Spillover Effects of Foreign Exchange Reserves (FER) Accumulation in Bangladesh: A Vector Autoregression Approach
SPILLOVER EFFECTS OF FOREIGN EXCHANGE RESERVES (FER) ACCUMULATION IN BANGLADESH: A VECTOR AUTOREGRESSION APPROACH

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Saidul Islam **

Abstract
The different financial crises over the world in the recent past have affected the level of reserves in many Emerging Market and Developing Countries (EMDC). Being mindful of repercussions of the back-to-back financial crisis in the nineties on the external sector front, Bangladesh has accentuated Foreign Exchange Reserves (FER) accumulation since the early 2000s. This paper explores the implications of such accumulation on the macroeconomic variables notably economic growth, inflation and exchange rate using a simple 4-variate Vector Autoregression (VAR) model during the period 1973-2017. Surprisingly, the estimate suggests that FER neither leads to higher economic growth nor spurs inflation in Bangladesh. However, disregarding the economic logic, the FER accumulation causes exchange rate appreciation during the period studied. The findings suggest that Bangladesh could not capitalize on the ample FER to enhance economic growth following an export-led growth strategy. But the country had been successful in containing potential inflationary pressures through prudent sterilization operations.

Key Words: Foreign Exchange Reserves, Economic Growth, Inflation, Exchange Rate, Developing Countries.

1. INTRODUCTION
Foreign Exchange Reserves (FER), also known as external reserves, consist of official public sector foreign assets of a country. These foreign assets are readily and largely available at the disposal of the country’s monetary authorities for direct financing of payment imbalances, through intervention in the exchange market to affect the currency or assets of central banks or other monetary authorities held in different reserves countries such as the United States dollars, pound, sterling, euro, yen, etc. (IMF, 1993). Foreign reserves are primarily maintained by countries to support monetary and foreign exchange policies. In addition, it also helps to meet the macroeconomic objectives of safeguarding currency stability and to smoothen the normal functioning of domestic and external payment system. It also serves as a veritable source of funds for the payment of government expenditures overseas, especially those with known import bills for the authorities to meet (Nugee, 1999).

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The fear of financial crisis has necessitated countries, both developed and developing to maintain certain level of foreign reserves in order to intervene in the foreign exchange markets and reduce foreign exchange volatility while also safeguarding the international value of their currencies. For instance, the Asian Financial Crisis has even further highlighted the importance of foreign exchange reserves in weathering a financial turmoil stemming from external sources.

In response to a series of financial crisis notably the Asian Financial Crisis, many Emerging Markets and Developing Countries (EMDCs) have opted for accumulating substantial amount of reserves surpassing the traditional benchmarks to withstand shocks stemming from external sources (IMF 2010, Prabheesh et al., 2007 and Ra, 2007). Drawing on lessons from some known crises and being mindful of the economic fundamentals, similar to other EMDCs, Bangladesh has continued to accumulate reserves over the last several years.

Bangladesh is a small open economy and is bestowed with limited tradable natural resources. Furthermore, with a constrained access to international financial market due to below investment grade sovereign credit rating (Tradingeconomics.com, 2019), the country relies heavily on exports and foreign remittances for foreign exchange reserves. Being an import oriented country, Bangladesh usually runs a sizable trade deficit in its balance of payments (Bangladesh Bank, 2019). Historically, export earnings and foreign remittances played a pivotal role in reducing the balance of payment pressures. As the economy is growing at a faster pace and the government is implementing mega-infrastructural projects across the country, the export earnings and foreign remittances may prove inadequate in accommodating burgeoning imports going forward. Moreover, global uncertainty, be it geopolitical or economic, potentially has great bearing on the foreign remittances. Hence, Bangladesh must accumulate FER on a sustainable basis to meet the domestic needs and cope with global uncertainty (Mansur, 2015).

EMDCs including Bangladesh must accumulate foreign exchange reserves to enable them to smooth out the fluctuations in international trade and capital flows in EMDCs since international trade is not denominated in those countries’ currencies. The current global financial system is susceptible to many risks ranging from currency crisis to sovereign default (Grabel, 2003). FER serve as a cushion or collective insurance in times of crisis (Ocampo, 2007). Feldstein (1999), Rajan (2008) and Banchs and Mollejas (2010) stress that FER hoarding by the EMDCs appears to be a rational response to the asymmetric monetary system since the world economy realizes that there is a lack of credible international lender of last resort as well as regional monetary cooperation. Hence, despite higher social cost, EMDCs are holding larger stock of FER as buffer (Rodrik, 2006).
Alongside financial stability, FER accumulation potentially leaves spillover effects\(^1\) either directly or indirectly on macroeconomic variables through a number of channels. Firstly, it changes the balance sheet of the central banks, financial institutions and economic agents of a country (Mohanty & Turner, 2006; Cruz & Walters, 2008; Shrestha, 2013). Secondly, it enables the authority concerned (mostly central bank) to arrest abrupt movement in exchange rate, which, otherwise, may result in disruptions in inflation and economic growth (Shrestha, 2013). Thirdly, acting as an indicator of the financial strength of a country FER improve the credit standing of that country in the global level. A higher credit standing necessarily helps a country access international capital market as well as avail credit from multilateral development agencies (Drummond et al., 2009; Hviding et al., 2004). Fourthly, FER is essential to import capital goods and raw materials (Shrestha, 2013). Fifthly, FER accumulation, if not perfectly sterilized, leads to growth in money supply, which, in turn, may create inflationary pressure in an economy (Shrestha, 2013).

Although, the issues discussed above are only theoretical possibilities, empirical examinations may reveal the impact of FER accumulation on other macroeconomic outcomes quite convincingly. Few studies have been conducted regarding the impact of FER accumulation on macroeconomic variables. In the context of Bangladesh, no such study has ever been conducted.

Thus, this paper aims to fill in the gap in the foreign exchange literature by exploring the impact/spillover effects of FER accumulation on macroeconomic outcomes, notably economic growth, inflation and exchange rate in the context of Bangladesh.

The rest of the paper is organized as follows: Section 2 reviews the literature on FER accumulation and macroeconomic variables, primarily on the developing countries. Section 3 describes the economic context of Bangladesh in details. Section 4 discusses the research methods and presents the model to be used. Section 5 presents the findings of the study and the following section concludes the paper with some policy recommendations.

2. LITERATURE REVIEW

This section of the paper reviews the relevant literature on FER accumulation. Analyzing a theoretical small open economy model, which includes tradable and non-tradable sectors, Fukuda and Kon (2010) explained the long-run macroeconomic consequences of FER accumulation in developing countries. Using the unbalanced panel data from the Pen World Table Version 6.2, the paper found that increase in FER caused decline in consumption to the extent that the interest rates on foreign

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\(^1\) By spillover effects, the authors mean that with abundant foreign exchange reserves the country may utilize the reserves in a growth enhancing way leading to higher economic growth and may influence the exchange rate favorably so as to minimize the trade gap to the extent possible. Further, reserve accumulation resulting in the level of foreign exchange reserves may contribute to the higher inflation.
exchange reserves are low. The cross-country evidence also showed that such increase in FER boosted up investment and led to higher economic growth provided that the tradable sector is more capital intensive than the non-tradable sector. However, the impact on economic growth is likely to depart when impact is controlled through investment.

In the cross-country study of 92 countries over the period 1960-1999, Polterich and Popov (2002) examined the relationship between reserves build up and long-term economic growth. Estimating a standard growth regression after controlling for other factors, the paper demonstrated that accumulation of reserves is associated with higher international trade, which, in turn, gave rise to higher capital productivity. The paper found that, with equal investment/GDP ratios and population growth, countries building up FER at a faster pace demonstrated higher growth in international trade. The results also showed that policy induced FER accumulation had stronger impact on economic growth than that of actual level of reserves suggesting that FER accumulation in excess of objective needs led to undervaluation of real exchange rate (RER) thereby having a positive impact on economic growth. Identifying a threshold level of GDP per capita equivalent to 67% of US level in 1975, the paper pointed out that countries remaining below that level boosted up growth by piling up FER in excess of objective needs whereas countries belonging to above that level experienced negative impact from FER accumulation. The result was consistent with underlining theory, which states that the logical outcome of FER accumulation is undervaluation of real exchange rate having potential to induce export and international trade in general and hence allows the country to enjoy the export externality (Rodrik, 2009). The developing countries as opposed to the developed countries are the most beneficiaries of such externality since they have not achieved optimal share of trade in GDP.

Elhiraika and Ndikumana (2007) conducted a study on sources, motives and implication of FER accumulation with a particular focus on the impact on the exchange rate, inflation, and public and private investment in the context of 21 African countries. The empirical results suggested that there exists a positive and significant relationship between reserves and public investment in the long-run, although no such relationship was found in the short-run. Going further, the paper investigated the implications of FER build up on private investment. The empirical evidence pointed to the fact that reserves strongly influence private investment in the long-run whereas the short-run influence is weaker. Analyzing the implications of FER hoarding on exchange rate the paper revealed that nominal exchange rate appreciates in both long-run and short-run in response to reserves build up suggesting that the African countries, as opposed to the emerging countries, could not utilize the reserves to keep the exchange rate low and promote international trade.
and competitiveness. The last issue empirically tested in this paper is impact of FER on inflation. The results showed that FER accumulation does not have significant impact on inflation but leaves some impact on price level in the long-run implying that monetary authorities had successfully sterilized the FER hoarding.

Developing a dynamic macro model with a new monetary policy rule (modification of Taylor rule), Shrestha (2016) investigated the effects of FER accumulation on macroeconomic outcomes such as economic growth and inflation. The panel VAR model is estimated using data for the period 1990-2013 of South Asian countries namely Bangladesh, India, Nepal, Pakistan and Sri Lanka. The paper found that the FER accumulation led to higher economic growth of these countries but did not lead to higher inflation significantly. The remittance inflow mainly had driven reserve accumulation in this region and contributed to the economic growth of these countries by enabling them to import capital goods. The paper concluded saying that the countries have the potential to utilize FER productively to materialize higher economic growth and maintain internal and external balances.

Although a score of empirical papers suggested that FER accumulation potentially leaves impact on macroeconomic outcomes, no such study had ever been conducted in the context of Bangladesh. Hence, the paper aims to lend empirical support to existing literature investigating the macroeconomic implications of FER accumulation in Bangladesh. The paper specifically addresses the following research questions.

- Does a higher level of FER enable Bangladesh to achieve higher economic growth?
- Does FER accumulation create inflationary pressure in the Bangladesh economy?
- Could Bangladesh adopt export-led growth strategy through exchange rate devaluation with ample FER?

3. THE MACROECONOMIC CONTEXT OF BANGLADESH ECONOMY

This section of the paper describes the different economic context of Bangladesh in order to understand the dynamics and pattern of foreign exchange reserves accumulation.

3.1 Macroeconomic Developments and Foreign Exchange Reserves

Before focusing on the pattern of foreign exchange reserves accumulation of Bangladesh, it is important to examine the key macro variables that have implications for reserve accumulation. The Bangladesh economy has demonstrated significant economic growth in the past one and a half decades, owing to remarkable improvements in its key macro variables including steady development in its external sectors (Islam, 2009). According to the central bank statistics, the domestic
macroeconomic situation remained resilient in FY 16 amongst global economic shock. The Bangladesh economy continued steady growth with real gross domestic product registering 7% plus growth in FY 2016 breaking the decade long 6% growth trap with inflation at moderate 5.9% (Bangladesh Bank, 2017).

On the other hand, exports and imports have been growing by approximately 225% and 172% respectively over the last decade. Furthermore, while reliance on aid including grant has substantially reduced over the years (Islam, 2009), foreign remittances are rising steeply. As a result, the country’s macroeconomic performance has appeared to be relatively better than that of a decade ago. However, the economy could not perform well in some areas as discussed below.

The figure 1 below highlights the gap between gross domestic savings (% of GDP) and total investment (% of GDP). Generally the gross national savings that incorporate imported savings largely meet the added demand for investment. Figure 1 also reveals that there has been a gap between gross national savings and total investment throughout the period (2005-2016) under study except the gap converging towards near zero in the FY 2014-15. From a macroeconomic point of view, as explained and defined by Islam (2009), this persistent gap between gross national savings (% of GDP) and total investment (% of GDP) is described as either savings glut (as observed in China) or investment drought (as seen in Asia) (Bernanke, 2005; Islam, 2009). In case of Bangladesh, the slope of the investment curve points to investment drought. The investment drought is attributable to an under-developed financial system and structural problems involving improper channeling of savings to investments (Islam, 2009). The savings-investment gap leads to reduced demand for import of capital machinery which in turn leads to a surplus in Bangladesh’s current account (BoP) that eventually ends up in reserves accretion (although the savings-investment balance does not necessarily imply reserve growth per se) (European Central Bank, 2006). The right scale shows the foreign exchange reserve position at the end of every fiscal year.

In order to provide a deeper insight into the foreign exchange reserves of Bangladesh, the dynamics of the balance of payments needs to be understood.

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2 Bangladesh Bank, Selected Economic Indicators, Various issues.
3 Bernanke (2005) defines the term savings glut as a situation when global savings exceed investment opportunity available worldwide; in that case, a country tends to finance its current account surplus instead of investments with those excess savings. This situation is common in developing or industrial countries.
3.2 Sources of Reserves for Bangladesh: Balance of Payments Identities

Evidence suggests that the origins of foreign reserve accumulation might differ across countries. For instance, Elhiraika and Ndikumana (2007) mentioned in their study that some countries manage to maintain positive overall balance in their balance of payment (BoP) accounts resulting from current account surplus. They mentioned that in Latin America, a persistent current account deficit was balanced by a current account surplus for most of the last decade resulting in an overall surplus in the BoP account.

Similarly, since the Asian financial crisis in 1997, many East Asian countries have run capital account deficits while they have managed to maintain current account surpluses continuously with an exception of China, who maintained dual surpluses (UN-DESA, 2007).

Given this, the balance of payments of Bangladesh can be explained using the framework in Elhiraika and Ndikumana (2007). The standard BoP identities as presented in Elhiraika and Ndikumana (2007) are:

\[ CA + KFA + \Delta RES = 0 \]
\[ CA + KFA = -\Delta RES \]

where CA is the current account balance, KFA is the capital and financial account balance and \( \Delta RES \) is the change in reserves. Net errors and omissions are accounted for on the left side.
The current account balance also holds the following identity:

\[ CA = GSA + IA + TA \]

Where, GSA represents balance on goods and services, IA reflects the balance on income and TA represents the balance of transfers.

In case of Bangladesh, the trade balance usually remains negative and IA balance does not contribute significantly to reserves as well. The primary contribution to Bangladesh’s reserve increase comes from foreign remittance, a component of transfer account. Additionally, until recently, capital and financial account balance had also been the source of FER.

### 3.3 Balance of Payment Dynamics in Bangladesh

The BoP position of Bangladesh as shown in figure 2 reveals that the current account balance was positive during the period studied with some volatility recorded. Likewise, the capital and financial account have been running modest surplus throughout the period under study (2003-2016), although a steady decline was reported during FY 2010-11. The balance of payments trend is explained in figure 2. The figure presents the noticeable improvement in the capital and financial account balance during FY 2012-2013. The reason for this improvement could be the sharp increase in aid receipts during July-November 2012 reporting 107% growth over the same period of the previous year, higher foreign direct investment during the same period and increased local borrowing from foreign sources with US $1.49 billion worth of borrowing approved in 2012 as against US $818 million in 2011 (Bangladesh Bank, 2013).

Another striking feature of the figure 2 is the evolving balance of payment pressure during 2010-2011 led by the sharp decline in the current account balance coupled with slowdown in capital and financial account balance. Although exports and imports had been growing fast in the first half of FY 2010-2011 recovering from the preceding year’s slowdown with exports and imports registering 35.9% and 36.7% year-over-year growth respectively in July-November 2010, the trade gap widened because of the larger import base (Bangladesh Bank, 2011). The widening trade gap coupled with moderate growth of workers’ remittance (posting an insignificant 0.21% year-over-year growth in the first half of FY 11 against double digit growth in the corresponding period of the previous year) reduced the current account surplus. With negative balances in the capital and financial account due to the slowing down of foreign aid, the overall balance of payment has dropped into negative in FY 11 (Bangladesh Bank, 2011).
Later, imports picked up substantially in July-November 2011 due to the surge in petroleum imports to fuel the quick rental power plants. However, the significant slowdown in import growth in the second half of FY 12 followed by rapid growth in the first half of FY 12 has led to an overall 7.2% slowdown in the import growth during July-May FY 12. Several factors had contributed to the sluggish import in the second half of FY 12 notably: low food grain import due to excellent harvest and restrained monetary policy leading to reduction in overall import demand (Bangladesh Bank, 2012). Moreover, workers’ remittance has been maintained at 10.3% growth in FY 12, which was significantly higher than that in the preceding period. After a sharp slowdown in the first half of the FY 12, foreign aid flow turned around in the second half reporting 14.8% growth in the FY 12 over the preceding period. As a result, the capital and financial account had also been picking up throughout FY 12. All the positive developments contributed to the overall balance to become surplus again, which in turn, leads to reserves build up.

3.4 Evolution of the Exchange Rate Regime in Bangladesh

Theory suggests that countries with fixed or heavily managed exchange rates should hold more reserves to defend their currency values than countries with more flexible regimes (Choi and Baek, 2007). However, this standard view is not supported by all empirical results of previous studies. Moreover, as countries have shifted from pegs to floating-exchange-rate regimes following the currency and financial crises of the 1990s, world reserve holdings have continued to rise.

In order to understand if the exchange rate regime has any relationship with the international reserves in Bangladesh, it is important to understand the exchange rate regime changes in Bangladesh. The exchange rate regime of Bangladesh can be broadly categorized into two distinct regimes: fixed exchange rate regime from 1972
to 2003 and floating exchange rate regime from 2003 to till date. There had been a number of variants within the fixed exchange rate regime (Wahab and Uddin, 2014). For example, the exchange rate practice began in 1972 by pegging the Bangladesh Taka with the Pound Sterling, which lasted till 1979. The system was characterized by the Pound Sterling being the intervention currency. But, with double digit and unstable inflation and feeble external position resulting from persistent balance of payment deficits, the country started experiencing volatile economic growth back then. Realizing that reduction in the fluctuations of BDT against other currencies while the currency is pegged with the pound sterling is crucial for trade settlement, the country abandoned pegging its currency with the pound sterling in 1979. Instead, the country pegged its currency with a basket comprising 11 major trading partner countries’ currencies. Going forward, in 1983, the BDT was pegged with a new trade-volume weighted basket currency comprising 8 major trading partners’ currencies. Due to the growing importance of US Dollar in international trade, the country replaces the Pound Sterling with the US Dollar for intervention. This system continued till 2003. Finally, the country adopted floating exchange rate regime in May 2003, wherein the exchange rate is to be determined by the interaction of market forces.

In the initial period of floating exchange rate system, the country could not accumulate substantial amount of foreign exchange reserves. However, the accumulation gained momentum since the FY 2011-12 (as shown in figure 1). Although, in a floating exchange rate era, a country does not need to hold a substantial amount of reserves, Bangladesh has been maintaining a large stock of reserves since the FY 2011-12. This may partly be due to the fact that the de jure and de facto exchange rate regime in Bangladesh are not identical. According to the IMF (2016), although the de jure exchange rate regime of Bangladesh is floating, its de facto regime resembles stabilized arrangement. Thus, Bangladesh essentially requires sizable reserves for intervention to ensure an orderly foreign exchange market.

3.5 Current Account Liberalization

Being mindful of the benefits both developing and developed countries gain by opening their countries, since the early nineties, Bangladesh has embarked on a path of accelerated external sector openness reforms. Such reforms necessarily included both trade liberalization and capital account liberalization. The first wave of exchange rate regime liberalization took the form of full convertibility of the Taka for current external transactions in 1993. The declaration as to the acceptance of current account convertibility has been a remarkable milestone for Bangladesh. Moreover, the range of exchange rate regulation enabling residents to conduct foreign exchange transactions related to the current account has been amply expanded since the onset of current account liberalization (Wahab and Uddin, 2014).
Bangladesh does not receive a significant level of FDI or portfolio investment but trade and net transfers are dominant parts of its BoP. Therefore, it is the current account-related factors of reserves criteria that are largely relevant for Bangladesh, and based on reserves to import bills, the country’s reserves level is marginally higher than what it requires.

4. METHODOLOGY

The objective of the paper is to identify the macroeconomic consequences of FER accumulation in the context of Bangladesh. Literature suggests that there exist potential interrelationships among the macroeconomic variables. In his dynamic macro model, Shrestha (2016) showed that inflation is driven by past period output, inflation as well as nominal exchange rate change. Theoretically, one variable affects other variables contemporaneously but in practice there are some lags between change in one variable and response of other variables such as recognition, decision and implementation lag. Hence, this paper taking the lead from Shrestha (2016) builds up a reduced form VAR model widely seen in macroeconomic literature. Therefore, the VAR model deems to be the most suitable model for this study because the model potentially captures the characteristics of and dynamic relationships among the aforesaid variables. Simple regression analysis with the ordinary least squares method may not be the best way to explore such relationships, because OLS requires all the data series to be stationary and the error terms must satisfy some strong Gauss-Markov assumptions notably they need to be uncorrelated with mean zero and homoskedastic with finite variance. In practice, economic and financial time series are non-stationary i.e. mean non-reverting. The VAR model that the paper used delineates the relationship among four variables akin to Shrestha (2016) such as GDP growth rate, inflation, nominal exchange rate and FER.

The reduced form 4-variate VAR(p) model is set up as follows:

\[ Y_t = \alpha_0 + A(L)Y_t + \epsilon_t \]

where, \( Y_t \) represents a set of endogenous variables namely GDP growth rate, inflation, nominal exchange rate and FER as percentage of GDP. The error term is represented by \( \epsilon_t \sim iid(0, \Sigma) \). \( A(L) \) is the matrix polynomial in the lag operator.

4.1 Data and Variables

The annual observations spanning from 1973 to 2017 are used for this study. The data is collected from world development indicator (WDI) of World Bank and Bangladesh Bank.
The operationalization of the variables of interest is given in the following table.

Table 1: Summary Table of the Dataset for the Empirical Study

<table>
<thead>
<tr>
<th>Series</th>
<th>Notation</th>
<th>Data Description</th>
<th>Frequency</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Exchange Reserves</td>
<td>FER</td>
<td>FER as percentage of GDP</td>
<td>Annual</td>
<td>WDI*</td>
</tr>
<tr>
<td>GDP growth rate</td>
<td>G</td>
<td>GDP growth rate</td>
<td>Annual</td>
<td>WDI*</td>
</tr>
<tr>
<td>Inflation</td>
<td>I</td>
<td>Inflation rate (GDP deflator)</td>
<td>Annual</td>
<td>WDI*</td>
</tr>
<tr>
<td>Nominal Exchange Rate</td>
<td>ER</td>
<td>Log(nominal exchange rate)</td>
<td>Annual</td>
<td>WDI*</td>
</tr>
</tbody>
</table>

*World Development Indicator, World Bank

Data have been analyzed using econometric models. The study estimates VAR model using EViews. Prior to estimating the model, the Augmented Dickey Fuller test is used to check the data stationarity. The stability of the model is confirmed by calculating the AR roots of the characteristic polynomial. Moreover, important tools such as Granger causality test and impulse response are used to complement the VAR analysis. In what follows is a brief discussion on unit root tests used to check the data stationarity.

A simple autoregressive process of order 1 is written as

$$y_t = \rho y_{t-1} + \epsilon_t$$

The parameter \(\rho\) is to be estimated while assuming that error term is a white noise process. For \(|\rho| \geq 1\), the series is a non-stationary series with variance of \(y\) increases over time i.e. time variant. On the other hand, for \(|\rho| \leq 1\), the series is a (trend) stationary process.

To determine whether \(|\rho|\) is strictly less than 1, unit root tests with null hypothesis \(H_0: \rho = 1\) against alternative hypothesis are \(H_1: \rho < 1\) are used. The standard Dickey Fuller (DF) test estimates above equation after a slight modification. Note that, DF test remains valid as long as the time series is an AR (1) process. However, for higher order process, the white noise distribution of error term does not hold. To address such higher order correlation, parameter estimation with higher order lagged difference terms is carried out under the Augmented Dickey Fuller test.

5. RESULTS OF THE STUDY

This section of the paper presents the statistical results of the study.

5.1 Unit Root Tests

VAR methodology essentially requires the data to be stationary. The economic and financial data are by nature non-stationary. Any statistical analysis using non-stationary data usually gives rise to spurious results. Thus it is essential to test for unit roots before deciding on the form of variable as well as conducting analysis. This paper uses the widely known Augmented Dicky Fuller (ADF) Test and Philips Perron Test to test for unit roots. The ADF and PP test results are represented in table 2. It is seen all variables except FER as a percentage of GDP are stationary at level.
Spillover Effects of Foreign Exchange Reserves (FER) Accumulation in Bangladesh: A Vector Autoregression Approach

Table 2: Unit root test for Time Series

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADF</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-stat</td>
<td>p-value</td>
</tr>
<tr>
<td>FER</td>
<td>-0.4455</td>
<td>0.6920</td>
</tr>
<tr>
<td>g</td>
<td>-7.9959</td>
<td>0.0000</td>
</tr>
<tr>
<td>π</td>
<td>-5.6734</td>
<td>0.0000</td>
</tr>
<tr>
<td>LR</td>
<td>-3.8132</td>
<td>0.0055</td>
</tr>
</tbody>
</table>

Notes: Optimal lags for ADF and PP test are determined based on AIC and Newey-West bandwidth selection using Bartlett kernel respectively. Probability values for ADF and PP test correspond to MacKinnon one-sided p-values.

5.2 Lag Selection

Choosing an appropriate lag for VAR estimation is of utmost importance. The importance of lag length determination is demonstrated by Braun and Mittnik (1993) who show that estimates of a VAR whose lag length differs from the true lag length are inconsistent as are the impulse response functions and variance decompositions derived from the estimated VAR. We can use information criteria (IC) to choose the lag length. EViews provides some lag length selection criteria. For this study, it is seen that Schwarz information criterion suggests that the appropriate length of lag should be 1 for this study which is shown in table 3. The paper decides on that lag length and continues to use the same lag for VAR estimation and other purposes.

Table 3: VAR Lag Order Selection Criteria

<table>
<thead>
<tr>
<th>Lag</th>
<th>Logl</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-99.689</td>
<td>NA</td>
<td>0.00208</td>
<td>5.1844</td>
<td>5.3333</td>
<td>5.2455</td>
</tr>
<tr>
<td>1</td>
<td>11.558</td>
<td>194.684</td>
<td>1.808e-05</td>
<td>0.4220</td>
<td>1.2664*</td>
<td>0.7273</td>
</tr>
<tr>
<td>2</td>
<td>35.740</td>
<td>37.49555</td>
<td>1.23e-05</td>
<td>0.0125</td>
<td>1.5125</td>
<td>0.5621</td>
</tr>
<tr>
<td>3</td>
<td>59.040</td>
<td>31.44240*</td>
<td>9.31e-06*</td>
<td>-0.3520*</td>
<td>1.8425</td>
<td>0.4418*</td>
</tr>
</tbody>
</table>

* 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
5.3 VAR Estimates

The VAR estimation is done by using time series data covering period 1973-2017. The results are shown in the table-4. The VAR estimate in EViews does not show the p-value but it displays t-value. Based on the value of t statistics and critical value of t statistics, we can ascertain the significant impact of lagged values of independent variable on dependent variable.

<table>
<thead>
<tr>
<th>Table 4: Vector Autoregression Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>D(FER)                  G            x            ER</td>
</tr>
<tr>
<td>---------------------------------------</td>
</tr>
<tr>
<td>(FER(-1))                -0.00065    -0.22489    -0.81535    -1.246465</td>
</tr>
<tr>
<td>(0.14263)                (15.6398)    (99.9318)   (0.53371)</td>
</tr>
<tr>
<td>[ 0.61528]                [-0.58983]    [-0.89216]  [-1.23548]</td>
</tr>
<tr>
<td>g(-1)                    0.000243     0.484755    4.307471    0.010399</td>
</tr>
<tr>
<td>(0.0120)                 (0.11531)    (0.73689)   (0.000394)</td>
</tr>
<tr>
<td>[ 0.20283]                [-4.20385]    [5.84622]   [1.264271]</td>
</tr>
<tr>
<td>π(-1)                    0.000267     -0.019154    0.170429    0.003103</td>
</tr>
<tr>
<td>(0.0099)                 (0.01862)    (0.19490)   (0.000664)</td>
</tr>
<tr>
<td>[ 1.37511]                [-1.02842]    [1.43112]   [4.88186]</td>
</tr>
<tr>
<td>ER(-1)                   0.006228     2.391851    -11.17402   0.955624</td>
</tr>
<tr>
<td>(0.0439)                 (0.42206)    (2.89678)   (0.01440)</td>
</tr>
<tr>
<td>[ 1.41914]                [5.06709]    [-4.14546]  [66.3499]</td>
</tr>
<tr>
<td>C                       -0.023359     -1.415163    27.12033    0.138976</td>
</tr>
<tr>
<td>(0.01095)                (1.63010)    (16.4156)   (0.05563)</td>
</tr>
<tr>
<td>[-1.37805]               [-0.88815]    [2.60458]   [2.49836]</td>
</tr>
</tbody>
</table>

R-squared: 0.081544, Adj. R-squared: 0.060558, Sum sq. resid: 0.000809, S.E. equation: 0.014713, F-statistic: 0.821251

The results depicted in table 4 show that the lagged value of foreign exchange reserves has significant effect on exchange rate albeit in opposite direction. The result, obviously, is contrary to this paper’s priori expectation. FER accumulation supposedly does not cause the domestic currency to appreciate. Moreover, contrary to Polterovich and Popov (2003), the paper does not find any convincing evidence on the positive impact of FER build up on GDP growth. This weak association may be attributable to failure of use of FER on productive purposes. The priori expectation was that FER helps country import capital goods, which in turn increase investment/GDP ratio and eventually increase GDP growth. Further, the FER accumulation does not tend to cause higher inflation evidencing that the central bank
perfectly sterilized its FX intervention. Theoretically, when a central bank intervenes in the FX market by purchasing foreign currency money supply gets increased, which potentially results in higher inflation. But this was not the case for Bangladesh.

Again, as expected, the lagged value of GDP growth leaves statistically significant effect on current period inflation, which is consistent with macroeconomic theory. The higher economic growth is indicative of higher consumption and investment, which, seemingly tend to push up the general price level i.e. inflation. Further, the empirical results suggest that the higher economic growth brings about depreciation in the currency value. The underpinning theory dictates that the higher economic growth enables consumers and business to import consumer goods and capital goods, which essentially puts downward pressure on the currency value.

While the past period GDP growth pushes up the general price level i.e. inflation, the opposite is not true according to the estimation results. This might make sense in that the higher inflation may result from higher cost of production and hence may not influence the GDP growth going forward. Moreover, the lagged inflation, in consistence with economic logic, necessarily causes the currency to depreciate. The higher inflation makes the tradable goods expensive in the international market, thereby exerting pressure on the domestic currency values.

Not surprisingly, exchange rate depreciation significantly and positively affects the current period GDP growth. The result is consistent with the theory as well as other empirical evidences. Theories dictate that exchange rate depreciation makes the country’s goods cheaper in international market. Hence, the demand for the tradable goods increase which eventually lead to economic growth according to standard IS-LM framework. The empirical result shows that Bangladesh could capitalize on the currency depreciation to accelerate growth. On the other hand, although currency depreciation might affect inflation in either direction, the result reveals that the same causes the inflation to decelerate. The result is attributable to the fact that the currency depreciation increases the demand for domestic goods in the international market leading to higher domestic production and lower prices.

5.3 Model Diagnostic

Stability of VAR Model

In order to check the stability of VAR model the AR root of the characteristic polynomial is calculated. The graphical representation of the root in a complex coordinate system is shown in the figure-3. It is seen that all the roots lie inside the circle suggesting that the VAR model is stable.
It is undeniably true that there involves a complicated dynamics in VAR model. The objective of this paper is to investigate whether there is a causal relationship between four economic variables. Stock and Watson (2001) argue that three important tools such as Granger-causality test, impulse response function and forecast error variance decomposition play a crucial role in VAR analysis by providing more information than VAR estimates. Generally a variable is said to Granger causes another variable if the latter variable can be better forecasted from the past values of both variables rather the past value of latter alone.

The practical interpretation is that the former variable is useful in forecasting latter variable. Table-5 summarizes the Granger causality test results. The results provide the Wald test statistics along with p-value for determining whether the coefficients are statistically different from zero. It is obvious from the results that none of the three variables either individually or jointly Granger causes FER implying that other three variables are not useful in forecasting FER, the result seems fairly consistent with our prior VAR estimates.
According to the Granger causality test, although change in foreign exchange reserves as percentage of GDP does not cause GDP growth and inflation, it is useful in forecasting exchange rate. Likewise, inflation becomes a significant predictor of exchange rate. However, in forecasting GDP growth, inflation may not be useful. On the other hand, similar to the VAR estimates, GDP growth proved useful for forecasting inflation as well as exchange rate. Finally, exchange rate is helpful in forecasting GDP growth and inflation as the former causes the latter.

**Impulse Response Function Analysis**

As mentioned in the research methodology section, impulse response functions (IRFs) are usually used to supplement the VAR estimates. IRF outputs derived from the VAR estimates single out the relative impact of FER accumulation on the three target variables namely GDP growth, inflation and exchange rate. The IRF outputs are depicted in figure 4. Basically, the IRF outputs present the response of one variable to a shock in other variables within the defined VAR system. Further, the IRFs are graphically presented with two standard deviation confidence interval (band) and the response of one variable is considered to be statistically significant if the zero line does not fall within the confidence band.

After careful eyeballing on the response of GDP growth to a shock in FER, it is seen that GDP growth responds negatively till the 2nd year and positively till the 3rd year and remain steady thereafter. However, the response is statistically insignificant as evident from the figure. The response of inflation to a shock in FER shows that the inflation continues to increase till the 4th year and remains flat.
throughout the remaining period. But, with zero line within the confidence band, the response appears to be statistically non-significant, which is also the case for GDP growth. Finally, the exchange rate responds negatively to a shock in FER for some years. Although the response is significant, the direction of movement is undesirable. Overall, the IRFs output produces same results as the VAR estimates.

6. CONCLUSIONS AND POLICY IMPLICATIONS

The primary objective of this paper is to explore the potential relationship among four macroeconomic variables namely GDP growth, inflation, exchange rate and foreign exchange reserves. The VAR model estimation shows that FER accumulation has insignificant impact on economic growth. This is in contrast to the findings of Polterovich and Popov (2003) and Elhiraika and Ndikumana (2007) and Sreshta (2016), who state that higher level of FER led to higher economic growth.

Hence, the findings suggest that the foreign exchange reserve does not matter for economic growth of Bangladesh. The buoyant FER in Bangladesh is mainly driven by remittance inflow contributing to necessary foreign exchange for import of capital goods. Bangladesh has been suffering from investment drought and hence could not utilize the foreign exchange reserves in productive purposes. Bangladesh will be able to boost the economic growth in future if it can utilize the FER in a growth enhancing way and should endeavor to follow an export-led growth strategy. The accumulated FER will help Bangladesh maintain competitive exchange rate through reducing upward pressure on exchange rate.

In case of inflation, the findings of this study do not reflect any positive and significant association between foreign exchange reserves and inflation, which is consistent with the results found in Sreshta (2016). This may be due to the fact that the central bank conducted subsequent sterilization operation prudently. Therefore, FER accumulation does not result in higher money supply and in turn higher inflation. The central bank usually sets the target for money supply in the monetary policy. Thus the sterilization operation should be continued in congruence to the money supply target.

This paper also reflects negative impact of foreign exchange reserves on exchange rate. It suggests as FER gets accumulated, the local currency gets appreciated. But usually central bank accumulates foreign exchange reserves on behalf of the government to contain the appreciation pressure on domestic currency by reducing
the supply of foreign currency from the economy. The findings suggest that appreciation pressure remained even if central bank kept accumulating foreign exchange reserves. This also implies that the central bank did not use its foreign currency reserves to increase the competitiveness of the exchange rate and thereby did not support the export-led growth to happen. On the contrary, it can also be assumed that Bangladesh is an import-based country with import outpacing export throughout the period under study. One of the main import goods is oil, which may be viewed as the engine of growth (Rahman, 2004). Additionally, Bangladesh also imports food grains and raw materials for many industries. Thus, if exchange rate depreciates, then the importers will get affected badly. In addition, the production cost will increase due to the increase in oil price and raw materials. As a result, producers will pass on some costs to consumers, thereby giving rise to general price level. Thus, the central bank has to maintain a delicate balance between exchange rate appreciation and depreciation. The real effective exchange rate (REER), the main gauge of external sector competitiveness, has appreciated steadily for the past three years after remaining broadly stable for last two decades (IMF, 2015). REER has appreciated by 24 percent since 2013 due to nominal effective appreciation and relatively higher domestic inflation (IMF, 2015). IMF (2015) also highlights that despite REER appreciation, there is no clear evidence of exchange rate misalignment or lack of competitiveness. Thus the authority should pay heed to the recent development in REER and devise appropriate stance with regard to fostering external sector competitiveness.

7. FURTHER RESEARCH SCOPE

This study determines the adequate level of reserves using some traditional benchmarks. Perhaps, further research on determining the optimal level of reserves in developing countries like Bangladesh is worth conducting. Furthermore, studies on macroeconomic implications of FER accumulation may be extended comparing different emerging markets and developing countries to identify whether the EMDCs adopt similar economic policies or not. For instance, exchange rate systems of many EMDCs fall somewhere in between fixed exchange rate system and fully flexible exchange rate system. Ascertaining fiscal cost of sterilized reserve purchase would be another interesting issue to explore in the context of Bangladesh.
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