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**Abstract**

Although emerging market Asian economies have experienced high growth without crises for close to a decade, many commentators find the large buildup of foreign exchange reserves among these economies both puzzling and evidence of incipient global imbalances. This paper reviews some of the experience of Asian countries over the last decade. We focus on the degree to which Asian economies have experienced financial globalization, meaning that their gross external asset and liability positions have grown significantly. In particular, while Asian economies have become significant gross creditors in bonds and other fixed income assets, their liability position in equity and FDI assets has also grown significantly. We show that a simple dynamic general equilibrium model of portfolio choice in an emerging market economy can account for this trend remarkably well.

**Keywords:** Asia; Financial Globalization; FDI; Foreign Exchange Rate Reserves
**JEL classification:** E52, E58, F41

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# 1 Introduction

Since the crises of the late 1990's, the major emerging Asian economies have experienced close to a decade of uninterrupted growth. Capital flows from industrial countries in the form of FDI as well as portfolio and bond investment have been strong, while on aggregate, Asian countries have been generating strong current account surpluses with the rest of the world. . Sovereign spreads have been low by historic standards for a number of years. In addition, these countries have to a significant extent eliminated their financial vulnerabilities displayed so clearly during the crisis years by correcting the currency and maturity mismatches in their national balance sheets. Some countries have abandoned tight exchange rate pegs and moved towards flexible inflation targeting. More generally, the quality of policy-making in the fiscal and financial domain has improved greatly.

There is no single explanation for this positive trend among Asian emerging market economies. High global saving has led to a prolonged period of low real interest rates, reducing the potential for crises. The buildup of strong positive net external positions as well as large stocks of foreign exchange rate reserves has had the same effect, and more generally has instilled a strong confidence in the investment potential of these countries. But in addition, real economic growth has been stimulated by high demand for exports from the industrial world (in particular the US), and commodity prices booms have generated huge net gains for many emerging countries.

One general feature of emerging economies recent experience that differs from previous episodes of high capital inflows and economic growth is the degree to which they have been participants in the globalization of financial markets. Rather than simply being recipients of net capital inflows or outflows, many emerging countries have displayed growth in gross external financial assets and liabilities that are much larger than net positions. In this sense, their experience mirrors that of many advanced economies, as documented in the seminal work of Lane and Milesi Ferretti (2001, 2005, 2006). Although recent discussion of global imbalances has mostly concentrated on the size of net external surpluses of China and other emerging economies, reflecting the apparently perverse situation of capital outflows from the developing world to developed economies (or more accurately, the US), in the background there is a large degree of two way capital flow. Emerging economies have been accumulating large stocks of US treasury bills going into official reserve and other fixed income assets, but they have also been receiving large inflows of FDI and portfolio

equity investment, as well as private bond market inflows. Lane and Milesi Ferretti (2006) document this turnaround on the portfolio position of emerging market economies taken as a whole. From the situation in the mid 1990's, where many of these economies were substantial net debtors in non-contingent assets such as bank loans and short term US dollar bonds, now they have substantial net positive positions in fixed income assets, while being on the whole net debtors in FDI and portfolio equity investment. There is an argument that this is in fact a much more efficient form of financing development lending for emerging market economies, in terms of achieving the most desired degree of international sharing risk.

This paper investigates the impact of financial globalization in emerging market economies, paying particular attention to the determinants of country portfolio positions. We explore the factors underlying the determinants of an optimal risk-sharing portfolio for an emerging market economy that needs to attract investment capital, but experiences country specific macroeconomic risk. This loosely approximates the positions of the fast-growing Asian exporting economies. The question is, how should investment be financed? One possibility is for these countries to borrow substantially in the form of non-contingent foreign bank loans, or international bond markets in order to finance their own investment. In the mid 1990's, this could roughly describe the financing patterns of many emerging economies. Another option however is to accept FDI and equity investment. As we noted, this is becoming more the norm for emerging economies in recent years. In our analysis, we interpret this financing choice as an implication of financial globalization. In an environment where emerging market economies can avail of a more enhanced menu of international asset markets, an optimal financing pattern is to accept inflows of FDI and portfolio investment, but balance this with outflows of investment in fixed income, non-contingent assets. This offers one way to interpret the build-up of international reserve assets on the part of emerging economies.

Our analysis is built around a dynamic stochastic general equilibrium model of the interaction between an emerging market economy and the rest of the world. We follow Devereux and Saito (2007) in constructing a stochastic continuous time framework with incomplete markets [1]. Our results indicate that financial globalization, wherein an

[1] There has been a rapid growth in the literature on incorporating portfolio dynamics in DSGE models. See Devereux and Sutherland (2006, 2007), Engel and Matsumoto, 2005, Evans and Hnaktkovska, 2005, and Tille and Van Wincoop, 2007, among other papers, for alternative approaches.

emerging market economy may simultaneously build up positive gross positions in non-contingent international bond assets, and negative positions in FDI and portfolio equity, offers both welfare benefits and a more stable form of financing than that available in the mid 1990's. In the model, the emerging economy holds nominal bonds of the advanced economy, while issuing FDI-equity claims which are held by the advanced economy. We interpret nominal bond holdings as a measure of foreign exchange reserves. The model delivers explicit solutions for the value of FDI, foreign exchange reserves, and total bond holdings in emerging market portfolios. The FDI position depends upon expected returns in the emerging market, as well as growth risk in both the advanced economy and the emerging market. Foreign exchange rate reserves depend on expected returns, and growth volatility in the emerging market, as well as in the advanced economy. In addition, foreign exchange rate reserve holdings are sensitive to the monetary policy followed by advanced economies. If the advanced economy follows a very stable volatility of monetary policy, this will significantly boost emerging market foreign exchange rate reserves. At the same time, a rise in the riskiness of the domestic income process in emerging markets will lead to an increase in foreign reserve holdings.

Although the model is extremely rudimentary, we argue that it can give a coherent account of the portfolio structure of emerging market Asian economies. The recent buildup in foreign exchange rate reserves in Asian countries can be rationalized as a response to observed movements in macroeconomic volatility in Asia and advanced industrial economies. In particular, a combination of a) higher volatility of GDP in Asian countries, b) a lower volatility of GDP in advanced economies, and c) a fall in the volatility of inflation in the US (more stable US dollar price level) all work together to increase foreign exchange rate reserve holdings in Asia. A simple calibration to the US China case leads to a remarkably close fit between model and data.

One qualification that should be noted is that the paper is not primarily focused on current account imbalances, or the size of net capital flows. Rather, we wish to explore the determinants of gross capital flows and the structure of the external portfolio positions for emerging market economies. Although our model does allow for current account imbalances, it can account for a trend in the current account only by allowing for trend differences in savings rates. To jointly account for the scale of global imbalances and the

shifting portfolio composition without arbitrary differences in savings propensities would require a more elaborate model than that developed here.

The paper is structured as follows. The next section discusses some recent features of Asian external imbalances and portfolio composition. Section 3 presents a review of recent literature on global imbalances and Asian reserve holdings. Section 4 develops the model and presents a simple quantitative analysis. Some conclusions follows.

# 2 Asian External Balance and Portfolio Structure

We focus on a subset of emerging market countries in Asia. The growing current account surpluses of Asian countries is to a large degree the counterpart to the US current account deficit. For many emerging Asian countries, these current account surpluses date back to the Asian crisis of the late 1990's. A large empirical and theoretical literature has attempted to provide an explanation for these surpluses.

Figure 1 describes the evolution of current account to GDP ratios for a number of Asian countries. All countries are currently in current account surplus, but this masks distinct differences in their historical record. The fast growing East Asian Tigers, Korea, Malaysia, Thailand, and to a lesser extent Taiwan, all experienced significant net capital inflows in the early 1990's, but were hit strongly by 'sudden stops' during the Asian crisis of 1997-98. Their current accounts swung sharply back into a surplus position. Indonesia had a similar experience. By contrast, China experienced net capital inflow only for one year in the 1990's. It was relatively immune to the direct effects of the Asian crisis. In fact its current account to GDP position deteriorated somewhat during this period. For the past five years however, all countries have experienced strong surpluses. In particular, China's current account surplus grew sharply in 2005 to nearly 7 percent of GDP.

Figure 2 breaks down the current account position into national saving and investment rates, relative to GDP. For Korea, Malaysia and Thailand, the current account improvement after the Asian crisis is substantially explained by a dramatic fall in investment, with a relatively stable savings rate. Taiwan started with a substantially lower savings and investment rate than the other Asian countries, but then had a surge in its savings and a fall in investment after the Asian crisis. For China, both investment and savings rates are quite stable in the late 1990's, but show a distinct increase after 2002.

The absolute savings rate in China is a remarkable 45 percent, but this is also true for Malaysia. The key difference between China and the other East Asian countries lies in the levels of investment. China has investment levels similar to those of the Asian Tigers in the mid-1990's - above 40 percent of GDP, while the latter countries have converged down to investment rates in the 20 to 30 percent of GDP range, comparable to those of the advanced economies. A similar pattern is shown in the comparative growth rates among countries (not shown). Growth rates in the Asian tiger economies fell sharply after 1997, but recovered quickly. Subsequent growth rates however were lower than those of the early 1990's, and in the range of the growth rates of the US in the recent past. By contrast, China's growth rate increased in the early 2000's to the 9-10 percent range.

Figure 3, based on the 'External Wealth of Nations' database of Lane and Milesi Ferretti (2006) (LMF). It shows the level of gross assets and gross liabilities to GDP, following the measurement adjustments made in LMF. For the period since 1990, all countries have been net debtors except for Taiwan, which is a substantial net creditor, although China's NFA also turned slightly positive in 2002. Net Foreign Assets for China and Korea is a relatively small share of GDP, while Malaysia and Thailand have higher net debt positions. Although valuation adjustment through equity prices and exchange rates in LMF break the direct link between the current account and NFA, all countries have exhibited an increase in NFA in the current decade.

Note that Figure 3 emphasizes that all the countries have substantial gross positions on each side. In particular, China and Korea, Malaysia, and Taiwan have experienced substantial 'financial globalization', in the sense that both gross assets and gross liabilities have approximately doubled, as a proportion of GDP, since the early 1990's. Indonesia and Thailand differ somewhat. They have had a substantial increase in the gross asset to GDP ratio in the current decade, but liabilities were substantially higher in the mid-1990's, well over 100 percent of GDP for both countries, and have come down considerably since then.

Figure 4 illustrate the composition of gross foreign assets and gross foreign liabilities between equity and debt instruments. Here, debt instruments include official reserve assets and portfolio debt. Equity includes FDI and portfolio equity. The Figure shows that on the asset side, for all countries, the biggest fraction is in debt instruments, with only a small portion in equity and FDI instruments. Figure 4 also highlights a less well

known aspect of recent portfolio behavior for Asian economies. The composition of gross external liabilities has switched strongly towards an increasing share of equity and FDI. For China, at the beginning of the sample, seventy percent of external liabilities were in debt instruments, and only 30 percent were in equity instruments. By the end of the sample, this proportion had been exactly reversed. Korea had an equally dramatic increase in the share of liabilities attributed to equity. A similar, though less strong turnaround is seen in Malaysia, Thailand, Indonesia and Taiwan.

Figure 5 shows that official reserves constitute a growing share of total assets in the current decade, rising to an astonishing 67 percent of total gross assets for China in 2004. This huge holding of low yielding assets (mostly in US dollar treasury bills), has led to an increasing debate in the economics literature over the last number of years.

# 3 Explaining Asian External Balances

Two strong features of the data come out of the previous section. First, and most prominantly, all Asian countries generated large current account surpluses following the Asian crisis, and these have persisted over the last 7 or 8 years. Secondly, most countries have also had substantial growth in both gross assets and liabilities, and had distinct changes in their national balance sheet composition, generating large stocks on foreign exchange rate reserves on the asset side, and a substantial growth in the share of equity and FDI on the liability side.

What explains the huge Asian surpluses in this decade? This question has generated a huge literature over the last few years. A number of alternative accounts have been presented. One view is that the persistent current account surpluses represent a form of hedging or precautionary saving against the possibility of future 'sudden stops', or abrupt cut-offs from access to capital markets. Caballero and Panageas (2005) develop a model of a small open economy subject to a risk of sudden stops, and examine the behavior of saving under a variety of alternative possibilities for hedging sudden stop risk. They note that saving is higher in an economy with the risk of sudden stops. Jeanne and Ranciere (2006) and Jeanne (2007) interpret the buildup in foreign exchange reserves in Asian economies as a form of collective insurance against sudden stops, where the public sector has an advantage in providing resources to smooth out the consumption effects of

sudden stops. Mendoza et al. (2007) develop a model of precautionary saving in response to non-insurable idiosyncratic income risk, and show that it can account for substantial foreign exchange reserve accumulation of the kind seen in the data. They argue that either financial liberalization or hedging against sudden stops can provide an explanation for the recent growth in emerging market market exchange rate reserves.

One problem with these theories of precautionary saving is that they all work on the savings side, and therefore do not provide an adequate explanation for one of the main features apparent in Figure 2; that a large part of the Asian current account expansion can be attributed to a fall in investment, rather than a rise in savings. As we noted, for Korea, Malaysia, and Thailand, current account surpluses were substantially driven by an investment collapse, with savings relatively unchanged. An alternative model of 'global imbalances', developed in Caballero et al. (2007), attributes the joint process of savings and investment in emerging markets as a result of the absence of financial markets by which savings may be converted into profitable assets. They argue that a key feature of emerging economies is an 'asset shortage'. Even though these economies may have high growth rates, real domestic returns may be low because of the absence of adequate instruments for saving, leading them to invest in advanced economies, which can offer a supply of assets unavailable in emerging markets. Caballero et al (2007) show that such financial distortions in emerging markets can explain why such countries could run current account surpluses with advanced economies. Moreover they show that the same financial distortions may lead to low rates of investment in emerging economies.

Relatively few commentators have focused on the nature of two-way capital flows between emerging markets and advanced economies. Dooley et al. (2007) argue that emerging market current account surpluses represent a collatoral payment for the risk of FDI in emerging markets, but do not offer an explicit model of this process. Wei and Ju (2007) argue that there is a 'by-pass' process of capital flows, whereby informational imperfections in financial markets in emerging economies make it desirable for residents to invest in advanced economies and then receive FDI from these economies. Neither of these papers however takes a general equilibrium portfolio approach, as is done here. We now turn to the explicit portfolio model.

# 4 A Portfolio Model of Reserve Accumulation

In this section we develop a simple dynamic portfolio model to determine the joint determination of optimal reserve holdings and FDI accumulation. The model is adapted from Devereux and Saito (2007). There is an advanced economy and an emerging market economy. There is a single world good, which can be consumed or invested by agents in each country. Two structural features differentiate the advanced economy (home) from the emerging market economy (foreign). In the advanced economy there is a single risky technology for producing output, while in the emerging economy (foreign) there are two risky technologies, which we could think of as a 'traditional' and a 'modern' sector. Investors in the home country can invest in the modern sector of the foreign country. We refer to this as FDI investment. The second key distinction between the two economies concerns the form of international traded assets. We assume that bonds denominated in the home country currency (e.g. the 'dollar') are traded between countries, but there is no trade in foreign currency denominated bonds. This captures the empirical feature world bond markets are still overwhelmingly dominated by a few major currency denominations, with the US dollar overwhelmingly still being the dominant acceptable denomination. In the model, foreign holdings of home currency bonds are defined as foreign exchange reserves of the foreign country. The equilibrium of the model may be used to illustrate the joint dynamics of home country FDI and foreign exchange reserve accumulation of the foreign country. The difference between the two determine the evolution of the foreign countries net foreign assets.

## 4.1 The Model

The model is explained in more detail in Devereux and Saito (2007), so we give just a very brief description here. In the home country there is a risky linear technology which uses capital and generates expected instantaneous return $\alpha_D$ with standard deviation $\sigma_D$. In the foreign country, there are two technologies; a traditional and a modern technology, with returns $\alpha_T$, $\alpha_M$ and standard deviations $\sigma_T$, $\sigma_M$ respectively. Capital can be turned into consumption without any cost. The return on the home technology (in terms of the homogeneous good) is given by:

$$\frac{dQ_i}{Q_i} = \alpha_D dt + \sigma_D dB, \tag{1}$$

where $dB$ is the increment to a standard Weiner process. For simplicity, we assume that the returns on all three technologies are independent, and that the covariances between $dB$, $dB_T^*$, and $dB_M^*$ are all zero.

International financial markets are incomplete. This is captured by the fact that foreign country residents cannot directly purchase shares in the technology of the home country, and home residents can only buy shares in the modern sector of the foreign country (FDI). Again, we don't explicitly endogenize this constraint, but we see it as reflecting the inability of residents of large emerging market countries such as China to directly invest in external equity markets. We do however allow for trade in the home currency nominal bond, and a real risk-free bond.

Nominal bonds are denominated in home currency by assumption. Although nominal bonds are risk-free in dollar terms, their real returns are subject to inflation risk. Home country inflation is modeled as follows

$$\frac{dP_i}{P_i} = \Pi dt + v dM.$$

Thus, inflation has mean $\Pi_i$ and standard deviation $v$. $dM$ represents the increment to a standard Weiner process. We assume that $dM$ and $dB$ have covariance given by the parameter $\lambda$, but $dB_T^*$ and $dB_M^*$ are independent of $dM$. Hence, $\lambda$ will be a critical parameter, capturing the way in which returns on nominal bonds co-vary with real returns on the home technology. If $\lambda < 0$, as most of our discussion below presumes, then real bond returns are pro-cyclical. We discuss the evidence for this assumption below.

Let the instantaneous nominal return on currency $i$ bonds be $\widehat{R}_i$. Then the real return on bond $i$ is

$$(R_i - \Pi_i)dt - v_i dM_i,$$

where $R_i = \widehat{R}_i + v_i^2$ is an adjusted nominal interest rate. This will be determined endogenously as part of the world bond market equilibrium.

The budget constraint for the home country may be written as:

$$\begin{aligned} dW &= W\left[\omega_D(\alpha_D - r) + \omega_N(R_h - \Pi_h - r) + \omega_M(\alpha_M - r) + r\right]dt \\ &\quad -Cdt + W\left(\omega_T \sigma_D dB - \omega_n v dM + \omega_M \sigma_M dB_M\right), \end{aligned} \tag{2}$$

where $W$ is home country wealth, and $\omega_D$, $\omega_N$, and $\omega_M$ are the portfolio shares, respectively, of the domestic technology, home currency nominal bonds, and FDI. Hence, $1 - \omega_D - \omega_N - \omega_M$ represents the share of the real risk-free bond.

The foreign country budget constraint is written symmetrically as

$$\begin{aligned} dW^* &= W^* \left[\omega_T^*(\alpha_T - r) + \omega_N^*(R_h - \Pi_h - r) + \omega_M^*(\alpha_M - r) + r\right] dt \\ &\quad -C^* dt + W^* \left(\omega_T^* \sigma_T dB_T - \omega_N^* v dM + \omega_M^* \sigma_M dB_M\right), \end{aligned} \tag{3}$$

Each country is populated by a continuum of identical agents with preferences given by:

$$E_0 \int_0^\infty \exp(-\rho t) \ln C_i(t) dt, \tag{4}$$

where $\rho$ is the rate of time preference.

## 4.2 Optimal Consumption and Portfolio Rules

With logarithmic utility, consumers follow the myopic consumption rule:

$$C = \rho W, \quad C^* = \rho W^*.$$

Optimal portfolio rules for the home country may be obtained as the solution to:

$$\begin{bmatrix} \omega_D \\ \omega_N \\ \omega_M \end{bmatrix} = \begin{bmatrix} \sigma_D^2 & -\lambda\sigma_D v & 0 \\ -\lambda\sigma_D v & v^2 & 0 \\ 0 & 0 & \sigma_M^2 \end{bmatrix}^{-1} \begin{bmatrix} \alpha_D - r \\ R - \Pi - r \\ \alpha_M - r \end{bmatrix} \tag{5}$$

For the foreign country, the equivalent conditions are:

$$\begin{bmatrix} \omega_T^* \\ \omega_M^* \\ \omega_N^* \end{bmatrix} = \begin{bmatrix} \sigma_T^2 & 0 & 0 \\ 0 & \sigma_M^2 & 0 \\ 0 & 0 & \nu^2 \end{bmatrix}^{-1} \begin{bmatrix} \alpha_T - r \\ R_h - \Pi - r \\ \alpha_M - r \end{bmatrix} \tag{6}$$

## 4.3 Asset Market Equilibrium

At any moment in time, an equilibrium in the market for nominal bonds determines the nominal rates of return $R_h$. The nominal bond market clearing condition requires that the sum of home and foreign demand for nominal home currency bonds is zero:

$$\omega_N W + \omega_N^* W^* = 0, \tag{7}$$

Note that the assumption here is that home currency nominal bonds are in zero world net supply. We could explicitly model a fiscal agency that issues home currency bonds, but this would have no impact on the equilibrium foreign holdings of these bonds.

We have also allowed for trade in a real, indexed bond, again in zero net world supply. The market clearing condition for the real bond is described as:

$$(\omega_D + \omega_N + \omega_M - 1)W + (\omega_T^* + \omega_N^* + \omega_M^* - 1)W^* = 0. \tag{8}$$

Using (5), these two conditions may be solved for $R$ and $r$. Define $\theta = \frac{W^*}{W^*+W}$ as the ratio of foreign wealth to world wealth. To simplify the presentation, we will assume for the rest of this section that $\alpha_T = \alpha_M$ and $\sigma_T = \sigma_M$. That is, the two sectors in the emerging market country have identical returns and volatilities. Then we can derive the solutions:

$$R(\theta) = Z(\theta)R_D + (1 - Z(\theta))R_M, \tag{9}$$

$$r(\theta) = H(\theta)r_D + (1 - H(\theta))r_M. \tag{10}$$

where $R_D = r_D + \frac{\sigma_D^2\lambda}{\sigma_D^2+\sigma_M^2}(\alpha_M - \alpha_D - \sigma_M^2) + \Pi$, $r_M = \alpha_M - \sigma_M^2$ ,$R_M = r_M + \Pi$, and $r_D = \frac{\sigma_M^2\alpha_D+\sigma_D^2\alpha_M-\sigma_D^2\sigma_M^2}{\sigma_D^2+\sigma_M^2}$. Here $R_D$ ($R_M$) denotes the equilibrium nominal return on home currency bonds when the home (foreign) country is arbitrarily wealthy, i.e. $\theta \to 1$ ($\theta \to 0$), and $Z(\theta)$ is a function of parameters and $\theta$ such that $Z(0) = 1$, and $Z(1) = 0$. Likewise, $r_D$ ($r_M$) denotes the equilibrium risk-free return when the home (foreign) country is arbitrarily wealthy, i.e. $\theta \to 1$ ($\theta \to 0$), where $H(\theta)$ is a function of parameters and $\theta$ such that $H(0) = 1$, and $H(1) = 0$.

Thus, solutions (9) and (10) indicate that the equilibrium world nominal and real rates of return are time-varying weighted averages of the rates of return that would hold were either country to become arbitrarily large, and the weights depend on the relative size of each country in world wealth. Note that $R_D$ is a function of both home and foreign technology parameters, because home country residents can invest directly in the foreign technogy, while $R_M$ depends only on the foreign technology. In addition, because home inflation is independent of foreign technology, $R_M$ is independent of $\lambda$ and $v$. On the other hand, for values of $\alpha_D \approx \alpha_M$ and $\lambda < 0$, we have $R_D > r_D$. This is because for $\lambda < 0$, the real return on the home currency bond covaries positively with the home portfolio.

In order for home agents to hold the home currency bond, it must pay a higher rate of return than $r_D$.

Using (9)-(10) in (5), we may derive the equilibrium portfolio holdings. Define $\Delta = \sigma_M^2(1-\theta) + \sigma_D^2(1+\theta)(1-\theta\lambda^2) > 0$. Then we can compute the equilibrium home country FDI holding as:

$$\widetilde{\omega}_D = \frac{(\alpha_M - \alpha_D)(1-\theta) + \sigma_D^2(1-\theta\lambda^2)}{\Delta}. \tag{11}$$

The FDI share of the portfolio is increasing in the return on the foreign modern sector, but decreasing in the volatility of this sector. FDI is also affected by the volatility of the home sector. When $\alpha_D \approx \alpha_M$, an increase in $\sigma_D^2$ increases FDI, but this may be reversed when $\alpha_M > \alpha_D$.

Using (9) and (10), we may also compute the share of reserves and risk-free bonds in the foreign country portfolio as:

$$\widetilde{\omega}_N^* = -\frac{\lambda\sigma_D}{v}\left[\frac{-(\alpha_M - \alpha_D)(1-\theta^2) + \sigma_M^2(1-\theta)}{\Delta}\right], \tag{12}$$

$$\widetilde{\omega}_R^* = -\widetilde{\omega}_N^* + (1-\theta)\left[\frac{2(\alpha_D - \alpha_M) + \sigma_M^2 - \sigma_D^2(1-\lambda^2\theta)}{\Delta}\right], \tag{13}$$

For $\alpha_D \approx \alpha_M$ and $\lambda < 0$, foreign exchange reserves are always positive, but holdings of risk-free real bonds may be positive or negative. The total holdings of bonds (the sum of risk-free bonds and nominal bonds) is positive when $\alpha_D \approx \alpha_M$ and $.\sigma_M^2 \approx \sigma_D^2$.

What determines demand for reserves? From (12), total reserve holdings are negatively related to the excess return on the foreign technology,$\alpha_M - \alpha_D$, and negatively related to the volatility of inflation in the home country, $v$. When $\alpha_D \approx \alpha_M$, demand for reserves is increasing in the volatility of the foreign technology, $\sigma_M^2$.

Note that both FDI, reserve holdings, and overall bond holdings will be time-varying, moving as the share of the foreign country in world wealth changes. The dynamics of $\theta$ are determined by variations in relative wealth levels, driven by the budget constraints (2) and (3) in combination with each country's saving and portfolio allocation decisions[2].

To illustrate this process, take the special case where $\alpha_D = \alpha_M$ and $\sigma_M^2 = \sigma_D^2$. Then

[2]Devereux and Saito (2007) discuss the conditions for the stability of the $\theta$ process.

FDI and reserves may be written as:

$$\widetilde{\omega}_D = \frac{(1-\theta\lambda^2)}{2-\theta\lambda^2(1+\theta)} > 0, \tag{14}$$

$$\widetilde{\omega}^*_N = -\frac{\lambda\sigma_D}{v}\left[\frac{(1-\theta)}{2-\theta\lambda^2(1+\theta)}\right] > 0. \tag{15}$$

In this case, equilibrium FDI holdings are independent of the return and volatility of technology risk in each country, and depend only on $\theta$ and $\lambda$. For a given value of $\theta$, FDI is declining in the absolute value of $\lambda$. This is because having a short position in home currency bonds allows some risk sharing for the home country, (when $\lambda < 0$) which acts as a substitute for investing in foreign FDI.

In the symmetric case of (14) and (15), total reserve holdings are higher, the greater is technology volatility. Reserves are increasing in (the absolute value of) $\lambda$. As $\lambda$ rises in absolute value, home currency bonds become a better hedging asset for the foreign country.

How do FDI and foreign exchange reserves depend on $\theta$? From (15), the relationship between $\theta$ and the FDI share is non-monotonic. For very low values of $\theta$, indicating that the home country is relatively wealthy, the foreign country has a high share in FDI, while when $\theta$ is in an intermediate range, this share is somewhat lower. Foreign exchange reserve holdings are negatively related to $\theta$. When the home country is very large, foreign exchange reserves are a large fraction of the foreign portfolio of the foreign country. These diminish as the foreign country wealth rises.

The foreign country has a gross asset position equal to $(\widetilde{\omega}^*_N + \widetilde{\omega}^*_R)\, W^*$, its total bond claims against the home country, and a gross liability position equal to $\widetilde{\omega}_D W$, the FDI holding of the home country. We can then define net foreign assets of the foreign country, relative to world wealth, as nfa$= (\widetilde{\omega}^*_N + \widetilde{\omega}^*_R)\theta - \widetilde{\omega}_D(1-\theta)$. Using the above solutions we obtain

$$\text{nfa} = (1-\theta)\frac{\left[(\alpha_D - \alpha_M) - \sigma_D^2(1-\lambda^2\theta)\right](1+\theta) + \sigma_M^2\theta}{\Delta}$$

This may be positive or negative. Net foreign assets are higher, the higher is the return on the home technology relative to the foreign technology, and the higher is the volatility of the foreign technology, but lower, the higher is the volatility of the foreign technology. Again, net foreign assets will be time-varying in response to movements in $\theta$.

Figure 6 illustrates the relationship between $\theta$ and net foreign assets of the foreign country. The dynamics of $\theta$ are driven by relative growth rates and the underlying technology shocks of the two countries. For a low $\theta$, the foreign country is relatively poor, and it is a net debtor, as the value of its FDI liabilities is large relative to its external bond holdings. As $\theta$ rises, this situation is reversed, as it builds up a large nominal and real bond claim on the rest of the world. As $\theta$ tends to unity, the foreign country would become dominant in the world economy, and its net foreign assets, relative to world wealth, would trend to zero[3].

## 4.4 Quantitative Assessment

For the general case, Table 1 provides a rough quantitative assessment of the size of FDI, foreign exchange rate reserve holdings, and total bond holdings implied by the model. For this calculation we use the following calibration, based partially on US data. Assume that the real risk-free rate of return on capital is 6 percent, approximately the long run return to equity in the US economy. The average real GDP growth rate of consumption since 1980 is approximately three percent, with a standard deviation of 1.7 percent. In a symmetric steady state, the real risk-free interest rate is $\alpha - \frac{\sigma}{2}^2$, and the expected consumption growth rate is $\alpha - \frac{\sigma}{2}^2 - \rho$. Setting $\sigma = 0.017$, $\alpha - \frac{\sigma}{2}^2 = 0.06$ and $\alpha - \frac{\sigma}{2}^2 - \rho = 0.03$ requires that $\alpha = 0.0601$ and $\rho = .0301$. The volatility of US inflation since 1980 is 1.3 percent, which guides our choice of $v = 0.013$. For the foreign country, we assume that $\alpha$ and $\rho$ are the same as the US, but we assume a more volatile GDP process, setting $\sigma_M, = 0.03$, to match China's GDP volatility over the 1980-2004 perdiod. In addition, we set $\theta = 0.5$ for the baseline case. Finally, a value of $\lambda = -0.6$ is used, following the estimate of Kydland and Prescott (1990). We then illustrate the models implications for alternative values of $\sigma_D^2$, $\sigma_M^2$, and $v$.

[3]The long run mean of $\theta$ will be determined by the underlying parameters and volatility of technologies and the inflation rate process.

Table 1 Assets and liabilities relative to GDP

| | FDI liabilities | Reserve Assets | Bonds Assets | NFA |
|---|---|---|---|---|
| Data | 0.33 | 0.37 | 0.39 | 0.08 |
| Baseline | 0.29 | 0.38 | 0.41 | 0.06 |
| High $\sigma_M$ | 0.21 | 0.47 | 0.59 | 0.19 |
| Low $v$ | 0.29 | 0.57 | 0.41 | 0.06 |
| Low $\sigma_D$ | 0.14 | 0.31 | 0.71 | 0.29 |

Table 1 measures the share of GDP held in each portfolio category. We compare this to the measured shares of equity and FDI liabilities, reserve assets, total bond assets, and net foreign assets for China in 2004, obtained from Lane and Milesi-Ferretti (2006). The baseline case in fact does a remarkably good job at matching the observed asset and liability positions of China. The implied reserve to GDP ratio is 38 percent, almost exactly that in the data, and the FDI-equity to GDP ratio is 29 percent, very close to the observed 33 percent in the data. The total bond assets-GDP ratio is 41 percent in the model, and 39 percent in the data, while the overall NFA in the model is 6 percent, slightly less than the 8 percent in the data.

Table 1 also reports the implications of a higher volatility of foreign technology, and a lower volatility of home country technology, as well as a lower volatility of home country inflation. An increase in $\sigma_M$ increases reserves, bond holdings, and NFA, while decreasing FDI holdings of the home country. Intuitively, a rise in $\sigma_M$ increases the demand for home country fixed income assets, reducing the rate of return $R$ and reducing the equilibrium FDI holdings of the home country. A fall in $v$ leads to a substitution out of real indexed bonds towards nominal bonds for the foreign country, while leaving FDI, overall bond holdings, and NFA unchanged. Finally, a fall in $\sigma_D$ leads to a fall in FDI, and a rise in reserves, real bond holdings, and NFA of the foreign country.

In summary, the model implies that a growth in reserve holdings of emerging market countries might be attributed to a) a rise in volatility of emerging markets, b) a fall in the volatility of inflation in advanced economies, or c) a fall in GDP volatility in advanced countries. In each case, there is a rise in reserve holdings of emerging economies, as well as a rise in the NFA position of these countries.

In summary, we may conclude that in terms of accounting for the qualitative and to some extent quantitative features of portfolio shares for emerging market economies, a

simple model driven by aggregate macroeconomic risk alone is reasonably successful.

# 5 Conclusions

Emerging market economies in Asia have experienced a remarkable episode of high and stable economic growth during the current decade. One view is that this stability is generated by these countries persistent current account surplus positions and the implicit 'hedging' potential that this provides against sudden stops. In this paper, we have emphasized a different mechanism, based on portfolio diversification principles and the growth of equity based financing of Asian investment. A simple portfolio allocation model can provide an interpretation of this phenomenon. A complete explation of gross and net capital flows in Asian economies however would combining this model with an account of the high savings rates in Asia. We leave this for future research.

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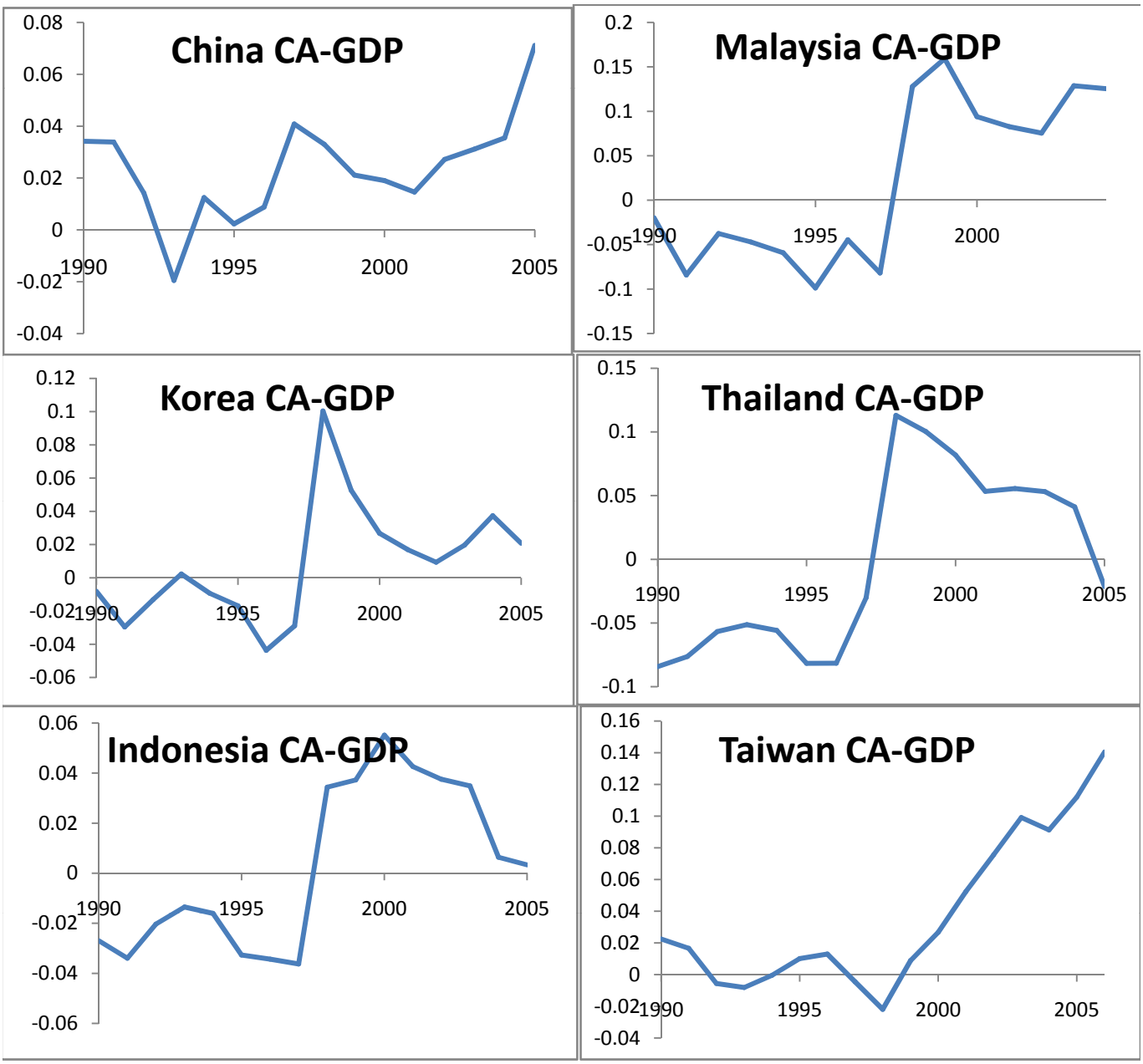
China CA-GDP
0.08
0.06
0.04
0.02
0
-0.02
-0.04
1990
1995
2000
2005
Malaysia CA-GDP
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
1990
1995
2000
Korea CA-GDP
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
1990
1995
2000
2005
Thailand CA-GDP
0.15
0.1
0.05
0
-0.05
-0.1
1990
1995
2000
2005
Indonesia CA-GDP
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
1990
1995
2000
2005
Taiwan CA-GDP
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
1990
1995
2000
2005

**FIGURE 1**

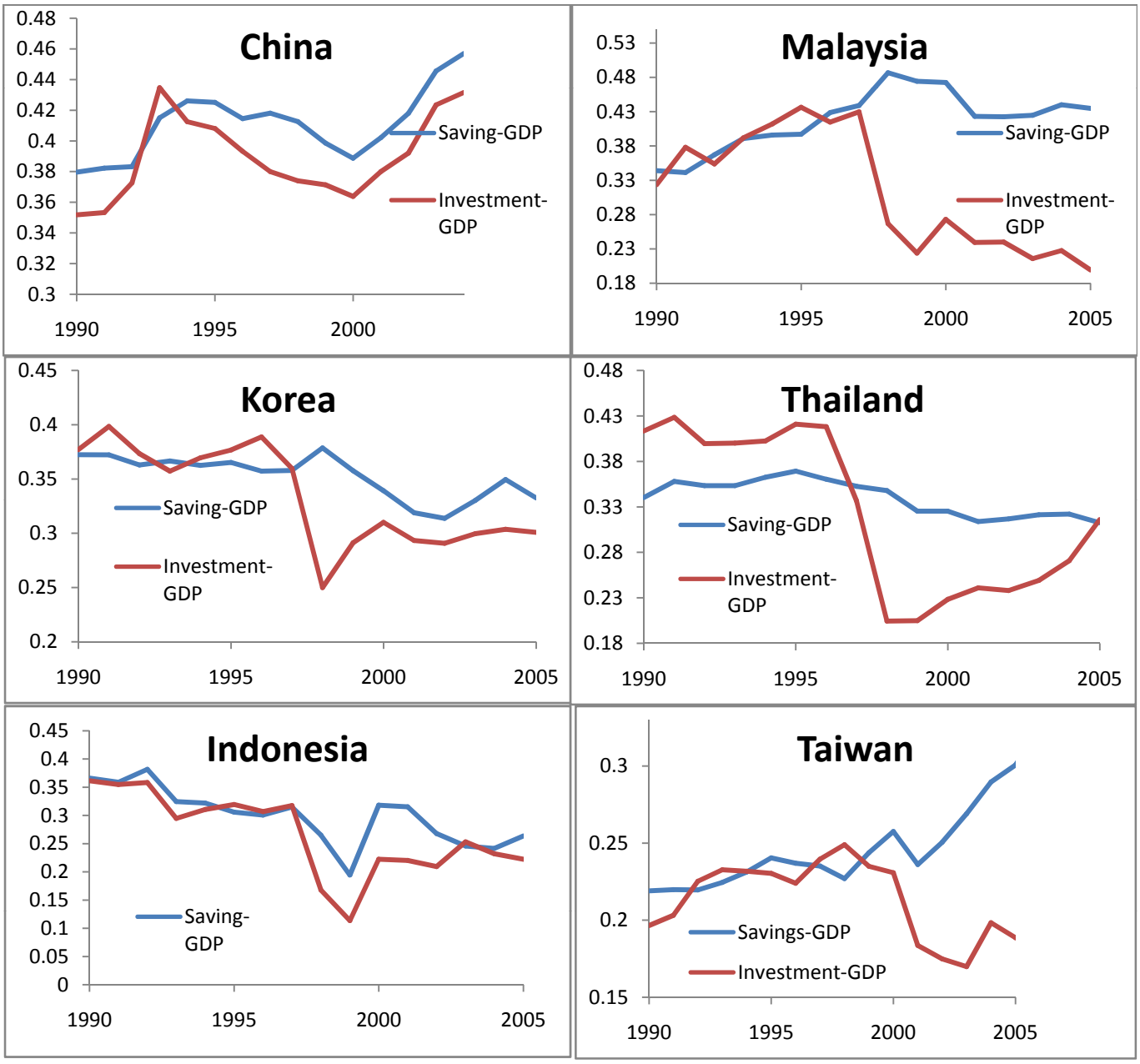
China
0.48
0.46
0.44
0.42
0.4
0.38
0.36
0.34
0.32
0.3
1990
1995
2000
Saving-GDP
Investment-GDP
Malaysia
0.53
0.48
0.43
0.38
0.33
0.28
0.23
0.18
1990
1995
2000
2005
Saving-GDP
Investment-GDP
Korea
0.45
0.4
0.35
0.3
0.25
0.2
1990
1995
2000
2005
Saving-GDP
Investment-GDP
Thailand
0.48
0.43
0.38
0.33
0.28
0.23
0.18
1990
1995
2000
2005
Saving-GDP
Investment-GDP
Indonesia
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1990
1995
2000
2005
Saving-GDP
Taiwan
0.3
0.25
0.2
0.15
1990
1995
2000
2005
Savings-GDP
Investment-GDP

**FIGURE 2**

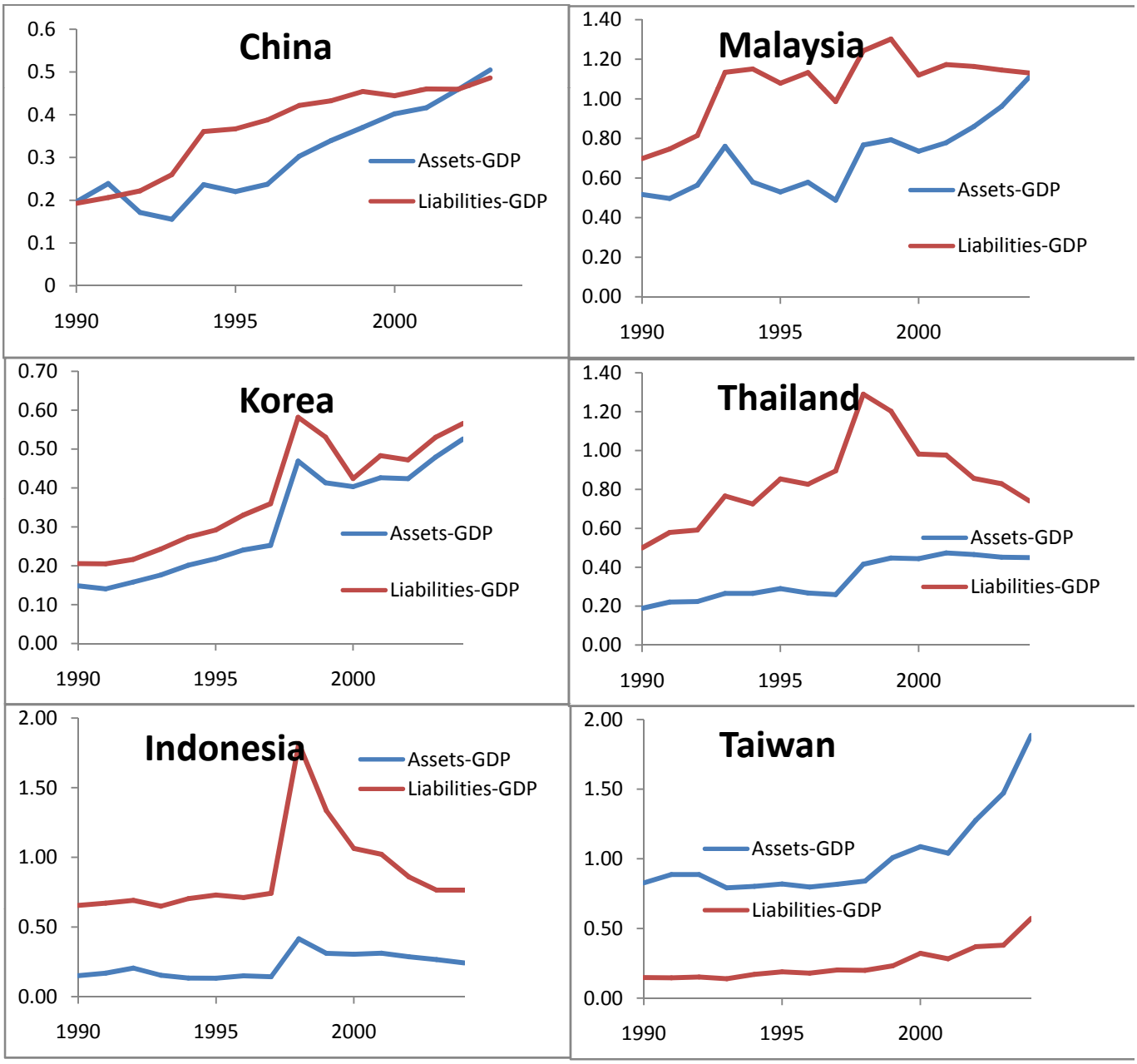
China
0.6
0.5
0.4
0.3
0.2
0.1
0
1990
1995
2000
Assets-GDP
Liabilities-GDP
Malaysia
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1990
1995
2000
Assets-GDP
Liabilities-GDP
Korea
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1990
1995
2000
Assets-GDP
Liabilities-GDP
Thailand
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1990
1995
2000
Assets-GDP
Liabilities-GDP
Indonesia
2.00
1.50
1.00
0.50
0.00
1990
1995
2000
Assets-GDP
Liabilities-GDP
Taiwan
2.00
1.50
1.00
0.50
0.00
1990
1995
2000
Assets-GDP
Liabilities-GDP

**FIGURE 3**

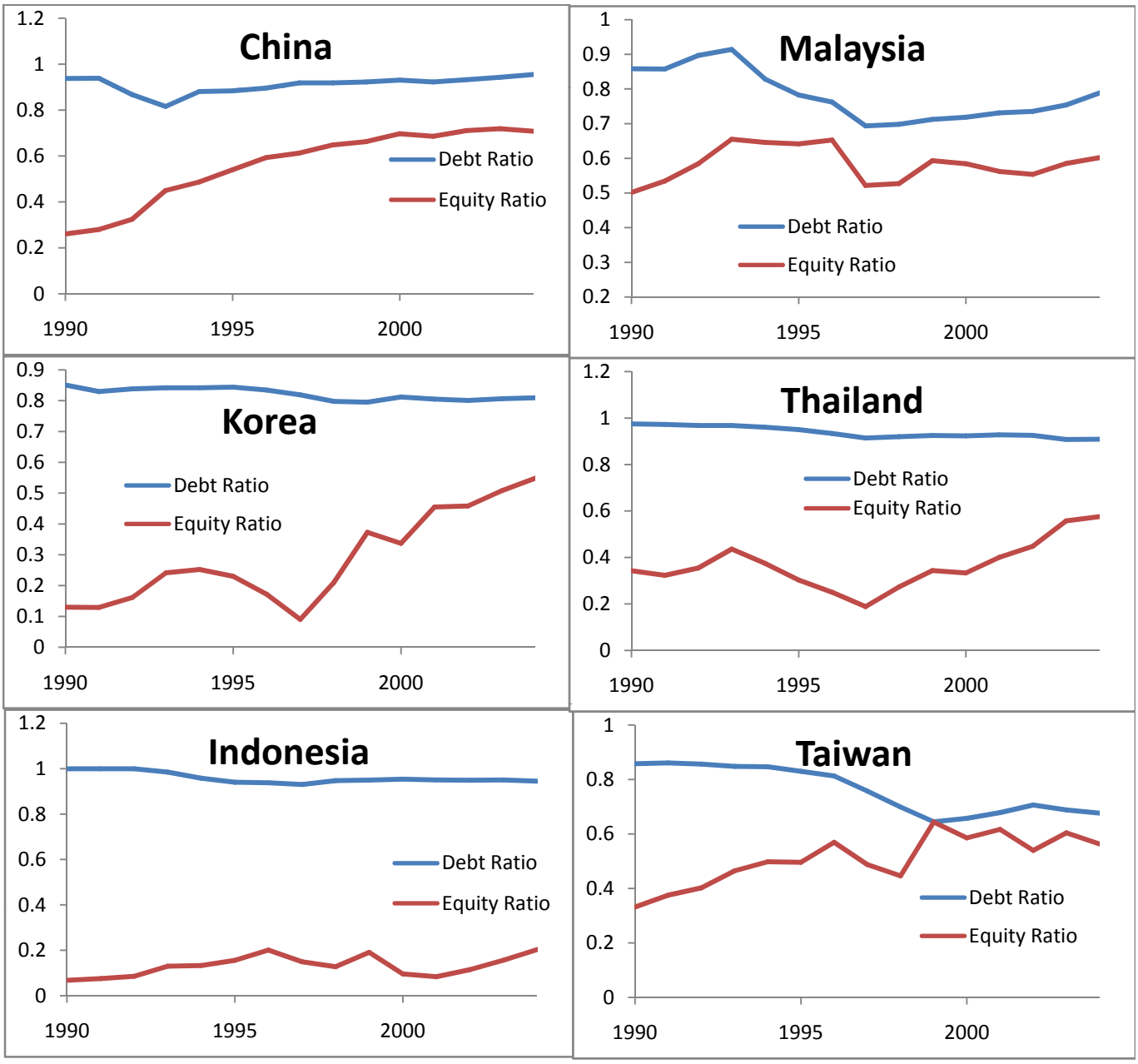
China
1.2
1
0.8
0.6
0.4
0.2
0
1990
1995
2000
Debt Ratio
Equity Ratio
Malaysia
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1990
1995
2000
Debt Ratio
Equity Ratio
Korea
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1990
1995
2000
Debt Ratio
Equity Ratio
Thailand
1.2
1
0.8
0.6
0.4
0.2
0
1990
1995
2000
Debt Ratio
Equity Ratio
Indonesia
1.2
1
0.8
0.6
0.4
0.2
0
1990
1995
2000
Debt Ratio
Equity Ratio
Taiwan
1
0.8
0.6
0.4
0.2
0
1990
1995
2000
Debt Ratio
Equity Ratio

**FIGURE 4**

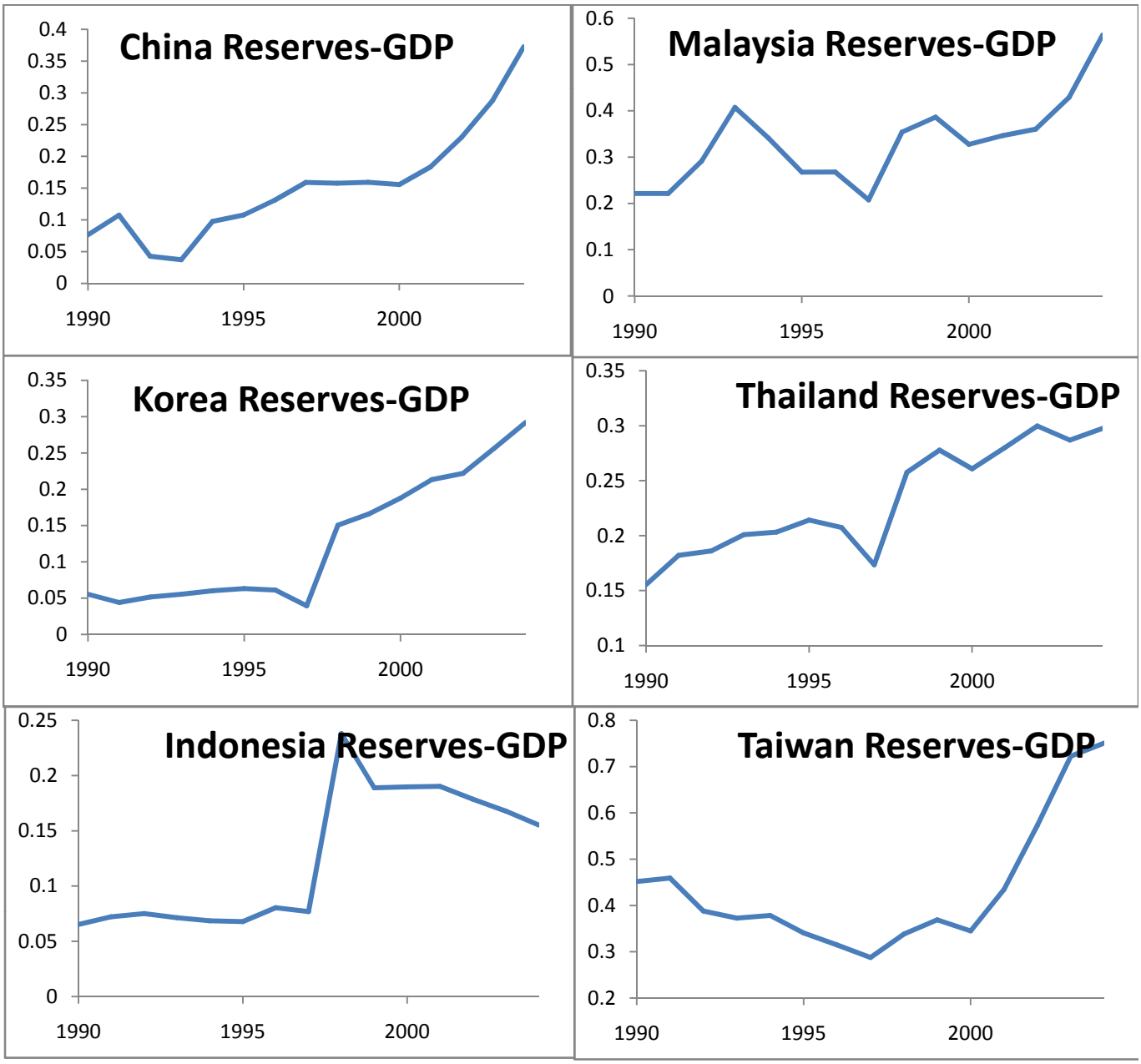
China Reserves-GDP
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1990
1995
2000
Malaysia Reserves-GDP
0.6
0.5
0.4
0.3
0.2
0.1
0
1990
1995
2000
Korea Reserves-GDP
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1990
1995
2000
Thailand Reserves-GDP
0.35
0.3
0.25
0.2
0.15
0.1
1990
1995
2000
Indonesia Reserves-GDP
0.25
0.2
0.15
0.1
0.05
0
1990
1995
2000
Taiwan Reserves-GDP
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1990
1995
2000

**FIGURE 5**

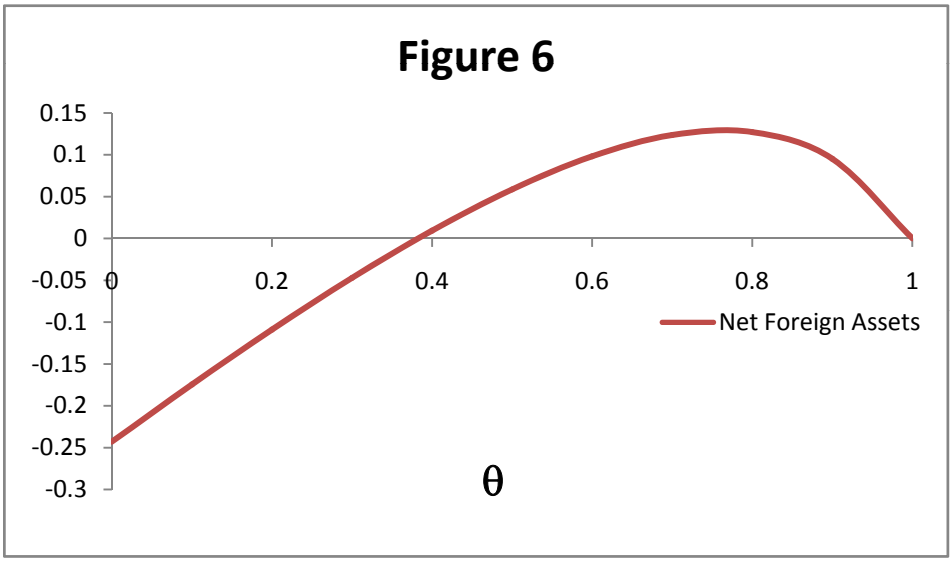
Figure 6
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
0
0.2
0.4
0.6
0.8
1
Net Foreign Assets
θ