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Comparative Study: Factors that Affect Foreign Currency Reserves in China and India

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Abstract

This paper empirically studies the accumulation of foreign exchange reserves by the countries of India and China. Particularly, it focuses on the determinants of this policy and on the role that the choice of exchange rate regime plays in driving it. Annual data points for the years between 1980 and 2003 were collected and their frequency increased to quarterly through a quadratic match process. The accumulation of foreign exchange reserves in India is best explained as a function of exchange rate volatility and the degree of openness of the economy. The impact of one-time shocks, such as currency devaluations, and structural shocks, such as trade liberalization, are captured in the estimating equation. Alternative independent variables are also tested. The factors driving the accumulation of foreign exchange reserves in China remain a puzzle.

I. INTRODUCTION

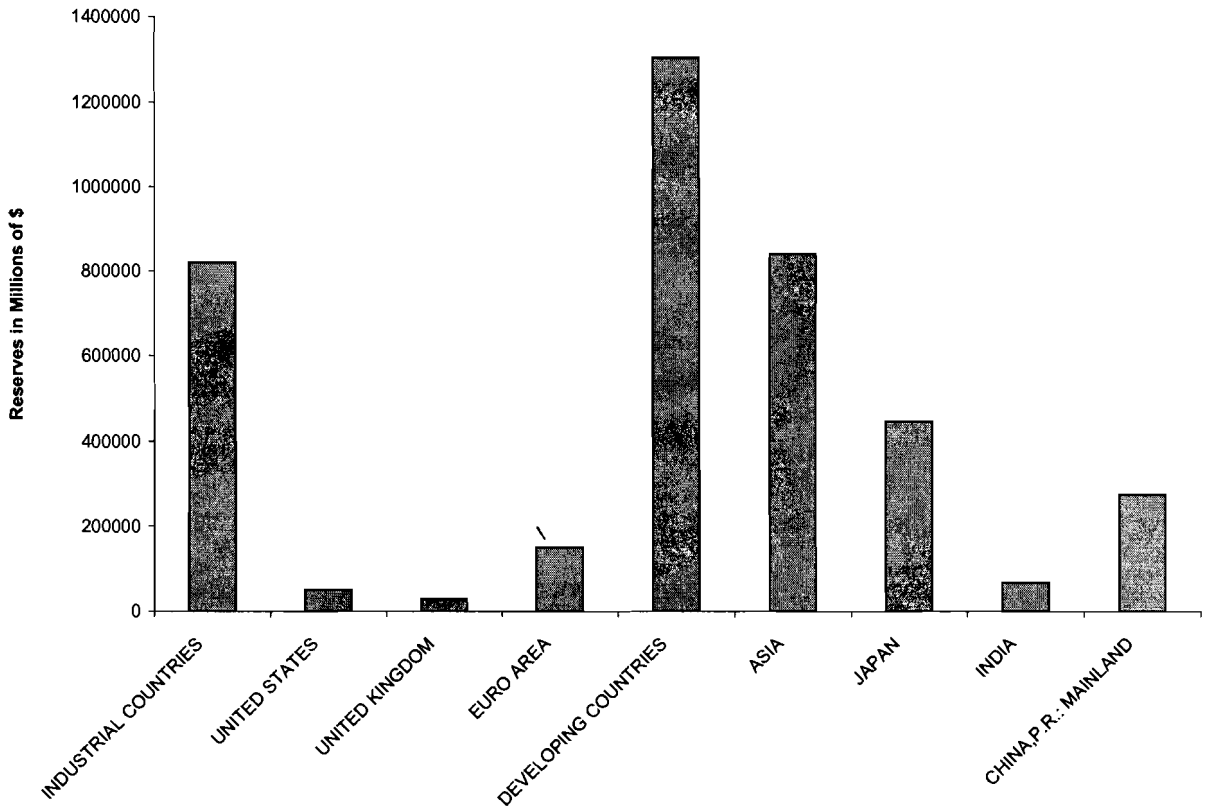
Since the Asian financial crisis in 1997, the world has seen foreign currency reserves holdings in Asian countries skyrocket. China and India rank as second and fifth in foreign currency reserve holdings in the world, respectively (IFS, 2005). Together, the Asian emerging economies comprise approximately 60% of all developing countries foreign currency holdings (IFS, 2005). The amount of reserves held world-wide is one of the highest in history. Furthermore, the pattern of reserve holdings has been increasing at a relatively faster pace since the early 1990s.

Figure 1 shows the reserve volumes in 2003 for selected industrial countries, China, India, industrial and developing countries, and Asia. Although the graph does not correct for the size of the economy for each country, it clearly illustrates that developing economies, such as China and India, hold the largest amount of reserves. It also shows that most of the reserve holdings are concentrated in Asia. From an economic viewpoint, it makes sense that developing countries hold most of the reserves, even though their economies are not the largest ones. Industrialized countries have more stable currencies, diminishing the risk of currency depreciations. Furthermore, they have more access to capital markets, making borrowing easier and cheaper than holding reserves.

Nonetheless, there is an ongoing debate about whether or not large holdings of international reserves are beneficial for a developing country. On the one hand, two benefits arise from this practice. Firstly, "high levels of reserves reduce the likelihood of a currency crisis or a 'sudden stop'- that is, a sudden unwillingness by international lenders to renew their credit lines at times of market uncertainty" (Hviding, Nowak and Ricci, 2004). Secondly, large reserve holdings are usually associated with lower external borrowing costs because the reserves

improve confidence and raise credit rating on sovereign foreign currency debt. Both benefits accrue because the government's risk of default is perceived as lower given the high levels of reserves (Hviding, Nowak and Ricci, 2004). In short-hand, large international reserves work as global insurance.

Figure 1: Reserve Holdings at the end of December 2003 (IMF, 2005)



At the same time, those who argue against large reserve holdings point out the investment opportunities available in developing countries rich in foreign reserves. Clearly, large reserve holdings represent a huge social opportunity cost. However, investing those reserves would bolster the money supply and increase inflation. For the most part, India and China have been sterilizing their reserve accumulation so that the effects of the foreign market intervention on the

money supply have been neutralized (Flood and Marion, 2001). Another argument against holding large volumes of reserves is the enormous financial opportunity cost of holding those reserves. Not only is money not being used to develop the country, but it is earning virtually no return. Reserves are usually held as short-term investments in order to guarantee their liquidity, so earning very low interest rates. Therefore, the foregone return of foreign reserves is very high. Overall, the literature offers no definite conclusion on the net gain or loss associated with holding reserves.

As for explaining the current reserve hoarding in Asia, several arguments have been set forth. One argument is that reserves are a by-product of the countries' exchange rate regime. Another theory suggests there is a precautionary motive behind reserve hoarding, suggesting that countries are insuring themselves against financial crises (Aizenman and Marion, 2002). Yet another possible explanation suggests that high level of reserves are a consequence of Asian countries' mercantilist desire to keep their real exchange rate devalued against the dollar to bolster the domestic economy (Flood and Marion, 2001).

This paper contributes to this particular line of literature by examining the effect that different exchange rate regimes have on reserve holdings. As mentioned before, central banks are generally thought to hold stocks of foreign reserves in order to stabilize their exchange rates through intervention in the foreign exchange market. Unchecked exchange rate instability would translate into internal imbalances (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. Although the nominal exchange rate is fixed, the market can still affect the real exchange rate. The central bank might find it necessary to use reserves or other monetary tools to maintain the peg. Simultaneously, a fixed currency can be

subject to speculative attacks. Large reserve holdings would be necessary to counteract those attacks. 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 not expected to maintain a currency peg, so requiring fewer amounts of foreign exchange reserves. These countries will still hold reserves, since they are important monetary tool and a means to self-insure against major financial crisis. However, their reserve holdings should be capped at some optimal level in order to avoid the cost of holding excessive reserves.

This paper will focus on China as an example of a fixed exchange rate regime, and India as an example of a flexible exchange rate regime. Both are developing countries who have greatly accelerated their foreign reserve accumulation in the last few years. The rest of this paper is organized as follows. Section II reviews the literature on reserve holdings. Section III discusses possible determinants of this practice and provides their theoretical background. Section IV presents the empirical model and estimating equation that will be employed to examine reserve holding behavior. Section V describes and summarizes the estimation data. Section VI analyzes the results obtained from the estimating equations and discusses the differences between the two countries. Section VII presents our conclusions and suggests avenues for research.

II. REVIEW OF LITERATURE

At the end of 1995, global reserves, excluding gold, were US$991 billion (IFS, 2005). By the end of 2003, reserves had soared to US$2,224 billion (IFS, 2005). 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 specifically what economic factors are included in this process.

Research on foreign reserves was particularly active during the 1960s, 1970s, and 1980s. During those decades, researchers were focused primarily on identifying the effects that 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 simultaneously arose (Flood and Marion, 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 issue and explain why the evidence seems to contradict the theory. Most of the current research stems from the theories developed in the 1970s and 1980s, so there has not been much new light shed on the subject. Following, is a brief overview of the theories that have been developed to explain foreign currency holdings.

Frenkel, in his 1978 seminal paper, argued that the marginal propensity to import (MPI) 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. Frenkel measured a country's MPI as the ratio of imports over GDP. His study concluded that "optimal reserve holdings would increase as the volatility of reserves increased." His empirical study showed that volatility of reserves is indeed a robust predictor of foreign reserve holdings.

Building from this argument, a precautionary theory of international reserve demand developed. This model proposed that reserves are held as self-insurance against financial crisis.

This explanation drew directly from the buffer-stock argument. The buffer-stock theory argued that reserves are financial stocks accumulated in times of abundance and are depleted in times of scarcity. Mendoza (2004) viewed this precautionary analytical framework as a "natural extension of all previous theories." Distayat (2001) built on his work and developed a reserve demand model "compatible with the second generation financial crisis".

Batten (1982) conducted an empirical study partly based on Frenkel's model to determine the demand for foreign reserves under fixed and floating exchange rates. He developed an argument he called the intervention model, which assumed that reserves are held only to enable the central bank to intervene in foreign currency markets. He identified four major determinants of reserve demand: the variability of international payments and receipts, the propensity to import, the opportunity cost of holding reserves, and a scale variable measuring the size of international transactions.

Aizenman and Marion (2002) focused on the demand for international reserves in the Far East compared to the demand in other developing countries. Their research found that reserve holdings for the 1980-1996 periods are the outcome of several factors such as: international transactions, international transaction's volatility, the exchange rate arrangement, and political considerations. After the 1997 Asian financial crisis, they found that this model significantly under- predicted reserve holdings. In their research they showed that "sovereign risk and costly tax collection to cover fiscal liabilities lead to a large precautionary demand in reserves".

Although the literature reviewed here proposes several variables as determinants of reserve holdings, little has been said about reserve adequacy. Traditional measures, developed after the Breton Woods system collapsed in 1971-1973, used to be rules of thumb, such as three months of import cover. Clearly, when India is holding over 20 months of imports cover (IMF,

2005), that measure doesn't apply today. Neither do most of the other measures proposed in the late 70s and early 80s literature.

Reserve adequacy measures changed after the onset of the financial crises in the 1990s. Calvo (1996) suggested that "a country's vulnerability to crisis should be measured, in part, by the size of its money supply, defined broadly, relative to its reserve holdings, since broad money reflects a country's exposure to the withdrawal of assets."

One of the most oft-cited reserve adequacy measures is the Greenspan (1999) measure. Greenspan expanded on a previous reserve adequacy measure, known as the Guidotti rule, which suggested that countries should hold enough reserves to be able to live without new foreign borrowing up to one year. This would require careful management of external assets and liabilities. Greenspan (1999) expanded to that suggestion by adding a test that "the average maturity of a country's external liability should exceed a certain threshold, such as three years."

III. DETERMINANTS OF FOREIGN RESERVES

Most of the empirical studies on reserve holdings consistently conclude that there are variables proven to be significant when determining reserve holdings. The two most significant variables are: (A) a measure of economic openness and (B) the exchange rate volatility. Each variable will be discussed individually.

A. Economic Openness

An open economy is an economy which engages in trade of goods and services with the international community at large. Increased exposure in the international markets could affect the domestic currency, asset pricing, and even the stock market (Salvatore, 2001). Wanting to offset the effect an external imbalance could have on the domestic economy is a powerful motive to

hold foreign currency reserves. For example, the Asian Financial Crisis of 1997 started in Indonesia, South Korea and Thailand. Hong Kong, Malaysia, Laos, the Philippines, and China were also affected by the crisis due to their economic ties to these countries. Another incentive to hold reserves is that countries with larger reserve holdings have faired better during financial and currency crises.

There are several measures of economic openness. The most widely used measure in the literature is the average propensity to import, first introduced by Frenkel (1974). This measure is often controversial. Frenkel predicted a positive relationship for the variables, while other researchers like Heller (1966) predict a negative relationship. Recent studies like Flood and Marion (2001) and Aizenman and Marion (2002) have concentrated on the role of the volatility of exports as a measure of international transactions' volatility. This paper uses both exports and imports scaled over GDP as a measure of economic openness. The former were more significant than the latter.

B. Exchange Rate Volatility

Foreign currency reserves are often held to influence the domestic exchange rate. Foreign reserves can be used to buy the domestic currency in the international markets and prevent large currency depreciations under a flexible exchange rate system. Under a fixed exchange rate system reserves become even more important, since they will help defend the pegged currency in the event the currency is attacked.

Aizenman and Marion (2002) suggest that exchange rate volatility should be used to measure the effect of the exchange rate on reserve holdings. Increased volatility of the nominal exchange rate is often associated with a flexible exchange rate regime. A flexible exchange rate regime allows the currency to absorb any macroeconomic shocks, which are then reflected as the

exchange rate appreciates or depreciates without any need for intervention. If there is less need for intervention, it follows that increased volatility should lead to less reserves.

Conversely, less volatility of the nominal exchange rate suggests a fixed exchange rate regime. If the nominal exchange rate is fixed, macroeconomic shocks will not be absorbed through currency depreciations and appreciations. Although macroeconomic shocks will not be reflected in the nominal exchange rate, they will be reflected in the real exchange rate (nominal exchange rate adjusted for inflation differentials between countries). Changes in the real exchange rate put pressure on the peg, so in order to keep the peg, the government will need to intervene in the open markets and use reserves to counteract the effects of macroeconomic shocks on the real exchange rate. Hence, countries with fixed exchange rates should hold more reserves to defend the peg.

IV. EMPIRICAL MODEL

This paper estimates reserve holdings for China and India and examines which variables affect one country more than the other. The generic estimating equation will be reserves as a function of the volatility of the exchange rate and economic openness, yielding a standard estimating equation of the form:

$$\mathrm{Ln}(R_t - R_{(t-1)}) = \alpha_0 + \alpha_1 \ln(\mathrm{volneer}_t - \mathrm{volneer}_{(t-1)}) + \alpha_2 \ln(\mathrm{open}_t - \mathrm{open}_{(t-1)}) + \varepsilon$$

where *lnR* is the natural log of reserves minus gold, valued in millions of U.S. dollars scaled by the real GDP, *lnvolneer* is the natural log of the volatility of the daily exchange rate in the

quarter, *lnopen* is the natural log of the ratio of the country's real export receipts over the real GDP. A more detailed explanation of each independent variable follows.

A. Reserves

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, but exclude gold. Reserves are scaled by the real GDP to account for differences in the sizes of the two economies being compared.

B. Openness Index

The openness index is calculated as a ratio of exports to real GDP. The higher the ratio of the two, the more open and vulnerable an economy becomes to external shock. The more open an economy, the more reserves it will need to insure against external financial shocks; therefore we expect a positive relationship between openness and reserves.

C. Nominal Exchange Rate Volatility ($volneer_{(t-1)}$)

A country's exchange rate regime determines the volatility of the exchange rate. A fixed exchange rate regime would have low volatility of the nominal exchange rate, while a flexible exchange rate regime would have high volatility. High or low volatility in the nominal exchange rate is then used to determine reserve holdings. A country with high volatility has a flexible exchange rate regime, which requires less intervention and therefore fewer reserves. A country

with low nominal exchange rate volatility has a fixed exchange rate and needs to intervene in open markets more to maintain the peg. In this paper the volatility of the exchange rate is defined as the variation of the daily nominal exchange rate over a quarter. The volatility is lagged, since past exchange rate levels are used to determine current reserve levels.

Finally, particular structural shocks in each country have been accounted for. For example, in 1991 India experienced a severe balance of payments crisis. Before 1991, India had a closed capital account with capital mobility being constrained through government controls and restrictions, much like China's capital account (Kohli, 2001). After the 1991 crisis India's pattern of reserve holdings changed (See Appendix A). India created an economic program that would transform a previously controlled economy into a market-driven one (Kohli, 2001). To reflect this balance of payments crisis and the subsequent economic change India experienced, a dummy variable for the fourth quarter of 1991, *d1991*, was introduced into the regression. India also announced in 1994 that it was moving towards a more flexible exchange rate regime. Previously, they had a managed exchange rate regime. Currently, they are classified as a managed float. Greater flexibility does not seem to have significantly impacted reserve holdings (see Appendix A).

Simultaneously, several aspects of the Chinese political/economic regime that impact the monetary system and reserves are worth mentioning. First of all, this model assumes that the same variables will affect both Chinese and 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 whether reserves are indeed affected by the same variables and if so, differences in the magnitude of the impact of each variable varies between the two countries.

Another aspect of the Chinese case that needs to be addressed is the control of its reserves. The RMB Yuan is inconvertible and foreign exchange in under tight control by the government. For example, 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 of how these quotas are used. This arrangement precludes substitution between domestic and foreign monetary assets, which is normal practice in a market economy.

Furthermore, this particular regulation makes the measure of Chinese overall reserves more accurate than Indian reserves indicator. Actual Indian foreign exchange holdings 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.

V. DATA

The dataset for this research is from International Finance Statistics, a compilation of data by the International Monetary Fund (IMF). This time series data bank summarizes information for all member countries from 1948 through 1991. Data for GDP, exports, imports, and reserves

are extracted from this database. The GDP deflator data were extracted from the World Development Indicators database from the World Bank.

The exchange rate data were obtained from the Federal Reserve Bank of St. Louis. Daily nominal exchange rate from the period between 1980 and 2003 were extracted and used to compute the exchange rate volatility for each quarter, defined as the variance of the nominal daily exchange rate in each quarter.

The original data for real GDP and the GDP deflator for both China and India were available only with an annual frequency. In order to increase the GDP data frequency from annual to quarterly, a quadratic match sum process was applied. For the GDP deflator, a quadratic match average process was used to convert the deflator from an annual frequency to a quarterly frequency. For a description of the processes and of each variable, see the data appendix.

The data were changed into quarterly frequency form primarily to increase the number of observations in the study. With annual data each country had roughly twenty-three observations, hardly enough to draw definite conclusions. Ideally, the data would have been available in a quarterly frequency, but prior reporting standards for both of these countries made it impossible to obtain the data. China began to fully comply with IMF reporting standards 1999, while India has complied since the mid-1980s.

Also, some of the data were in the national currency, such as GDP, imports and exports for India. In order to be consistent, the data were transformed into dollars using the average nominal exchange rate for the period provided by the IMF. Nominal data were transformed into real terms using the GDP deflator for each country. This was the only inflation measure consistently available through the 1980-2003 time periods.

The functional form for the estimating equation is a log-linear form with first order differences. The log-linear model was used to eliminate the trend inherent in times series data while the first order differences were used to eliminate autocorrelation present in the regressions.

VI. RESULTS

The results obtained from the estimating equations for each country are presented below. The equations differ because a dummy variable was introduced for India. The Durbin-Watson (D-W) statistic, testing for autocorrelation, is also included in the table.

The first estimating equation is the simplest formulation, an ordinary least squares regression where reserves scaled over GDP were regressed against the nominal exchange rate variance and the openness index (and the dummy variable for the Indian case). The initial results for India show that the openness variable is significant at the .01 level while the nominal exchange rate variance is significant at the .1 level. For China, only the openness variable is significant. Both regressions appear to suffer from autocorrelation, according to the Durbin-Watson (D-W) statistic.

To correct for autocorrelation, the second regression uses the log-linear model. In this regression the measure of openness is the only variable that appears to be significant for the two countries. The low D-W statistic indicates that autocorrelation is still present. To further correct for this problem first order differences are taken. This seems to improve the regression for India; all variables become significant at the .01 level. The D-W is high, indicating possible negative autocorrelation. This statistic falls under inconclusive range of the test, so it is possible that there is no autocorrelation. The dummy variable for the 1991 crisis appears to be statistically

significant too. Additionally, a Chow test is employed in the last regression in order to test for a structural break after 1991. This test is significant at the .01 level.

Table 1: Determinants of Foreign Reserves for India

	R(1)	R(2)	R(3)
volneer	-0.03	-.009	-.017
(t-statistic)	(-1.97)*	(-.46)	(3.3)***
Open	10.99	3.47	.58
(t-statistic)	(13.95)***	(16.59)***	(3.1)***
D1991	-.015	-0.90	.67
(t-statistic)	(-1.01)	(-1.44)**	(4.2)***
N	95	93	91
R^2	.67	.75	.33
D-W	.31	.31	2.45

* Significant at .10 level
** Significant at .05 level
*** Significant at .01 level

Table 2: Determinants of Foreign Reserves for China

	R(1)	R(2)	R(3)
volneer	-.003	-.009	-.002
(t-statistic)	(-.20)	(-.40)	(-.78)
Open	3.69	2.34	.005
(t-statistic)	(14.79)***	(18.47)***	(.11)
N	91	83	79
R^2	.71	.81	.008
D-W	.65	.87	.91

* Significant at .10 level
** Significant at .05 level
*** Significant at .01 level

The study of this relationship for the case of China presents particular challenges. The estimating equation that performs well for India fails to capture the behavior of Chinese reserves. Our empirical work contradicts the theoretical position arguing that both countries should follow

the same fundamentals. The D-W statistic also indicates that the autocorrelation problem was not corrected. However, the D-W statistic for the last regression is not significant, hence it is possible that there is no autocorrelation and the D-W statistic is not showing it. Another problem associated with the study of the Chinese case is that the introduction of natural logs drops eight observations from the data set. Under a fixed exchange rate regime the nominal exchange rate variance is zero. It would have been more appropriate to use real exchange rate variability, but data constraints made this impossible at this point. However, the coefficients do have the expected signs and they are consistent with the coefficient signs in the India regression.

Alternative independent variables were also considered in order to explain the accumulation of Chinese reserves. To capture the degree of economic openness we calculated the ratio of imports to GDP and the ratio of the current account balance to GDP. The ratio of imports to GDP did not significantly improve our estimation results, whereas employing the ratio of the current account balance to GDP posed some functional challenges. In particular, since China experienced several years of current account deficits in the early 1980s this measure of openness yields negative values. These observations are dropped from the data set when computing the natural logarithms and so our estimation efforts are greatly constrained. Additionally, we computed the ratio of Chinese inflation over inflation in the USA in order to capture the influence that inflation differentials would play in driving exchange rates and reserves hoarding. The purchasing power parity principle would signal overvaluation or undervaluation of the domestic currency, and so potential re-alignments of the exchange rate requiring the use of reserves to smooth out. Nonetheless, these pressures build up over long periods of time and our use of lagged values of this independent variable were not able to capture this phenomenon.

Comparing the results of this empirical study to the results found in previous literature is somewhat difficult. Although the general lines of analysis in this paper are consistent with the ones followed by other authors the data employed here and the definition of specific variables are unique. To begin with, previous studies have used panel data with annual frequency, whereas we employ time series data with quarterly frequency. Furthermore, the definition of variables is heterogeneous. For example, Aizenman and Marion (2002) consider export volatility as an indicator of economic openness, instead of the ratio of exports over GDP. Additionally, their functional form is significantly different. Instead of their log-linear model we employ first order differences of the natural logs in order to make the variables stationary in variance.

However, the signs of the coefficients are consistent with the findings of previous studies. In both of Aizenman and Marion's papers (2002, 2004), the nominal exchange rate volatility is negatively related to the volume of reserves. Similarly, our analysis replicates their finding of a positive relationship between economic openness and reserves. Although they find the ratio of imports over GDP -instead of the ratio of exports over GDP, to be a better predictor of actual reserves, in both cases the relationship is positive and statistically significant.

VII. CONCLUSIONS

Much research has been done on the topic of contemporary accumulation of foreign currency reserves by Asian countries. Although there is no conclusive evidence in the literature as to which variables determine foreign exchange reserve levels, the results of this study in the case of India seem to be consistent with the findings of previous works.

The results for China could be explained by the 'unique' nature of their economy. Ford and Huang's (1994) assumed that reserve holdings for China would be determined the same way

as reserve holdings for open economies. However, the Chinese government remains in tight control of many aspects of the economy, including reserves and the exchange rate. The preliminary results in this paper show that market-oriented variables don't explain reserve holdings for China. Although the results are interesting, they aren't conclusive.

There were several issues left unexplored in this paper due to data constraints. In particular, it would be interesting to examine the relationship between the real exchange rate variance and the level of reserves. Furthermore, this paper did not touch upon the topic of optimal reserve levels. It would be illuminating to examine what the literature considers the optimal level of reserves to be and compare those estimates with the actual reserve holdings. The study of potential excessive reserve accumulation would be likely to take this line of analysis is a very different direction.

APPENDIX A


Log Monthly Reserves ($) - China
Log Monthly Reserves
12
11.75
11.5
11.25
11
10.75
10.5
10.25
10
9.75
9.5
9.25
9
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
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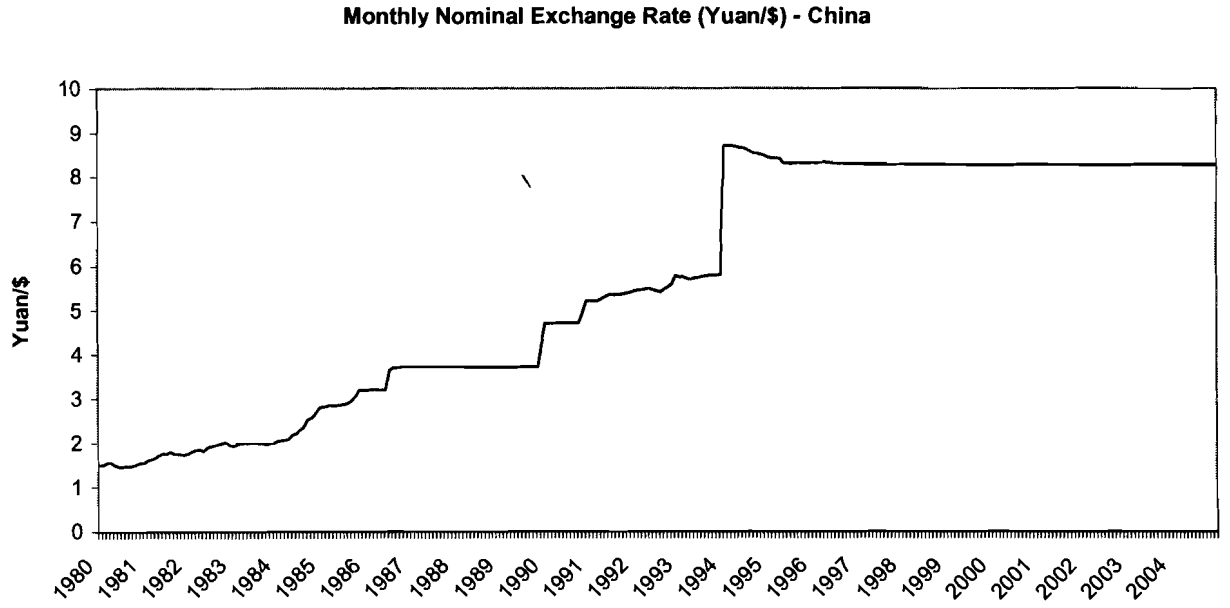
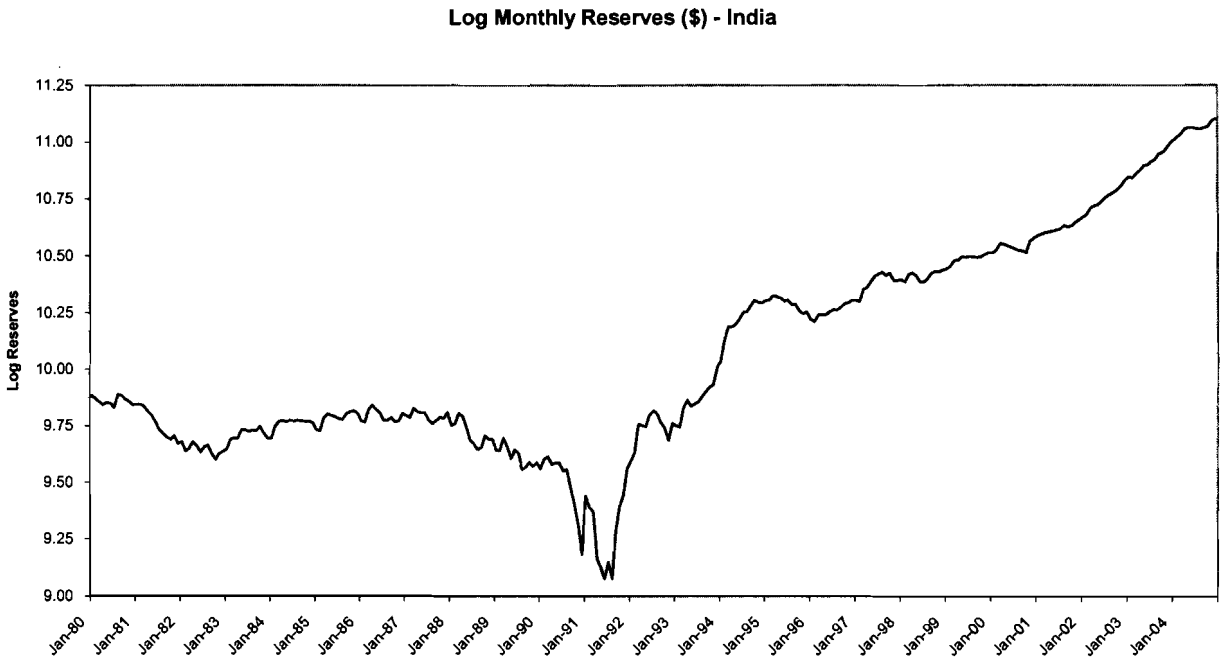
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04


Monthly Nominal Exchange Rate (Yuan/$) - China
Yuan/$
10
9
8
7
6
5
4
3
2
1
0
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004


Log Monthly Reserves ($) - India
Log Reserves
11.25
11.00
10.75
10.50
10.25
10.00
9.75
9.50
9.25
9.00
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
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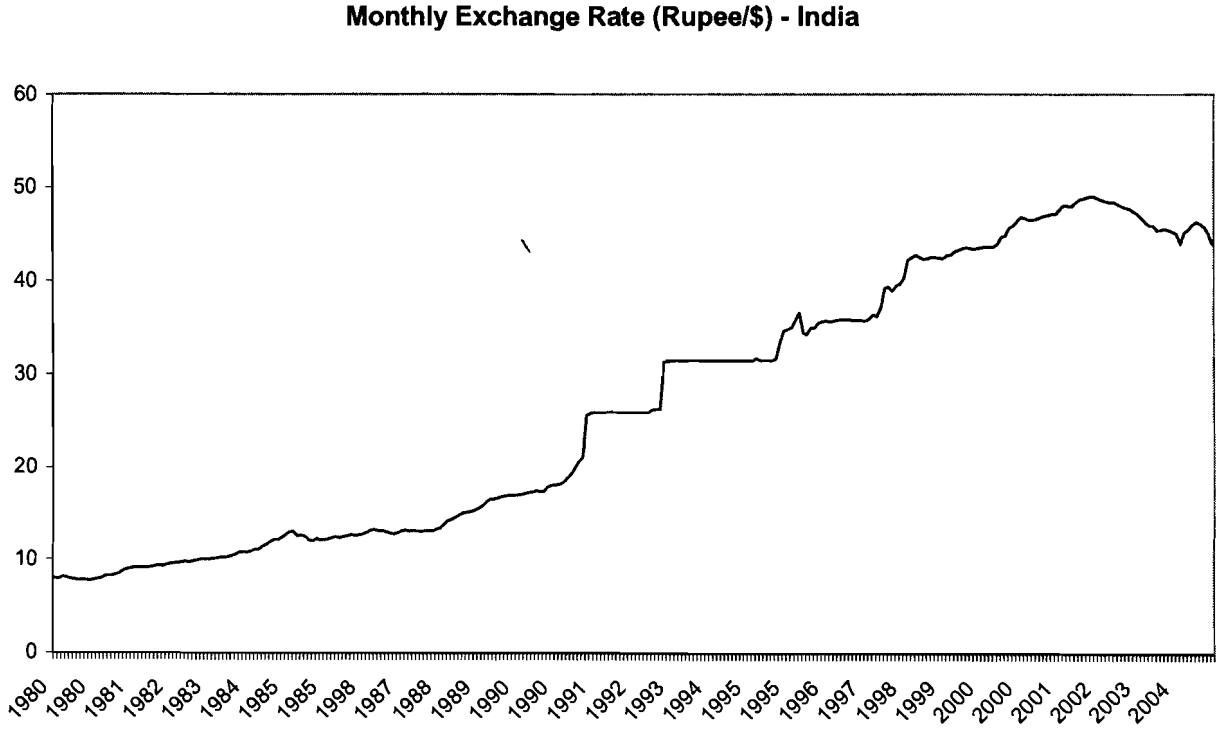
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04


Monthly Exchange Rate (Rupee/$) - India
60
50
40
30
20
10
0
1980
1980
1981
1982
1983
1984
1985
1985
1998
1987
1988
1989
1990
1990
1991
1992
1993
1994
1995
1995
1996
1997
1998
1999
2000
2000
2001
2002
2003
2004

DATA APPENDIX

[All series are obtained from the IMF's *International Financial Statistics* Database unless otherwise indicated]

- **Reserves Excluding Gold**. Series '534.1L.DZF..." for India, and series 924.1L.DZF... for India. Both were quoted in dollars ($).
- **Period Average Exchange Rate**. Series '534..RF.ZF..." for India and series '924.WF.ZF…' for China. Both series were quoted in the national currency per US$ at the end of the period.
- **Nominal Daily Effective Exchange Rate**. Data obtained from the Federal Reserve Bank of St. Louis. The series ID is DENIXUS for India and DEXCHUS for China. The original source is The Board of Governors of the Federal Reserve System. Note: the exchange rates correspond to noon buying rates in New York City for cable transfers payable in foreign currencies.
- **Exports**. Series '53470...ZF...' for India, quoted in Rupees and transformed into $ using the period average exchange rate. Series '92470..DZF...' quoted in $.
- **GDP Deflator**. Obtained from the World Bank's *World Development Indicators* database.

Quadratic Match Sum Process

This method fits a local quadratic polynomial for each observation of the low frequency series and then uses polynomials to fill in all observations of the high frequency series associated with the period. The quadratic polynomial is formed by taking sets of three adjacent points from the source series and fitting a quadratic so that either the average or the sum of the high frequency points match to the low frequency data actually observed. For most points, one point before and one point after the period currently being interpolated are used to provide the three points. For end points, the two periods are both taken from the one side where the data is available. This method is a purely local method. The resulting interpolation curves are not constrained to be continuous at the boundaries between adjacent periods. Because of this, the method is better suited to situations where relatively few data points are being interpolated and the source of the data is fairly smooth.

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