The Park Place Economist

Volume 13 | Issue 1 Article 16

4-2005

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Abstract

Since the Asian financial crisis in 1997, the world has seen foreign currency reserves holdings in Asian countries skyrocket. China and India rank as second and fifth in foreign currency reserve holdings in the world, respectively. Together, the Asian emerging countries comprise approximately 40% of all world foreign currency holdings (Aizenman, 2003). The amount of reserves being held is one of the highest in history. Because of this, it is interesting to examine the factors that are driving this increase in reserves.

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I. INTRODUCTION

Since the Asian financial crisis in 1997, the world has seen foreign currency reserves holdings in Asian countries skyrocket. China and India rank as second and fifth in foreign currency reserve holdings in the world, respectively. Together, the Asian emerging countries comprise approximately 40% of all world foreign currency holdings (Aizenman, 2003). The amount of reserves being held is one of the highest in history. Because of this, it is interesting to examine the factors that are driving this increase in reserves.

It is important to examine why countries would hold large amounts of reserves. To that extent, there is an ongoing debate on whether having large holding of international reserves is beneficial or not. The critics' main argument is that those resources could and should be used in a more productive manner to develop the economy, such as investing in building roads, bridges and schools (Aizenman, 2003). In particular, the Indian Planning Commission Chairman announced on October 12th, 2004 the viability of using foreign reserves to finance local infrastructure projects. In his opinion, since the reserves are enough to finance 17 months of imports (www.indiadaily.com), excess reserves should be used to finance projects that would help India eradicate poverty.

On the other hand, those who support large holdings of reserves argue that the opportunity cost of holding the foreign reserves is small compared to the economic consequences of sharp devaluation of the currency (Aizenman, 2003). Reserves are held to influence the exchange rate of a currency and prevent devaluations. This is done by purchasing and selling the country's own currency to affect its demand and supply; thus, helping maintain a stable value in the international markets.

This argument is valid mostly for emerging economies, whose debt is mostly denominated in foreign currencies and would be greatly affect by devaluation. Devaluation would also affect the cost of inflated goods and raise inflation. This was the counter argument of the Indian Central Bank to the plan to use foreign exchange reserves domestically. They argue that doing so would fuel inflationary pressures in the economy and lead to instability (www.indiadaily.com). This argument describes the precautionary theory for reserves, that is, to hold reserves as a means of self-insurance in case of a financial crisis.

"China and India hold approximately 40% of the world foreign currency holdings."

Clearly, there are pros and cons to holding large amounts of foreign reserves. However, regardless of whether reserves are being held as self insurance or as ways to manage the exchange rate system, there have to be variables that help determine the optimum level. What this paper seeks to examine is the effect that different exchange rate regimes have on reserve holdings. As I mentioned before, central banks are generally thought to hold stocks of foreign reserves so their economies can avoid incurring the cost of adjusting to every international imbalance that would be transmitted to the domestic economy through changes in exchange rates (Batten, 1982).

Under a fixed exchange rate system, reserve holdings are expected to be larger, since they are necessary to maintain the exchange rate stable. The rea-

son for this is that although the nominal exchange rate is fixed, the market can still affect the real exchange rate and the central bank might find it necessary to use reserves or other monetary tools to maintain the peg. A fixed currency might also be subject to speculative attacks, and large reserve holdings are necessary to counteract these attacks as well. Therefore, under a fixed exchange rate system holdings of reserves are expected to be larger, since they are needed to maintain the fixed exchange rate stable.

Countries with a flexible exchange rate are expected to absorb these changes through changes in their exchange rate, requiring fewer amounts of foreign currency reserves. These countries will still hold reserves, since they are important monetary tool and a means to self insure against major financial crisis. However, reserves would be capped at some benchmark amount computed using import coverage.

What this paper seeks to analyze is how the exchange rate system impacts the level of reserves in a country. The focus is on China as fixed exchange rate system and India as a flexible exchange rate system. The rest of this paper is organized as follows. Section II reviews the existing theories for reserve holdings given recent reserve trends. Section III discusses the determinants of reserve holdings and explains the theoretical reasoning behind them. Section IV presents the empirical model and estimating equation that will be used to examine the difference in reserve holdings. Section VI explores the results obtained from the estimating equations and analyze the variables that seem to differ more for each country. Section IV discusses the conclusions that can be drawn given the results of the empirical model.

II. REVIEW OF LITERATURE

At the end of 1994, global reserves, excluding gold, were US$1,254 billion (Aizenman, 2002). By the end of 2002, reserves had soared to US$2,223 billion. This represents almost a doubling of reserves, in nominal terms, in a relatively short period of time. This dramatic increase in foreign reserves reignited researchers' interest in determining how countries determine their optimal level of reserves and what economic factors are included in determining the optimal level.

Research on foreign reserves was particularly active during the sixties, seventies and early eighties. During those decades, researchers were focused primarily on identifying the effects the Bretton Woods system, and its collapse, had on foreign reserves. An interest in whether developed and developing countries differed in their demand for reserves also arose (Flood, 2002). However, in the words of Flood and Marion (2002):

> Eventually attention was directed away from reserve holdings by the widespread assumption that international reserves would be stable—and probably low—in an era of increased exchange-rate flexibility and very high capital mobility.

The increasing growth of foreign reserves, contrary to what was predicted, has forced researchers to revisit this area and put forth new theories to explain why the evidence seems contradictory to the theory. However, most of the current research stems from the theories developed in the seventies and eighties, so there has not been much new light shed on the subject. Following, is an overview of the theories that have been developed to explain foreign currency holdings.

Heller (1966) theorizes that reserve demand is essentially an inventory control problem. In other words, he predicts that reserves are buffer stock, which is accumulated in times of abundance and depleted in times of scarcity. His main hypothesis is that a country's holding of international reserves is negatively related to its marginal propensity to import (MPI). He also includes measures for the current account balance and exchange rate regimes in his study.

Frenkel (1978), on the other hand, argues that MPI only measures an economy's openness to external shocks and therefore, would be positively related to foreign currency reserves if the reserves were held as a precautionary measure. His model is that "optimal reserve holdings would increase as the volatility of reserves increased." His empirical study demonstrates that volatility of reserves is indeed a robust predictor of foreign reserve holdings.

Building from this theory, a precautionary theory of international reserve demand has developed. This theory proposes that reserves are held as self-insurance against financial crisis. This theory draws directly from the buffer-stock theory mentioned earlier. Mendoza (2004) views this precautionary theory as a "natural extension of all previous theories." Distayat (2001) builds on this theory and

develops a reserve demand model "compatible with the second generation financial crisis".

Batten (1982) conducts an empirical study partly based on Frenkel's model to determine the demand for foreign reserves under fixed and floating exchange rates. He considers two types of models of central bank behavior. The first model, which he calls the intervention model, assumes that reserves are held only to enable the central bank to intervene in foreign currency markets. He identifies four major determinants of reserve demand: the variability of international payments and receipts, the propensity to import, the opportunity cost of holding reserves and scale variable measuring the size of international transactions.

The second model, which he calls the asset-choice model, treats foreign reserves as one type of asset in a central bank's portfolio held to enable the central bank to conduct domestic monetary policy (Batten, 1982). According to this model, the central bank's portfolio should include at least these three types of assets: foreign reserves, government securities and claims on commercial banks. It also separates the assets into two categories: committed and uncommitted. Uncommitted assets are defined as that portion of foreign reserves that are not used in the normal course of conducting monetary policy and are held as a precautionary measure in case of an external shock.

Aizenman and Marion (2002) develop a good estimation equation to predict the level of reserves over the 1980-1996 period based on the buffer-stock theory developed in the seventies. They found that there are four key factors in predicting the level of foreign reserves. These four key factors are: the size of international transactions, their volatility, the exchange-rate arrangement and political considerations. Their model accounts for 70% of the variation in foreign currency reserves.

The Aizenman and Marion (2002) model is similar to the Batten (1982) intervention model. For the purposes of this paper, I will assume that India and China are using foreign reserves to influence their exchange rate rather than as part of a portfolio of monetary tools. Thus, my model could be properly classified as an intervention model in which the level of reserves is a function of the exchange rate, the current account balance, the marginal propensity to import and the opportunity cost to hold the reserves. Following is a theoretical explanation for each variable's inclusion in the model as my hypothesis as to their relationship to reserves.

III. DETERMINANTS OF FOREIGN RESERVES

In past empirical studies, the following variables have been found to be robust predictors of a country's holdings of international reserves: current account balance, exchange rate regime, and marginal propensity to import. I am interested in examining how well this model will perform in explaining China and India's holdings of international reserves given their exchange rate regimes.

A. Current Account Balance

The net flow of capital out of a country is equal to domestic saving minus domestic investment; it is also equal to the current account (Higgins and Klitgaard, 2004). For a detailed explanation see Appendix A, extracted from Higgins and Klitgaard's (1998) research. A current account surplus then translates into net capital inflows into the country. Net capital inflows would strengthen the domestic currency. Under a fixed exchange rate system such capital flows must be counterbalanced to maintain the peg, under a flexible exchange rate system the currency would appreciate. If a country wishes to maintain its fixed exchange rate or just wishes to maintain a weaker currency in order to be more competitive, it has to balance the net capital inflows with capital outflows. Purchasing foreign reserves is one way to increase capital outflows since domestic resources are used to purchase foreign currency. From this I hypothesize that the current account will be positively correlated to the level of reserves. As for China, I predict that the current account will have a greater impact on its reserves holdings than the other variables included in the model, since its current account balance is the principal mechanism through which they get the official reserves.

B. Exchange Rate

Beaufort and Kapteyn (2001) point out that the type of exchange rate system influences reserve demand. Frenkel (1983) found evidence that after the collapse of the Bretton Woods agreement the move to floating exchange rates decreased the level of reserves. This follows macroeconomic theory. In a fixed exchange rate scenario market forces will still act to change the real exchange rate. Therefore, the

government will have to intervene to keep the nominal peg. As established earlier, the use of foreign reserves is one such method. In a floating exchange rate regime, movements in the exchange should not affect reserves as much. This results because the exchange rate is expected to absorb the macroeconomic shocks. Even if a country wished to keep a managed float, the exchange rate under this type of regime is allowed to vary within certain parameters, so adjustment would not occur quite as often and therefore fewer reserves would be necessary.

The exchange rate is said to have devaluated when the exchange rate goes up. Essentially, more of the domestic currency is needed to buy a unit of the foreign currency. In order to counteract this devaluation of the currency, the central currency will have to buy some of its own currency in the open market. Reserves would be used to buy the domestic currency, thus depleting reserves. I hypothesize that China's reserves will be negatively correlated to the level of the exchange rate.

"I hypothesize that marginal propensity to import will be positively correlated with the level of reserves."

I hypothesize that India's reserves will be positively correlated to its exchange rate. Having a flexible exchange rate allows India to let its currency depreciate without using reserves immediately. Because there will be no intervention from the central bank to counteract currency depreciation, India will continue accumulating reserves due to other factors such as the current account balance or its import activities without regard to its currency's depreciation. This hypothesis works under the assumption that India doesn't have a managed float, which would mean that they would only allow depreciations and appreciations of its currency up until a threshold level determined by central bank officials.

C. Marginal Propensity to Import

As mentioned in the literature review, there have been disagreements by previous researchers as to what the correlation between reserves and marginal propensity to import is. In this paper, I am assuming that the marginal propensity to import reflects the openness of the economy. A more open economy is more vulnerable to shock than a closed economy. If reserves are held as a precautionary measure to insulate against shock, it follows that the higher the marginal propensity to import the higher the level of reserves that are needed. Therefore, I hypothesize that marginal propensity to import will be positively correlated with the level of reserves. I also hypothesize that this variable will impact India more, since they are a more market oriented economy than China.

D. Opportunity Cost

Theoretically it is reasonable to assume that there is an opportunity cost related to holding extra reserves. However, it is difficult to predict what this opportunity cost is. First, a benchmark for "necessary" reserves needs to be developed. Again, the literature does not agree as to what the appropriate benchmark is, so they are mostly arbitrary. Second, once a benchmark is set and excess reserves identified a suitable proxy for opportunity cost needs to be found. Several financial variables have been used in the past, such as interest rates and lending rates. However, these variables tend to be correlated to reserves themselves, therefore yielding few satisfactory results. For the purposes of my research I have left this variable out of my empirical model, but theoretically it should be included.

On a side note, several aspects of the Chinese regime that impact the monetary system and reserves are worth mentioning. First of all, this model assumes that the same variables will affect Chinese reserves as Indian reserves, even though China is a centrally planned economy. According to Ford and Huang (1993). Although a centrally planned economy is fundamentally different from a market economy, there is no obvious reason to assume that its reserve holdings should be determined in a different manner.

Since, theoretically, Chinese and Indian reserve holdings are affected by the same variables, this model will be examining if exchange rates are indeed affected by the same variables and if so, if the magnitude of the impact of each variable varies between the two countries.

Another aspect of China that needs to be addressed is their control of their reserves. The RMB yuan, the Chinese currency, is inconvertible and for-

eign exchange is under tight control of the government. Their foreign exchange regulations restrict the use of foreign exchange earnings by enterprises. Any earnings in foreign currencies must be sold to the government. Since 1979, businesses have been allowed to maintain a quota, which entitles them to retain a portion of the foreign exchange they earn (Ford and Huang, 1993). However, there is strict control as to how these quotas are used. This arrangement precludes substitution between domestic and foreign monetary assets, which is normal in a market economy.

Furthermore, this means that the measure of Chinese overall reserves is more accurate than Indian reserves. Actual Indian foreign currency reserves are held both by the government and by businesses and individuals. However, there are only accurate measures for those reserves held by the Indian Central Bank. I am disregarding this disparity in reserves measurement since I am assuming that both countries hold reserves primarily to manage their exchange rates. Reserves held by businesses and individuals cannot be used to manage the exchange rate and are therefore irrelevant in this particular study.

"Theoretically, it is reasonable to assume that there is an opportunity cost related to holding extra reserves. However it is difficult to predict."

IV. EMPIRICAL MODEL

In this research paper, I wish to estimate reserve holdings for China and India, and examine which variables affect the country more so than the other. The standard estimating equation is:

$$\text{Reserves} = \alpha_0 + \alpha_1 \text{CA} + \alpha_2 \text{API} + \alpha_3 \text{ER} + \varepsilon$$

where *R* is the reserve holdings minus gold, valued in millions of US dollars, *CA* is the the current account balance, *API* is the average propensity to import, and ER is the exchange rate. A more detailed explanation of each explanatory variable follows.

A. Reserves (R)

Reserves, as defined by Heller (1966), must possess two qualities. First, "they must be acceptable at all times to foreign economic units for payment of financial obligations." Second, "their value, expressed in foreign units of account, should be known with certainty." Using this definition, the four assets that qualify as reserves are official holdings of gold, special drawing rights (SDRs), convertible foreign exchange, and the unconditional drawing rights with the IMF (Flood and Marion, 2002). Reserves for this study include convertible foreign exchange and SDRs.

B. Current Account Balance (CA)

This variable measures the size of the current account balance in millions of US dollars. Beaufort and Kapteyn (2001) have proposed the use of the variability in the current account, indicating that it is the changes in the current account, not its size that drives reserves. However, this notion has not been proved empirically and variance and current account balance have both been used as explanatory variables.

C. Average Propensity to Import (API)

This variable is a proxy variable that measures the degree of openness in an economy, thus indicating the degree to which the economy is vulnerable to external disequilibrium (Batten, 1982). It is computed as the ratio of imports to GDP.

D. Exchange Rate (ER)

This variable measures the exchange rate in India and China. For China, an index for the real exchange rate is used to account for the impact of inflation and other macroeconomic changes that are not reflected on the nominal exchange rate. The base year is the year 2000. The exchange rate is in yuans for US dollar. For India, the real exchange rate of rupees per US dollar is used.

In past empirical studies the log-linear form has been used as the standard functional form. No formal explanation has been given as to why this particular form should be used, so I'm assuming that during the model selection process this form yielded the highest R-squared. This type of functional form describes a linear relationship, only when the rela-

tionship is between the logarithms of the variables.

My estimating equation is in the linear form. The reason why I am not using the traditional log-linear form is that this form requires variability measures for the current account balance. To be able to use a variance measures I would need quarterly data for each year to be able to aggregate observations per year. Due to data constriction problems I am not able to use variability because it would greatly reduce my degrees of freedom.

The dataset for this research is from International Finance Statistics, a compilation of data by the International Monetary Fund (IMF). This time series data summarizes information for all member countries from 1948 through 1991. Information on balance of payments, trade, reserves, exchange rates and international liquidity is available. This dataset has been used in several recent empirical studies about foreign currency reserves, such as Flood and Marion (2002) and Aizenman and Marion (2002). Because I am mainly looking at Chinese reserves, I'm using annual data from 1980 to 2003. I don't use more historical data because before that period data on the Chinese economy is scarce and unreliable.

V. RESULTS

Tables 1 and 2 summarize the descriptive statistics for the key variables used in the estimating equation. Since the data for reserves and the current account is given in billions of dollars, scientific notation is used to facilitate interpretation and comparison of the numbers.

From the summary statistics it can be seen that both countries have relatively large standard deviations for their reserves, suggesting that reserves from this sample have been growing over time. Although the large standard deviation is consistent with the trend observed since the collapse of the Bretton Woods agreement, this steady increase in reserves is not what theory predicted. As mentioned in the literature review, it was thought that high capital mobility and exchange rate flexibility would reduce the amount of reserves over time. The mean reflects the magnitude of the holdings. In China's case, the mean for reserves is roughly eighty-four billion dollars. For India it is a modest (in comparison with China) eleven billion dollars. As mentioned in the introduction, these high levels of reserves have placed China and India as second and fifth largest reserve holders in the world, respectively.

Graph 1 plots the nominal reserve levels from 1980 to 2003. Both countries show an upward trend in reserve levels, particularly in the mid and late nineties. This is due to the financial crises in the world during this time period. Also, since reserves haven't been scaled, the difference in country size and population is not accounted for in this graph.

The results of the regression equations are presented in Table 3. For India, the first regression yields goods results. All three variables were significant at the .01 level and had the expected coefficients. The regression has an R^2 of .878 which means that almost 88% of the variation in reserves can be explained by the current account, the average propensity to import and the exchange rate. This is consistent with the findings of Flood and Marion (2002) and Batten (1998), who found these variables to be robust predictors of reserve holdings.

TABLE 1
Summary Statistics for India

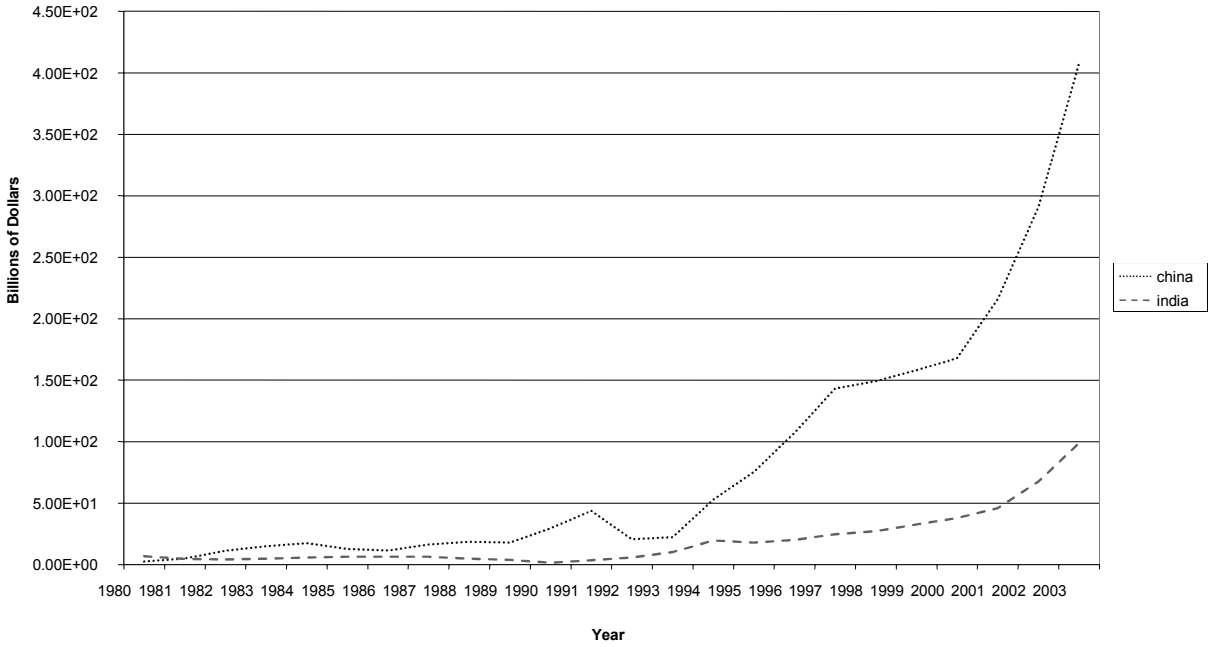
Variable	Mean	Std. Deviation	Minimum	Maximum
Reserves	19.5 billion	23.5 billion	15.2 billion	98.9 billion
CA	-35.5 billion	2.8 billion	-7.17 billion	5.82 billion
ER	26.56	12.56	7.93	48.18
API	.0859	.0167	.06	.12

TABLE 2
Summary Statistics for China

Variable	Mean	Std. Deviation	Minimum	Maximum
Reserves	83.9 billion	104 billion	2.55 billion	408 billion
CA	10.5 billion	15.9 billion	-11.6 billion	45.9 billion
ER	132.35	66.11	69.81	289.96
API	.25	.085	.03	.40

The regression results for the China were different. Although it also had a high R-squared, of .727 only the current account variable was significant. The high R-squared coupled with the insignificant coefficients suggested there might be multicollinearity among the independent variables. I ran correlations between the variables and only found a strong correlation between the average propensity to import and the current account. I chose not to eliminate either variable despite the correlation because my results are still BLUE, although the coefficients and t-statistics are fragile.

GRAPH 1
Reserve Holdings in China and India 1980 -2003



VI. CONCLUSIONS

Given the data constrictions, the results were as expected. The regression for India yielded good results, with a high R-squared and significant coefficients. The regression results for China are somewhat disappointing, since the regression seems to have explained very little.

In both equations the current account variable proved to be very significant. The significance of the current account for both countries reaffirms Stanley Fischer's comments to an IMF forum that "emerging market countries with open capital accounts need more reserves rather than less, and that we should look to the capital account in determining the country's needs for reserves" (Fisher, 2001).

TABLE 3
Regression Results

Variable	India	China
Constant	-1.54×10^{10}	4.98×10^{9}
	(-1.344)	(.090)
CA	2.139	5.93
	(3.668)***	(6.98)***
API	2.71×10^{11}	2.09×10^{11}
	(4.433)***	(1.28)
ER	6.28×10^{8}	-2.17×10^{8}
	(3.668)***	(-.901)
R^2	**.878**	**.727**

*** Significant at the .01 level

The estimating equation for India yielded very good results. India might conform better to this equation since the model was originally designed for emerging market economies such as India. One of the main differences between India and China is the magnitude of the current account coefficient. According to regression results, the current account impacts reserve holdings in China roughly three times more than it does reserve holdings in India.

One possible explanation for this might be the correlation between the MPI and current account variables for China. As mentioned in the results section, these variables are correlated at the .01 level for China, but not for India. This correlation might be affecting the results and magnitude of coefficients. However, China's current account does play a more important role in the Chinese economy since their current account surplus stems from their undervaluated currency, a trading advantage that India does not have. Also, Chinese reserves reflect almost all foreign currency acquired through trade, while Indian reserves only reflect foreign currency held by the government, without taking into consideration foreign reserve held by private individuals.

For China, particularly, the explanatory variables might have been insignificant because of the

time period that is being studied. China only started opening its economy around the 1980s. This model assumed that China was functioning as a market economy. However, the period studied has been a period of transition for China. Even today, China is not as open as an economy as India. This might account for the lack of significance of the variables, since reserves levels might have been determined through political considerations rather than economic variables.

Another thing to keep in mind with China, is the pressure that it has been experiencing in recent years to abandon its peg to the dollar. Currently, the Chinese currency is undervalued with respect to the dollar, giving China an advantage in international trade. The IMF and other international organizations have been pressing the Chinese government to let go of the peg to promote fair trade.

If international pressure keeps mounting and China is indeed forced to abandon its peg, there might be another financial crisis in Asia. Distayat's (2001) model predicts such a crisis when a peg is abandoned. Fischer (2004) mentioned in his remarks to the IMF forum that countries that have high level of reserves have faired better when financial crisis strikes. China might be accumulating reserves for the future when it will be forced to abandon its peg and thus its reasons to accumulate reserves are different than those for any other economy that is not at risk of having a currency crisis. This would also explain the escalating demand for reservers among other Asian countries that have close ties with China, and it will also align China's motives with the self-insurance model mentioned in the literature review. If that is the case, an intervention model like the one that is used in this paper would not predict China's reserve levels very accurately. Mendoza (2004) found that both China and India could be properly classified as self-insurers with respect to their reserve holdings. Kapur and Patel (2003) also concluded that India is acting as a self insurer.

This is an interesting area to continue research. There are different aspects of reserve holdings that need to be explored. One of them is determine a model that would predict reserves given a self-insurance motivation. Another aspect is approximating the opportunity cost of holding reserves, not only in the short term, but in terms of the investment in human capital and infrastructure that is given up.

APPENDIX A

Saving, Investment and the Current Account Balance

Using national income accounting, we can demonstrate how the equivalence of the current account balance and net capital inflows arises. Specifically, the national income accounts treat gross national product (GNP) as the sum of income derived from producing goods and services under the following categories: private consumption (C), private investment (I_P), government goods and services (G), and exports (X). Imports (M) are treated as a negative item to avoid the double counting of consumption or investment goods purchased at home but produced abroad. Thus, GNP is given by:

$$\mathbf{GNP = C + I_P + G + X - M}$$

With X – M represent net exports plus net factor income (return on domestic and foreign assets).

A second basic equation in the national income accounts is based on the insight that any income received by individuals has four possible uses: it can be consumed (C), saved (S_P, for private savings), paid in taxes (T), or transferred abroad (Tr). Because GNP is simply the sum of the income received by all individuals in the economy, we have

$$\mathbf{GNP = C + S_P + T + Tr}$$

By equating the two expressions for GNP developed above, canceling out C, and rearranging terms, we derive the following equation:

$$\mathbf{X - M - Tr = (S_P - I_P) + (T-G)}$$

with X – M – Tr equaling the current account.

In other words, the current account balance is equal to the surplus of private savings over investment and the gap between government tax receipts and government expenditure on goods and services, that is, the government budget surplus.

A final equation is needed to clarify the link between the current account and the net flow of foreign investment capital. A dollar of savings can be classified according to the type of asset it buys. In particular, the dollar can be used to purchase domestic physical capital, domestic government debt, or a

foreign asset (FA) of some sort. Recalling the net issuance of government debt is equal to the government budget deficit, G – T, we have

$$\mathbf{Sp = Ip + (G-T) + FA}$$

Rearranging, we have

$$\mathbf{FA = (Sp-Ip) + (G-T) \rightarrow FA = X-M}$$

This last equations can be interpreted as representing the fact that a country accumulated foreign assets (or equivalently, is a net lender to the rest of the world) when domestic private saving is more than sufficient to finance private investment spending plus the government budget deficit.

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