-0.0528		-0.0346		-0.0409		-0.0413	
	(-1.40)		(-1.49)		(-1.50)		(-0.98)		(-1.16)		(-1.17)	
GDP per capita	0.1864	***	0.1662	***	0.1706	***	0.1612	***	0.1546	***	0.1592	***
	(7.33)		(6.46)		(6.58)		(6.22)		(5.95)		(6.08)	
Initial GDP per capita	-0.1380	***	-0.1304	***	-0.1335	***	-0.1266	***	-0.1248	***	-0.1280	***
	(-6.92)		(-6.43)		(-6.54)		(-6.34)		(-6.14)		(-6.26)	
Investment share							0.0972	***	0.0682	***	0.0698	***
							(4.58)		(2.91)		(2.98)	
Asia-dummy			1.9815	***	1.9749	***			1.3815	**	1.3602	**
			(3.33)		(3.32)				(2.20)		(2.16)	
Africa-dummy			-0.6740	**	-0.6568	**			-0.4730		-0.4492	
			(-2.23)		(-2.17)				(-1.53)		(-1.45)	
After98-dummy					0.4010						0.4455	
					(1.28)						(1.42)	
adj.R squared	0.0311		0.0397		0.0400		0.0402		0.0431		0.0436	

Notes:

1) Number of observations = 2108 (134 countries, 1980–2004, unbalanced panel). The sample includes developing countries only.

2) The method of estimation is pooled-OLS; t-statistics are in parentheses.

3) Asia-dummy takes on a value of 1 for 5 Asian countries (PRC, Indonesia, Malaysia, Philippines, and Thailand).

4) Africa-dummy takes on a value of 1 for African countries listed in the appendix.

5) Dependent variable is growth rate of real GDP per capita (variable "grgdpch" of PWT 6.2).

6) GDP per capita is relative to the U.S. (variable "y" of PWT 6.2).

6. CONCLUDING REMARKS

The recent accumulation in foreign exchange reserves has reached record-breaking levels in many developing countries. This paper investigated the long-run macroeconomic impacts of this trend in developing countries. In the first part of the paper, we analyzed a simple open economy model where increased foreign exchange reserves reduce the costs of liquidity risk. An increase in foreign exchange reserves raises both liquid and total debt, while shortening debt maturity. It also leads to a decline in consumption, although investment and economic growth may improve when the tradable sector is capital intensive. In the second part of the paper, we attempted to provide empirical support for our theoretical analysis.

During the last decade, financial globalization has been accompanied by frequent and painful financial crises. During these crises, countries with smaller liquid foreign assets had difficulty averting panic in financial markets and preventing sudden reversals in capital flows.

Many developing countries thus came to recognize increased liquidity as an important form of self-protection against crises. Raising foreign exchange reserves was a popular strategy adopted by many developing countries. However, the accumulation of foreign exchange reserves is accompanied by considerable social costs. It is therefore important to reconsider the optimal level of foreign exchange reserve accumulation in developing countries.

APPENDIX: LIST OF SAMPLED COUNTRIES

Africa	Asia	Europe	Middle East	Western Hemisphere
Algeria	Bangladesh	Albania	Egypt	Argentina
Angola	Bhutan	Armenia	Iran	Barbados
Benin	Cambodia	Azerbaijan	Jordan	Belize
Botswana	Fiji	Belarus	Lebanon	Bolivia
Burkina Faso	India	Bosnia and Herzegovina	Oman	Brazil
Burundi	Indonesia	Bulgaria	Syria	Chile
Cameroon	Lao PDR	Croatia	Yemen	Colombia
Cape Verde	Mongolia	Czech Republic		Costa Rica
Central African Republic	Nepal	Estonia		Dominica
Chad	Pakistan	Georgia		Dominican Republic
Comoros	Papua New Guinea	Hungary		Ecuador
Congo, Dem. Rep.	People's Republic of China (PRC)	Kazakhstan		El Salvador
Congo, Republic of	Philippines	Kyrgyzstan		Grenada
Cote d`Ivoire	Samoa	Latvia		Guatemala
Djibouti	Solomon Islands	Lithuania		Guyana
Equatorial Guinea	Sri Lanka	Macedonia		Haiti
Eritrea	Thailand	Malaysia		Honduras
Ethiopia	Tonga	Maldives		Jamaica
Gabon	Vanuatu	Moldova		Mexico
Gambia, The	Viet Nam	Poland		Nicaragua
Ghana		Romania		Panama
Guinea		Russia		Paraguay
Guinea-Bissau		Serbia and Montenegro		Peru
Kenya		Slovak Republic		St. Kitts & Nevis
Lesotho		Tajikistan		St. Lucia
Liberia		Turkey		St.Vincent & Grenadines
Madagascar		Ukraine		Trinidad &Tobago
Malawi		Uzbekistan		Uruguay
Mali				Venezuela
Mauritania				
Mauritius				
Morocco				
Mozambique				
Niger				
Nigeria				
Rwanda				
Sao Tome and Principe				
Senegal				
Seychelles				
Sierra Leone				
Somalia				
South Africa				
Sudan				
Swaziland				
Tanzania				
Togo				
Tunisia				
Uganda				
Zambia				
Zimbabwe				

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