Working Paper Series: WP 1402

The demand for international reserves of Bangladesh

By

Sadia Afrin[1]
Md. Waheduzzaman Sarder[2]
Md. Golzare Nabi[3]

January, 2014

1 and 2 Deputy Director and Joint Director of Monetary Policy Department and 3 Deputy General Manager of Research Department, Bangladesh Bank, Head Office, Motijheel, Dhaka-1000.
Email: sadia.afrin@bb.org.bd; waheduzzaman.sarder@bb.org.bd; golzare.nabi@bb.org.bd

Contents

List of Tables

List of Figures

The demand for international reserves of Bangladesh

Abstract

Many emerging economies are stockpiling their international reserve holdings including the South Asian countries like Bangladesh. Holding foreign exchange reserves involves both benefits and costs. Thus holding reserves to an optimal level and knowing the determinants of foreign exchange reserves are important. This paper attempts to analyse the adequacy of current reserve holding of Bangladesh by some benchmark ratios and then estimates the reserve demand function applying Johansen cointegration technique and then estimates the short run dynamics by error correction model. Along with other determinants of long run reserves, the study includes monetary disequilibrium following Badinger (2004) in the short run model. The findings of the study based on quarterly data over period 1997-2012 suggest current account vulnerability (import to GDP) and exchange rate flexibility play important role in Bangladesh's reserve demand.

Key words: International reserves, monetary disequilibrium, GARCH, Johansen cointegration test, Bangladesh.

JEL Classification Numbers: F4, F31, F32, C22

The opinions expressed in this paper are those of the authors and do not reflect the views of Bangladesh Bank.

The demand for international reserves of Bangladesh

1 Introduction

The rationales for maintaining adequate level of foreign exchange reserves include safeguarding value of domestic currency, international payment obligations, boosting a country's credit worthiness and providing insurance against external shocks. In the aftermath of the East Asian crisis in 1997-98, developing countries concentrated on increase their international reserves holding as a safeguard of external imbalances and to protect the value of their domestic currencies. At the end of March 2012, emerging markets and developing economies together held 60.24 per cent of world's total international reserves. Management and associated marginal benefits and costs of holding such huge reserve are now important issues for central bankers. The reserve basket of Bangladesh, like most other countries, consists of different foreign currencies, gold, reserve position in the IMF and special drawing rights (SDR), which are under control of the central bank and readily available for any balance of payments financing. Bangladesh, like other emerging Asian countries, is also stockpiling international reserves and achieved the second position in South Asia in August 2013 with a reserve level of above USD 16 billion.

Holding international reserves has both benefits and costs; therefore, it is important to know the optimal level of international reserves for a country. Some critics argue that holding dollar denominated reserves is costly as keeping reserves in US treasury gives only a modest return and far below the costs of borrowing of the government. Rather, a higher return can be achieved by making real investment in the economy such as roads, bridges. So, why should the money be kept as reserves and why should the government pay higher interests for outstanding liabilities. Summers (2006) thinks excessive reserves to be wasteful because of large infrastructure and social needs in emerging markets. Certainly, Bangladesh has huge investment needs for infrastructure and other economic sectors.

On the other hand, proponents of stockpiling reserves stress more on macroeconomic imbalances such as currency or financial crisis in today's macro environment than the opportunity costs of holding reserves. In the event of balance of payment crisis international capital market may shut their doors and IMF bailout is also not guaranteed. So, to forestall or weather such crisis this group believes that it is necessary to build high reserves stock (Aizenman and Marion, 2003). Another theoretical and traditional role of holding reserves is

to maintain the fixed exchange rate. Monetary authorities frequently use foreign exchange to intervene in market to keep the value of the domestic currency at target level. So, theoretically if countries increasingly move to a free floating regime where exchange rates are allowed to move freely in the market, then demand for reserves are supposed to be smaller. But in reality, the 'fear of floating' (Calvo and Reinhart 2002) may keep central bankers stockpiling reserves of foreign currencies. Foreign exchange reserves can also save the domestic banking sector and the credit sector in particular, from outflows of domestic or external resources (Obstfeld, Shambaugh and Taylor 2007).

Based on the debate of these two groups it can be concluded that reserve accumulation to a certain level is a prudent macroeconomic decision while slowing down the pace of reserve accumulation is also advisable as it may lead to increasing costs beyond a certain level. For effective reserve management, the monetary authority needs to know what factors generate demand for reserves in the economy and analyse the level of reserves to know whether it is truly higher than the safe level.

There are five key factors that explain reserve holdings such as economy size, current account vulnerability, capital account vulnerability, exchange rate volatility and opportunity cost (IMF World Economic Outlook 2003). One of the prime motives for which countries hold reserves is to smooth unpredictable fluctuations in consumption and import payments which can be called the 'precautionary motive' of holding reserve (IMF 2003). Countries want to avoid the risks of devaluation of domestic currencies and maintain their sovereign risk ratings in the face of macroeconomic imbalances. At the onset of severe currency devaluation, the central bank can easily buy its currency with its foreign exchange reserve to preserve the value of the domestic currency at target level. Disequilibrium in the national money market can also translate into reserve demand in the short run; hence, reserve demand analysis without the money market ignores an important role of monetary approach to balance of payments (Badinger 2004). If the monetary approach to balance of payments holds for a country, then it implies that excess demand for money is associated with an inflow of international reserves. This paper intends to find out whether this theory holds for Bangladesh following Badinger (2004).

Bangladesh has recently been acquiring foreign exchange reserves at a good pace in the South Asian region and as an emerging economy; it also has huge real investment demand. Thus it is important to investigate whether the reserve position of Bangladesh is higher than

warranted by fundamentals and the factors actually determining the international reserve demand of Bangladesh. Thus, the paper attempts to analyse the reserve demand of Bangladesh.

Literature Review

There are numerous empirical works on the demand for foreign exchange reserves based on single country as well as cross country data that takes into account various motives and factors into the reserve demand model. The East Asian economic crisis (1997-98) led many countries to compile huge foreign exchange reserves. Consequently many investigations have been done on the level of holdings of the countries in this region. The World Economic Outlook (September 2003) investigates whether the reserve holding of emerging economies is too high using panel data of 122 emerging market economies over period 1980 to 2002. The main finding is,- reserves in many emerging economies have risen more rapidly since 2001 than warranted by fundamentals. The study therefore concludes that the reserve accumulation of these countries has reached to such a level that some slow down in the pace of reserve accumulation is desirable.

Aizenman and Marion (2004) derive a precautionary demand for international reserves in the presence of sovereign risk and find that political economy considerations change the optimal level of reserve holdings. They find that opportunistic behaviour by government and political corruption increase current consumption, external borrowing and reduce reserve demand. But a strict government with planned fiscal expenditure tends to chose higher reserve holding.

Using the vector error correction approach Badinger (2004) estimates the international reserve demand function for Austria and takes into account the role of monetary approach to balance of payments. This study finds that imports, uncertainty and the opportunity cost of holding reserves determine the long run reserve demand of Austria and confirms that monetary disequilibrium affects the short run reserve demand based on data for the period 1985-1997. For example, an excess demand (supply) for money in domestic money market will induce inflow (outflow) of international reserves. The finding of this study is important as it takes into account the disequilibrium in the domestic money market in reserve demand function, something not commonly found in earlier literature of the subject.

The international reserve demand function of Nigeria has been estimated by Irefin and Yaaba (2012) using the autoregressive distributed lag approach. This study estimates a modified

'Buffer Stock models' of Frenkel and Jovanovic (1981) to identify the determinants of Nigeria's reserve demand and finds strong evidence that income is a major determinant of reserve holdings and the inverse relation between imports and reserves debunks the buffer stock model.

Not only the East Asian but also the South Asian countries are increasing their holdings of international reserves especially India, Bangladesh. India is the highest reserve holder in South Asia. Prabheesh et al (2007) estimate the foreign exchange reserve demand of India using the co-integration and vector error correction approach for the period 1983 to 2005. Their findings suggest that ratio of imports to GDP, ratio of broad money to GDP, exchange rate flexibility and interest rate differential determine India's long run demand for international reserves. In addition, they find that reserve accumulation is highly sensitive to capital account vulnerability and less sensitive to opportunity costs. The study however does not take into account the monetary approach to balance of payments.

Although some empirical works as mentioned earlier have found that reserve position in emerging market economies is higher than the safe level, a panel data study conducted by Ruiz-Arranz and Zavadjil (2008) on emerging Asian economies finds a different conclusion. Using insurance model of reserve demand they show that the reserve holdings of emerging Asian countries' (except China) is not too high and these countries can still acquire benefits from reserve accumulation. In this study the authors conducted traditional benchmark analysis of reserve adequacy such as reserves to import, broad money, short term external debts as well as to gross external liabilities which is an indicator not used in most other studies.

The international reserve demand model of India estimated by Sharma and Mishra (2011), addresses the shortcoming mentioned above in the study of Prabheesh et al (2007) by considering the effect of monetary disequilibrium in the model. This paper calculates the exchange rate volatility by extracting the conditional variance from an estimated GARCH model which is more reasonable than earlier rolling standard deviation method of calculating exchange rate volatility. The study identifies that scale of foreign trade, uncertainty (short term external debt) and profitability considerations play significant role in determining India's reserve holding. An important finding of this study is that national monetary disequilibrium has an important role in short run reserve movements, a finding similar to that of Badinger (2004) for the Austrian economy.

Although a good number of empirical works on determinants and adequacy of international reserves have been done on emerging market economies, no significant empirical work on Bangladesh has been done yet. The main determinants of international reserves of Bangladesh as well as the adequacy level are yet to be investigated. Islam (2009) tries to analyse these issues by carrying out some traditional benchmark analysis for reserve adequacy over the period 1997-98 to 2008-09 but fails to apply any econometric model to determine the significant factors playing role in reserve demand function of Bangladesh or its adequacy level. The study finds that Bangladesh's reserve holding is not markedly higher than what is required and concludes that Bangladesh's reserve build up is due to an 'investment drought' in the economy which is due to underdeveloped financial system and infrastructure problem.

The international reserve demand function of Bangladesh has not been established empirically till now. Hence, it is important to carry out a quantitative analysis to determine the factors in this function and the adequacy level as Bangladesh's reserve holding is increasing continuously in recent years. This paper attempts to fill this gap in reserve demand literature by carrying out an empirical investigation of reserve demand function for Bangladesh and its sufficiency level for the period 1997-2012. The main research question of this study is then is as follows: what factors determine the international reserve demand of Bangladesh and has the current reserve holding reached a level sufficiently higher than what is required? The result of this study indicates that the ratio of import to GDP (average propensity to import) and exchange rate flexibility are important determinants of long run reserve demand in the case of Bangladesh.

The study expects to contribute to existing empirical works by identifying the factors playing role in the short run and long run reserve demand function of Bangladesh for the first time using econometric model with most recent data. Second, testing the adequacy level of international reserves with most recent data will indicate whether Bangladesh really holds higher levels of reserves than warranted by fundamentals. Third, the study will test whether the monetary approach to balance of payments has been working in case of Bangladesh following Badinger (2004) to find out if disequilibrium in domestic money market induces change in reserve flow in the short run. Fourth, the estimated reserve demand function of the study can be used to know the optimal reserve level and the outcome can shed light on the reserve management of Bangladesh. In sum, this study not only attempts to investigate the international reserve demand of Bangladesh for the first time to know the significant factors

behind it but also uses well established econometric model to quantify their effects using most recent data.

The rest of the paper is organized as follows: Section 2 analyses the adequacy of Bangladesh's reserve level using the benchmark analysis, Section 3 describes the methodology of estimating long run and short run reserve demand functions and data description, Section 4 presents the empirical estimates of the long run and short run reserve demand function along with the intermediate steps taken for calculating exchange rate volatility and monetary disequilibrium. Finally, Section 5 brings out policy implications and draws concluding remarks.

2 Foreign exchange reserves adequacy of Bangladesh

Each country has its own unique characteristics and comparing simply the level of reserves between countries cannot indicate their adequacy levels. Based on the above discussions of various empirical works on reserve determinants and particularly following IMF World Economic Outlook (2003), we analyse the level of sufficiency of Bangladesh's international reserve holding using three ratios: reserves to import payments, reserves to broad money and reserves to short term debts.

2.1 International reserves in terms of months of imports

The ratio of reserves to import payments measures how many months a country is able to pay for its imports, if all other inflows and outflows are stopped. It is a widely used rule of thumb that sufficient reserves of a country should be a level equivalent to three or four months' import payments of that country (Fischer 2001).

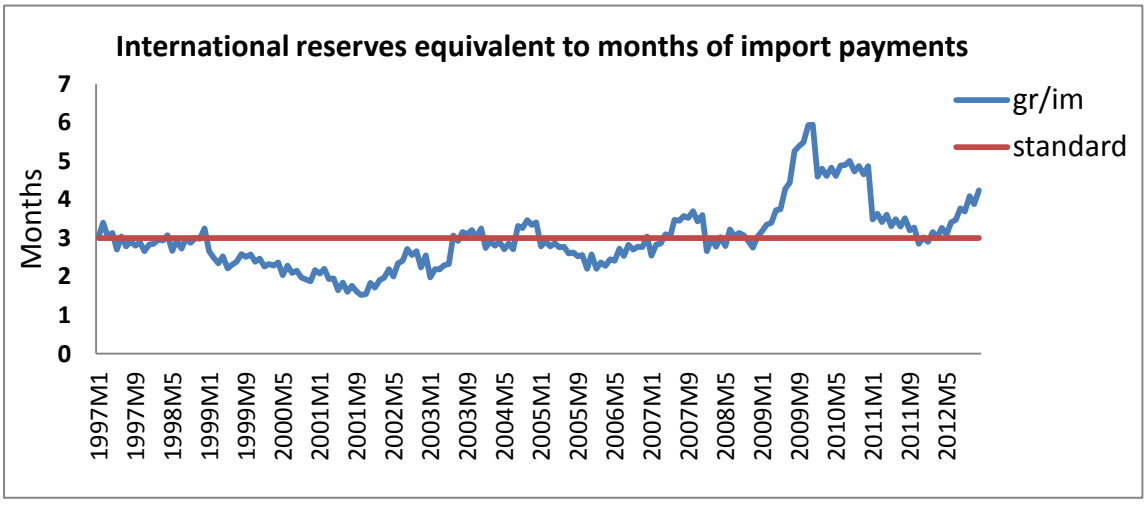

Figure 1 Ratio of international reserves to imports payments. **Data Source** International Financial Statistics (IFS) and Bangladesh Bank (BB)

This measure is simple and particularly useful indicator in cases where the balance of payments instability arises mostly from current account (Bird and Rajan 2003). The reserves (excluding gold) to import ratio of Bangladesh as depicted above fails to meet the traditional benchmark of 3 months of imports (though the rule is not substantiated theoretically) (Ruiz-Arranz & Zavadjil 2008) for several years after 1998. However, the reserves inflow of Bangladesh has been increasing significantly since 2009 and reaching to a level equivalent to six month's import payments in 2009. So, this ratio indicates Bangladesh's current reserve level (which is equivalent to months import payment) has reached a level sufficient enough to tackle current account instability but not too high than required to slow down the pace of reserve accumulation.

2.2 International reserves to broad money

The ratio of reserves as a percent of broad money is a measure of resilience of outflows from the domestic banking system but this rule too does not have theoretical substantiation (Ruiz-Arranz & Zavadjil 2008).

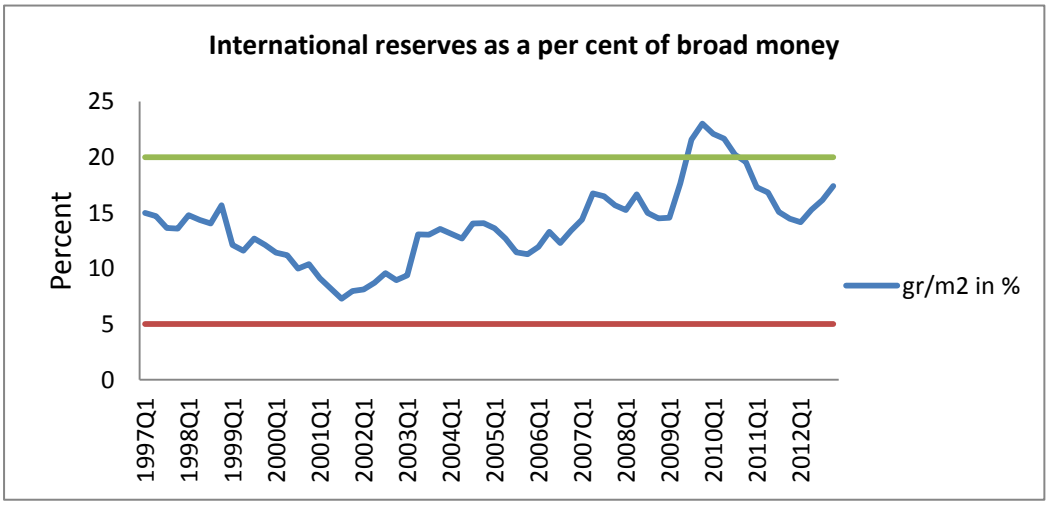

Figure 2 Ratio of international reserves to broad money. **Data source** IFS & BB

Wijnholds and Kapteyn (2001) recommend a range of 5-20 per cent for this ratio for countries with a free floating exchange rate regime and the range for fixed or managed float is 10-20 per cent. This ratio in case of Bangladesh is within the range of 5-20 per cent over the period 1997 to 2012. So, this indicator implies Bangladesh has sufficient reserves to avoid any currency crisis over the period of our analysis.

2.3 International reserves to short term external debt

This indicator is relevant most for countries which borrows heavily from international financial markets (Mishra and Sharma 2011). Bangladesh's short term borrowing from international market is not that high. Bangladesh Bank (BB) has recently allowed private enterprises to take advantage of low-cost borrowings from international financial markets for working capital loan (short term) in the form of 'buyers credit' and 'discounted export bills' (BB MPS July-December 2013).

The bench mark for the ratio of reserve to external debt should be one according to the Greenspan-Guidotti rule.

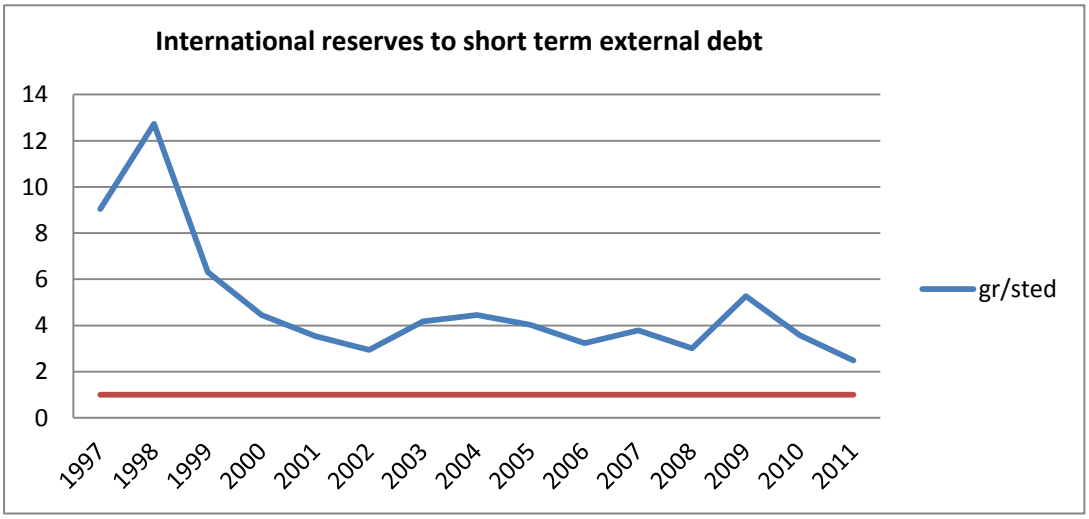

Figure 3 Ratio of international reserves to short term external debt. **Data source** IFS & World Development Indicators.

The ratio of reserves to short term external debt for Bangladesh is quite high (greater than 1) suggesting that the current holdings of international reserves as adequate.

3 Model specifications and data description

Next we turn to the empirical model that incorporates various determinants of reserve demand for Bangladesh. Following IMF World Economic Outlook (2003) and in the context of Bangladesh, the determinants and their relevant explanatory variables that we include in our model are, current account vulnerability denoted by imports to GDP ratio (average propensity to import), capital account vulnerability by M2 to GDP ratio, exchange rate volatility and opportunity cost of reserve holding by the difference between domestic and foreign interest rates. So, the long run reserve demand equation can be stated as:

$$LGR = a + bLAPI + cL\left(\frac{M2}{GDP}\right) + dLXVOL + eIRD \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, LGR = log ($gross\ reserve - gold$); LAPI = average propensity to import = log ($\frac{import}{real\ GDP}$); L ($\frac{M2}{GDP}$) = log ($\frac{M2}{real\ GDP}$) and M2=broad money; LXVOL= log (exchange rate volatility); IRD = domestic interest rate – foreign interest rate. The coefficients of the respective variables are b, c, d, e, and a is the constant term. All the variables in (1) except the interest rate differential (IRD) are in log form.

While considering reserves, we exclude gold from gross reserve data in the entire study as gold is not considered as an intervention asset by the central bank of Bangladesh.

The import/GDP ratio, or, the average propensity to import, is a measure of current account vulnerability which is expected theoretically to appear with a positive sign in the reserve demand model. The ratio broad money to GDP accounts for the capital account vulnerability in our model which also is expected to appear with a positive sign. The measure of exchange rate volatility gives us the measure of exchange rate flexibility in the economy. If exchange rate is allowed to fluctuate freely, then the central bank requires no reserve for pegging purposes. Alternatively, in a fixed exchange rate regime (lower volatility) the demand for reserves should be high to maintain the fixed peg. Thus, XVOL should have a negative sign theoretically. Finally, we include interest rate differential in the model to know whether opportunity costs of holding reserves affect reserve accumulation of Bangladesh. If opportunity cost of holding foreign exchange reserves is high, the central bank should then reduce its reserve holdings, hence the IRD variable should appear with a negative sign. Therefore, our long run international reserve demand function reduces to current account vulnerability, capital account vulnerability, exchange rate flexibility and opportunity costs.

To calculate exchange rate volatility series, we estimate an ARCH model following

Mishra and Sharma (2011). In this study, the conditional variance is extracted from the estimated Generalized Autoregressive Conditional Heteroscedastic (GARCH) model designed by Bollerslev (1986). There are benefits of using conditional variance of the GARCH model over the traditional rolling standard deviation method. First, GARCH specification incorporates volatility clustering features of data and accounts for heteroscedasticity in the model (Bollerslev 1986). Second, unlike rolling standard deviation, this model allows the exchange rate variance to be time dependent (Mishra and Sharma

2011). Finally, the model allows exploiting the existing pattern of and persistence in volatility behaviour (Pozo 1992). The GARCH (p,q) model can be written as,

$XVOL_t = \mu + \varepsilon_t$ ..... (2)

Where, μ is the mean, and $\varepsilon_t / \Omega_{t-1} \sim N(0, h_t)$. ε_t is the error term conditional on information set Ω_{t-1} and normally distributed with mean zero and variance h_t.

$$h_t = \partial + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \beta_i h_{t-i} \quad \text{..... (3)}$$

Given that, $\delta > 0$; $\alpha_i \geq 0$ and $\beta_i \geq 0$. Equation (2) is the conditional mean equation and (3) is variance equation. The above inequality restrictions ensure that conditional variance h_t is positive. The significance of α_i indicates the presence of volatility clustering in the model. The sum of α and β in our GARCH(1,1) model should be around 1. If this is not the case, we impose the I-GARCH restriction on the model while estimating and then arrive at the conditional variance from the estimated model.

For interest rate differential (IRD) variable we can consider either call money rates, deposits rate or Treasury bill rates for Bangladesh and United States. Aizenman and Marion (2004) use all these rates for different countries in their panel data study based on availability criteria. Here, we choose 91 day T-bill rates for Bangladesh and US T-bill rate to calculate the opportunity costs of reserve holding following Aizenman and Marion (2004):

$IRD = \ln[(1+i)/(1+i^{us})]$ where i^{us} is the US T-bill rate and i is the corresponding rate for Bangladesh. Other commonly used variables in reserve literature such as foreign portfolio investment, short term external debt can not be included in the model due to their very small magnitude and unavailability in required frequency in some cases.

Next we apply cointegration technique developed by Johansen (1988) and Johansen and Juselius (1990) to determine whether there exists any long run relationship among the variables given that all our variables are integrated of order one (I(1)). Because of common use and frequent citation we do not mention the theoretical mechanism of Johansen (1988) and Johansen and Juselius (1990) cointegration technique here.

After confirming cointegration, we estimate the error correction model to get the short run dynamics of reserve demand of Bangladesh and the speed of adjustment. The monetary approach to balance of payments implies that disequilibrium in the domestic money market may affect reserve demand in short run. Badinger (2004) for Austrian economy, Mishra and

Sharma (2011) for Indian economy test whether this theory applies in those countries by including monetary disequilibrium in the short run reserve demand function. In a similar manner, this paper attempts to test this theory in the case of Bangladesh. If there is excess demand (supply) for money in domestic economy, it will induce more inflow (outflow) of reserves and vis-a-vis. The coefficient of disequilibrium variable in the short run model will take positive or negative sign accordingly if this theory does apply to Bangladesh.

In calculating monetary disequilibrium, first, we need to estimate a simple but standard money demand function for Bangladesh. We estimate the following long run money demand equation by using Johansen cointegration technique given the variables included in the model are integrated of order one. If they are stationary at level then we can simply run OLS to get the long run money demand function.

$$M2_t = \varphi_0 + \varphi_1 GDP_t + \varphi_2 R_t + \varphi_3 ER_t + v_t \quad \text{..... (4)}$$

Where, M2t = log(broad money) at time t; GDP_t is the log of real GDP; R is the 3-4 months deposit rate, ER is the log(quarter end rate of BDT per USD) and $v_t$is the stochastic error term.

After estimating the above equation, following Badinger (2004), the monetary disequilibrium ($M2_t^{Dis}$) can be calculated as follows:

$$M2_t^{Dis} = M2_{t-1} - M2_t^* \quad \text{..... (5)}$$

Where, $M2_t^*$ is the equilibrium value of money demand. If $M2_t^{Dis}$ is negative then it indicates excess demand for money and vis-a-vis. Then we incorporate this calculated series into our short run model.

Data

The model is developed using quarterly data from1997 to 2012 from various sources. The gross international reserve (GR) data, excluding gold, is taken from International Financial Statistics (IFS) database in million USD. Average propensity to import (API) is the ratio of import to GDP in log form. The data for import (c.i.f) payments in million USD is taken from a publication of Bangladesh Bank (BB). The data source for real GDP is Bangladesh Bureau of Statistics and quarterly GDP data is not available for Bangladesh, only the annual data series is available. Since all series have quarterly frequency and considering the importance

of GDP data in the model, we have utilised a frequency conversion method- called the quadratic match sum technique – to convert annual GDP into quarterly frequency. This, although not perfect, can give us a picture of the quarterly GDP level to enable us to continue our model with higher frequency data than annual.

The exchange rate (ER) is the amount of Taka per USD at the end of each quarter, taken from IFS. The interest rate differential (IRD) involves two series, first, the 91 day T-bill rate of Bangladesh which is taken from Bangladesh Bank and second, the US T-bill rate is taken from International Financial Statistics (IFS) database. In money demand model, the M2 money data in million USD is taken from Bangladesh Bank. The M2 money in case of Bangladesh is the summation of M1 and time deposits, where, M1 consists of currency outside banks, deposit of financial institutions with BB and demand deposits (Afrin 2013).

4 Empirical results

One of our long run variables is the exchange rate volatility used to measure the effect of exchange rate flexibility on reserve demand. According to our discussion in section 3 we get the following results from estimating GARCH(1,1) model with IGARCH restriction for exchange rate volatility,

$$XVOL_t = \underset{(5.67^*)}{0.2} + \underset{(108.12^{**})}{0.95}XVOL_{t-1} \quad \text{..... (6)}$$

$$h_t = \underset{(0.91)}{0.022}\varepsilon_{t-1}^2 + \underset{(40.89^{**})}{0.97}h_{t-1} \quad \text{... ... ... (7)}$$

[Diagnostic tests: * and ** imply significant at 5% and 1% level respectively. t-value in parenthesis; ARCH = 0.011(p value: 0.91)]

Here, quarterly changes in exchange rates are modelled as first order auto regressive and estimation suggests that the ARCH effect is not significant but that there exists significant GARCH effect in the model as coefficient of h_{t-1} in (7) is highly significant. We extract the conditional variance from this estimated model and use this series as a measure of exchange rate volatility (XVOL) in our reserve demand model.

Before estimating reserve demand function, we have another estimation to perform- this is the money demand function of Bangladesh which is required to calculate monetary

disequilibrium. To do so, first we test unit roots of all the variables mentioned in (4). The unit root tests of the variables in equation (4) are presented in the appendix.

All the variables become stationary at their first difference (integrated of order one, I(1)) except the LM2 variables which is stationary at level at 10 % significance, according to the ADF test criteria. But the Phillips-Perron test suggests LM2 is integrated of order one and we accept this criteria.

Therefore, we use Johansen cointegration technique as discussed in section 3 to estimate the long run money demand function. For cointegration test appropriate lag order need to be selected. In the appendix, we present the lag length selection table after estimating unrestricted Vector Auto Regression. Most of the criteria choose complex model but we choose lag 1 based on the Schwarz information criteria. Afterwards we perform Johansen cointegration test, the result of which is presented in Table 1 below along with cointegrating coefficients (both unrestricted and normalized).

Table 1 Johansen cointegration test for money demand function

Trace test			Maximum Eigenvalue		
Rank	Eigenvalue	Trace statistic	Rank	Eigenvalue	Max-Eigen statistic
None	0.423397	70.45797*	None	0.423397	34.13732*
At most 1	0.317716	36.32065*	At most 1	0.317716	23.70315*
At most 2	0.182752	12.61750	At most 2	0.182752	12.51240
At most 3	0.001694	0.105100	At most 3	0.001694	0.105100
Cointegrating vector					
	LM2	LGDP	R	LER	
Unrestricted	16.1	-48.90	-0.155966	-26.74678	
Normalized	1.00	-3.04	-0.01	-1.66	
(s.e)		(0.170)	(0.0109)	(0.117)	

Note: * significant at 5% level. VAR specification selects optimal lag length 1 according to Schwarz criteria.

Both the Trace and Maximum Eigen value test statistic find at least two cointegrating vectors, tested at 5% level. Normalizing the cointegrating equation with respect to money we see,

$$M2_t = 3.04\, LGDP + 0.01R + 1.66LER \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

The coefficient of GDP has expected sign and is significant. The sign of interest rate coefficient is not as expected and the magnitude is small and statistically insignificant. The coefficient of exchange rate can take either negative or positive sign depending on whether an increase of exchange rate increases the value of foreign assets (positive sign) in domestic currency or increases the expectation of further depreciation (negative sign). Here we find the demand for money increases as exchange rate increases and the coefficient is significant as well.

So, the Johansen cointegration test suggests that the variables in money demand function share a common stochastic trend. After developing the money demand equation we can now calculate the equilibrium money demand $M2_t^*$ to get monetary disequilibrium series:

$$M2_t^{Dis} = M2_{t-1} - M2_t^* \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (9)$$

The negative value of the series $M2_t^{Dis}$ indicates excess demand for money. We incorporate the $M2_t^{Dis}$ series into our short run model as the monetary approach to balance of payments theory suggests that monetary disequilibrium affects reserve demand only in the short run.

Long run reserve demand model

In order to estimate the long run relationship among variables in reserve demand model first we test the stationarity property of the variables using both Augmented Dicky-Fuller (ADF) and Phillips-Perron (PP) test procedure. The unit root test results are presented in Table 2:

Table 2 Unit root test for long run reserve demand function

Variables	ADF		Phillips-Perron	
	level	1st difference	level	1st difference
LGR	-2.24	-7.27*	-2.26	-7.27*
LAPI	- 2.52	-8.86*	-2.52	-8.97*
LMGDP	0.58	-5.04*	0.85	-8.42*
LXVOL	-1.69	-7.74*	-1.75	-7.74*
IRD	-2.77**	-4.74*	-2.29	-4.67*

Note: * denotes significant at 1% level & ** significant at 10% level

Summarising the table, we can conclude based on Phillips-Perron test that all the variables in reserve demand function are integrated of order one. Therefore, we can apply Johansen and Juselius (1992) cointegration technique to determine if there exists any long run relationship

between the foreign exchange reserve and other explanatory variables in the model. After estimating an unrestricted Vector Auto Regression (VAR) we choose an appropriate lag length for the cointegration test. We choose lag order 4 based on the Akaike information criterion (AIC) from our estimated VAR (see appendix for lag order selection) and the residuals of this VAR are found uncorrelated and homoscedastic. Next we perform the Johansen cointegration test, the result of which is presented in Table 3 below.

Table 3 Johansen cointegration test for reserve demand

Trace test			Maximum Eigen value test	
Rank	Trace statistic	5% critical value	Max-Eigen statistic	5% critical value
None*	76.01*	69.82	35.55*	33.88
At most 1	40.46	47.86	20.18	27.58
At most 2	20.28	29.80	12.86	21.13
At most 3	7.42	15.50	6.81	14.26
At most 4	0.61	3.84	0.61	3.84
*denotes reject null hypothesis at 5% significance level				
Cointegrating coefficients				
	LGR	LAPI	LMGDP	LXVOL	IRD
Unrestricted	9.41	-21.12	2.72	19.20	24.82
Normalized	1.00	-2.25*	0.30	2.04*	2.64
(standard error)		(0.341)	(0.355)	(0.329)	(2.018)

Note: *denotes significant at 5% level

We see both trace and Eigen value test find one cointegrating vector. So, there is a common stochastic trend in the variables of long run reserve demand function tested at 5% level. The lower part of the table gives unrestricted and normalized (with respect to reserve) cointegrating coefficients with standard error in parenthesis. So, the long run cointegrating equation among the reserve demand function for Bangladesh can be written as,

$$LGR = 2.25\ LAPI - 0.3\ LMGDP - 2.04 LXVOL - 2.64\ IRD \dots\dots\dots\dots\dots\dots\dots\dots\dots (10)$$

The normalized cointegration equation (10) finds that all the variables, except (M2/GDP) ratio, have desired sign and the standard error in parenthesis in Table 3 shows, two variables have significant impact on the long run reserve demand of Bangladesh.

First, we see the ratio of import to GDP has a positive and high extent significant impact on the international reserve demand of Bangladesh. A one per cent increase of import to GDP ratio increases reserve demand by more than two per cent, given, the impact of all other variables are stopped. So, one of the main reasons of reserve holding by Bangladesh Bank is the precautionary motive and in reality the result is supported by the persistent deficits in current account balance till the recent past. The result is also similar to the findings of Prabheesh et al (2007) and Mishra & Sharma (2011) on Indian economy. The coefficient of broad money to GDP on the other hand is small in extent and the sign is not desired. However, the coefficient is statistically insignificant suggesting that the capital account vulnerability has no impact on the long run reserve demand of Bangladesh. This is in line with reality as the capital account of Bangladesh is not fully open due to fear of capital flight. So this does not pose any significant risks on the economy in long run. Therefore, this indicator does not appear to influence the central bank to accumulate reserves in this study.

The coefficient of exchange rate volatility has desired sign as discussed in the model description and is statistically significant. The result indicates that a one per cent increase in exchange rate volatility reduces the reserve holding by two per cent roughly. Bangladesh has a floating exchange rate regime, not entirely market determined but managed to some extent. The estimated result suggests that the more Bangladesh moves to a free floating regime, the less foreign exchange reserve it will demand in the long run, assuming that the effects of all other determinants constant. If the exchange rate is allowed to move freely, then the central bank will not need to stockpile reserves to keep the peg or increase its credibility. The finding of this study is similar to Aizenman & Marion (2004) for panel data of 100 developing countries and Mishra and Sharma (2011) for the Indian economy. Hossain and Ahmed (2009) find low relative volatility of reserve, exchange rate and interest rates from 2006 to 2008 indicating active intervention by Bangladesh Bank in this period in the foreign exchange market. So, this partly explains the increasing reserve accumulation by Bangladesh Bank. Finally, the coefficient of interest rate differential appears with expected negative sign but is statistically insignificant. Ben-Bassat and Gottilieb (1992) show that if the opportunity cost is measured properly, it can be a significant determinant of foreign exchange reserve. The interest rates in Bangladesh became gradually market oriented during 1997 (Bangladesh Bank 1997, BCD circular 1). The calculated interest rate differential in the model may not reflect the true opportunity cost of holding reserve. Aizenman & Marion (2004) find the reasons behind poor explanatory power of interest rate differential as, 1) interest rates are not

market determined, 2) the yield on international reserve should reflect their currency composition, which is not fully captured by US treasury rate and 3) the standard interest differential probably does not capture the true opportunity costs of holding reserve. So, any one of these limitations may have affected our estimation and made the impact of interest rate differential insignificant.

Short run model and the role of monetary disequilibrium

To see the short run dynamics, the speed of adjustment and the role the monetary disequilibrium play on reserve demand, we estimate an error correction model where we include the $M2_t^{Dis}$ variable. The week exogeneity test in our cointegration test suggests that L(M2/GDP) and IRD variables are weekly exogenous. In addition the Jarque-Berra normality test for LAPI and LXVOL are significant at 10 % and 1 % level respectively. In this situation rather than adopting structural approach, we opt for single equation error correction estimation following Badinger (2004) where $M2_t^{Dis}$ enters into the model as an exogenous variable. The estimated result of the short run model is presented below:

$$\Delta LGR_t = -10.2 - 0.001\Delta LGR_{t-1} - 0.027\Delta LAPI_t - 0.02\Delta LAPI_{t-1} + 0.01\Delta LMGDP_t -$$

(4.053)* (0.1405) (0.119) (0.117) (0.4105)

$$1.4\Delta LMGDP_{t-1} - 0.23\Delta \mathrm{LXVOL_t} - 0.1\Delta \mathrm{LXVOL_{t-1}} - 1.05\Delta \mathrm{IRD_t} - 0.80\Delta \mathrm{IRD_{t-1}} -$$

(0.452)* (0.311) (0.282) (1.387) (1.375)

$$0.15\mathrm{ECM_{t-1}} - 0.41\mathrm{MDIS_{t-1}} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad (11)$$

(0.074) ** (0.162) *

(Diagnostic tests: R-square = 0.33, F statistic = 2.23 [0.03], Durbin-Watson =1.92, Jarque-Bera= 3.67[0.158], BG LM test $\chi2$ (2) = 0.86 [0.65], Heteroskedasticity: BPG test statistic $\chi2$ (11) = 11.22 [0.43])

Note: Δ *is for difference,* * indicates significant at 1% & ** indicates significant 5% level. Values in parenthesis are standard errors and in diagnostic test part, the values in square brackets are p-values of the respective test.

The diagnostic tests of the estimated equation (11) indicate that the short run model is well fitted and overall significant, tested at 3 per cent level (F-test). Durbin-Watson and BG LM test show the model has no autocorrelation problem. The Jarque-Bera normality test confirms

that residuals are normally distributed and the BPG heteroskedasticity test ensures no heteroskedasticity problem in the model.

The result shows that the coefficient of lagged difference of reserve appears with negative sign representing the oscillating behaviour around the long run equilibrium level though this is not significant statistically. The ratio import to GDP and the exchange rate volatility that appear to have significant impact on reserve demand in the long run are not significant in the short run. The difference of broad money to GDP ratio although has the desired positive sign but not statistically significant while the one period lagged difference of this ratio is statistically significant but has a negative sign. One of our main concerns in the short run model is the coefficient of monetary disequilibrium which has a theoretically correct sign (negative) and statistical significance. According to the theory, the excess demand for money should induce inflows of reserve in the short run. So, the construction of this series in (9) suggests the coefficient has correct sign with statistical significance. Thus we find the theory of monetary approach to balance of payments holds for Bangladesh economy. Finally, the error correction (adjustment) coefficient has the desired sign and magnitude (-0.15) to ensure the system's convergence to long run equilibrium, tested at 5% level. So, 15 per cent of the deviations from its long run level in the reserve demand function is corrected within a quarter. The low speed of adjustment with increasing accumulation of foreign exchange reserve is similar to Clark's proposition (Clark 1970) that a country with low speed of adjustment requires higher foreign exchange reserves to finance its balance of payments. The speed of adjustment may increase if Bangladesh Bank involves itself in active reserve management.

5 Conclusion and policy implications

The objective of this study was to investigate what factors determine the demand for international reserves of Bangladesh and whether the current holding of reserves is adequate in relation to the fundamentals of the economy. The finding of the study indicates that imports and exchange rate volatility play the most important role in determining reserve demand in the long run whereas disequilibrium in the domestic money market has a significant role in the short run reserve demand.

The significance of the average propensity to import (log (import/GDP)) in the study suggests that current account vulnerability leads the central bank to stockpile foreign exchange reserve. So the reserve accumulation of Bangladesh is a precautionary measure against its

current account vulnerability as in the case of many other developing countries as found in various empirical works. Although Bangladesh has resorted to a floating exchange rate regime, it frequently intervenes in the foreign exchange market to reduce excessive fluctuations of exchange rates. Thus, the central bank has incentives to gather reserves to avoid excessive fluctuations and keep exchange rate volatility in a narrow band. So, this tendency of managing float by Bangladesh Bank may lead it to stockpile foreign exchange reserves.

The benchmark analysis for reserve adequacy suggests that Bangladesh currently holds adequate reserves in terms of traditional indicators but the level does not appear to be too high than required during the period of our analysis. Therefore, the central bank can still concentrate on reserve accumulation so that no sudden financial crisis hampers Bangladesh's international transaction or disrupt macroeconomic stability. However, the demand for investment fund in domestic economy needs to be considered also. Spending funds on infrastructure projects has higher return than stockpiling the money as excessive reserve in foreign bank account. Governance plays role in economic decision making. Aizenman and Marion (2004) find corruption can act as a tax on the return of reserve holding and thus can reduce optimal holdings. So, analysing reserve demand in view of the political economy of Bangladesh can be an interesting future research area.

Thus the study identifies the main determinants of foreign exchange reserves for Bangladesh and is able to conclude that though the current reserve meets adequacy requirement, it is not too high at least in comparison with many other Asian countries. Hence, the central bank's accumulation of high foreign exchange reserves seems prudential in the current context of Bangladesh.

Appendix

Table 1 Unit root test: money demand function

Variables	Augmented Dicky-Fuller (ADF)		Phillips-Perron (PP)	
	level	1st difference	level	1st difference
LM2	2.65***	-9.75*	-2.34	-12.22*
LGDP	-2.42	-3.12@	0.65	-2.98**
R	-2.52	-5.67*	-1.63	-5.59*
LER	-2.16	-3.85*	-1.46	-7.72*

Note: *, ** & *** denote significant at 1%, 5%, 10% level respectively and @ significant at11% level.

Table 2 Lag order selection: money demand function

VAR Lag Order Selection Criteria
Endogenous variables: LM2 LGDP R LER
Exogenous variables: C
Sample: 1997Q1 2012Q4
Included observations: 59

Lag	LogL	LR	FPE	AIC	SC	HQ
0	92.87411	NA	5.78e-07	-3.012682	-2.871832	-2.957699
1	449.3047	652.4491	5.63e-12	-14.55270	-13.84845*	-14.27779
2	475.0766	43.68125	4.08e-12	-14.88395	-13.61630	-14.38911
3	500.0574	38.95306*	3.07e-12*	-15.18839	-13.35734	-14.47362*
4	515.9435	22.61750	3.20e-12	-15.18452	-12.79007	-14.24983
5	533.9597	23.20731	3.18e-12	-15.25287*	-12.29502	-14.09824

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 3 Lag order selection: Reserve demand function

VAR Lag Order Selection Criteria
Endogenous variables: LGR LAPI IRD LXVOL LMGDP
Exogenous variables: C
Sample: 1997Q1 2012Q4
Included observations: 58

Lag	LogL	LR	FPE	AIC	SC	HQ
0	219.8260	NA	4.17e-10	-7.407795	-7.230170	-7.338606
1	538.1537	570.7945	1.70e-14	-17.52254	-16.45680*	-17.10741*
2	570.3878	52.24141	1.35e-14*	-17.77199	-15.81813	-17.01092
3	585.9822	22.58494	1.96e-14	-17.44766	-14.60567	-16.34065
4	621.9119	45.84134*	1.48e-14	-17.82455*	-14.09444	-16.37159
5	641.1825	21.26417	2.14e-14	-17.62698	-13.00875	-15.82809

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

References

Aizenman, J & Marion, N 2004, 'International reserve holdings with sovereign risk and costly tax collection', *The Economic Journal*, vol.114 (July), pp.569-591.

Aizenman, J, & Marion, N 2003, 'The high demand for international reserves in the Far East: What is going on?', *Journal of the Japanese and International Economics*, vol.17, pp. 370-400.

Afrin, S 2013, 'Fiscal deficits and inflation: the case of Bangladesh', Chief Economist's Unit Working Paper 1303, Bangladesh Bank, Dhaka.

Annual Report of the Executive Board, April 30 2012, International Monetary Fund.

Badinger, H 2004, 'Austria's Demand for International Reserves and Monetary Disequilibrium: The case of a small open economy with fixed exchange rate regime', *Economica*, vol.71, pp.39-55.

Bangladsh Bank, the central bank of Bangladesh: < http://www.bb.org.bd/>

Bangladesh Bank 2013, 'Monetary policy statement, July-December 2013', Chief Economists Unit and Monetary Policy Department, Bangladesh Bank, Head Office, Dhaka.

Bangladesh Bureau of Statistics, : <http://www.bbs.gov.bd/home.aspx>.

Ben Bassat, A, & Gottlieb, D 1992, 'Optimal international reserves and sovereign risk', *Journal of International Economics*, vol.33, pp.345–62.

Bollerslev, T 1986, 'Generalized autoregressive conditional heteroskedasticity', *Journal of Econometrics*, vol.31, pp.307–327.

Bird, G, & Rajan, RS 2003, 'Too much of a good thing? The adequacy of international reserves in the aftermath of crises', *World Economy*, vol.26, pp.873-891.

Calvo, G & Reinhart, C 2002, 'Fear of floating', *Quarterly Journal of Economics*, vol.117, no.2, pp.379-408.

Clark, PB 1970, 'Optimum international reserves and the speed of adjustment', *Journal of Political Economy*, vol.78, pp.356-76.

Edison, H 2003, Are Foreign Reserves Too High?', *Staff Studies for the World Economic Outlook, September 2003*, International Monetary Fund, Washington.

Fischer, S 2001, IMF/WB international reserves: policy issues forum, Opening remark, International Monetary Fund, Washington DC. Viewed 12 December 2013,

<https://www.imf.org/external/np/speeches/2001/042801.htm>.

Frenkel, JA and Jovanovic, B 1981, 'Optimal International Reserves: a stochastic framework', *Economic Journal*, vol.91, no. 362, pp.507-14.

Hossain, M & Ahmed, M 2009, 'Exchange rate policy under floating regime in Bangladesh an assessment and strategic policy options' BIDS-PRP Working Paper no. 2, Policy Research Programme, Bangladesh Institute of Development Studies, Dhaka.

International Financial Statistics (IFS) database (CD-ROM) April 2013, International Monetary Fund.

Irefin, D & Yaaba, B N, 2012, 'Determinants of foreign reserves in Nigeria: an autoregressive distributed lag approach', *CBN Journal of Applied Statistics*, vol.2, no.2.

Islam, MS, 2009, 'An economic analysis of Bangladesh's foreign exchange reserve', ISAS Working Paper No. 85, Institute of South Asian Studies, National University of Singapore, Singapore.

Johansen, S 1988, 'Statistical analysis of cointegration vectors', *Journal of Economic Dynamics and Control*, vol.12, no.2-3, pp.231–254.

Johansen S & Juselius, K 1990, 'Maximum likelihood estimation and inference on cointegration with application to the demand for money', *Oxford Bulletin of Economics & Statistics,* vol.52, no.2, pp.169–210.

Mishra, RK & Sharma, C 2011, 'The demand for international reserves and monetary equilibrium: new evidence from India', *Journal of Policy Modelling*, vol.33, no.6, pp.901-919.

Obstfeld, M, Shambaugh, JC and Taylor, AM 2008, 'Financial stability, the trilemma, and international reserves', NBER Working Paper No. 14217, National Bureau of Economic Research.

Prabheesh, KP, Malathy, D, & Madhumati, R 2007, 'Demand for foreign exchange reserve for India: a cointegration approach', *South Asian Journal of Management*, vol.14, no.2, pp.36-46.

Pozo, S 1992, 'Conditional exchange rate volatility and the volume of international trade: Evidence from the early 1900s', *The Review of Economics and Statistics*, vol.74, pp.325-329.

Ruiz-Arranz, M & Zavadjil, M 2008, 'Are emerging Asia's reserves really too high?', IMF Working Paper No. WP/08/192, International Monetary Fund, Washington.

Summers, L H, 2006, 'Reflections on Global Account Imbalances and Emerging Markets Reserve Accumulation', L. K. Jha Memorial Lecture. Reserve Bank of India, Mumbai.

Wijnholds, JOB, & Kapteyn, A 2001, 'Reserve adequacy in emerging market economies', IMF Working Paper No. WP/01/143, International Monetary Fund (IMF).

World Economic Outlook (Chapter 2), September 2003, International Monetary Fund, viewed online 28 August 2013: <http://www.imf.org/external/pubs/ft/weo/2003/02/>.

World Development Indicators databank: <http://data.worldbank.org/data-catalog/world-development-indicators>.