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# An econometric analysis of the determinants of foreign exchange reserves in Bangladesh

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**Abstract:** This study undertakes an econometric analysis of the determinants of foreign exchange reserves. Yearly time series data have been used to figure out that type of relevant variables that are very much momentous for the determinants of foreign exchange reserves. This paper attempts to identify the key determinants of foreign exchange reserves in Bangladesh using Augmented Dicky Fuller (ADF) unit root test to examine the stationarity, Engle Granger residual based co-integration approach to show the co-integrating relationship among variables, and diagnostic tests for better modeling. The empirical results confirm that there exists a strong relationship among foreign exchange reserves, exchange rate, remittance, home interest rate, broad money ( $M_2$ ), UPI of export and import, and per capita GDP. The coefficients are found to change smoothly, as a function of seven threshold variables- out of nine candidates where six variables are statistically significant. Drawing inferences from these findings, it can be suggested that exchange rate, a strong remittance related policies, quality items of exports, and sustainable GDP can keep a substantial and feasible roles to make up a healthy amount of foreign exchange reserves for the host country like Bangladesh.

**Keywords:** Co-Integration, ADF, Diagnostic Test, Imports, Broad Money and Foreign Exchange Reserves

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## 1. Introduction

The term of foreign exchange reserves refers to the supply of foreign currency currently being kept by the central bank of a special country. Alternatively known as forex reserves or FX reserves, this is comprised of a variety of international currencies but the US dollar is one of the most common currencies available in reserves of most countries. Foreign exchange reserves is defined by IMF in 2000 by this way "foreign reserves are defined as external stock of asset, which is available to the country's monetary authorities to cover external payment imbalances or to influence the exchange rate of the domestic currencies through intervention in exchange market or for other purposes". Historically under the Breton –Woods system, the foreign exchange reserves were used by the central bank across the world to maintain the external value of their respective currencies at a fixed level. With the break down of Breton – Woods system in the early 1970s, countries started adopting

a relatively flexible exchange rate system, under which the reserves play only a less important role. Yet, the global exchange reserves have increased from 1.75 to 7.8 percent of world GDP between 1960 and 2002(Flood and Marion, 2002)

Either from political or economic perspective a very sensitive indicator for any government is to maintain a satisfactory level of international reserve in its coffer. It is general notion that a country requires to have at least three months import bill but IMF suggest that reserve of the four months import bill is a prerequisite. So it is called that, if the amount of international reserve of the central bank below the country's three months import bill, the situation is considered as critical.

Generally, a country needs foreign exchange reserves mainly for two reasons, 1) to synchronize its receipt and payments with the rest of the world; and 2) to withstand occasional speculative raid by the dealers in the foreign exchange market. It somewhat resembles the household precautionary demand for cash balance. One of the main

functions of the regulation of foreign reserve is to maintenance of specific currency stability. In a flexible exchange rate regime, foreign exchange reserves assets enable central bank to purchase the local currency that is considered a liability for central bank. This action mainly stabilizes the value of domestic currency.

Foreign reserves plays an important role in the design and evaluation of current and future macro policies aimed at achieving trade balance (Arize, 2012). However, holding large foreign exchange reserves is generally desirable and beneficial because this gives the country more power to ensure the stability of its economy. The pattern of reserve holdings has been increasing at relatively faster race since the early 1990's and most of the reserves holding countries are concentrated in Asia. Over the past few years, there has been a tremendous increase in foreign exchange reserves with central banks of developing economies around the world, especially in the aftermath of East Asian crisis 1997-98 and foreign exchange reserves hold by developing countries have risen from 30 percent of global reserve to almost 60 percent by 2005.(Prabheesh, Malathy and Madhumati,2007). The source of foreign exchange reserves of Asian developing countries are export earning, remittance of Asians residing abroad and in few cases foreign assistance. However, from an economic viewpoint, it makes sense that developing countries hold most of reserves, even though their economies are not the largest one. Industrialized countries have more stable currencies diminishing the risk of currency depreciations. Furthermore, they have more access to capital markets, making borrowing easier and cheaper than holding reserves

The present paper analyzes the determinants of foreign exchange reserves in the context of Bangladeshi economy. Historically international reserves of Bangladesh have not been much promising. On many occasions its reserve balances were not able to pay for its import bill. Bangladesh is defined as a net importing country and always remains in large trade deficit. But, Bangladesh had been accumulating a high level of foreign exchange reserves in the last few years. A significant increase was observed only after 1990-91, the years of wide opening up the Bangladeshi economy.

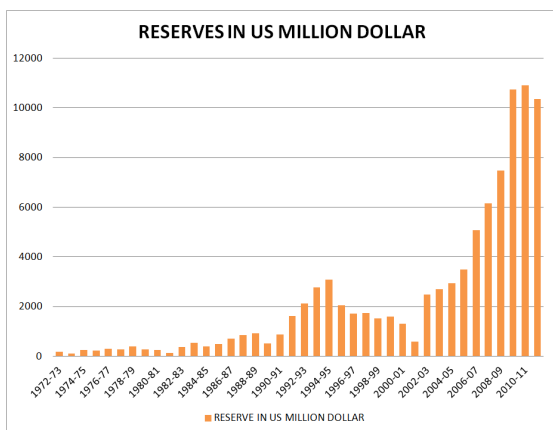


Figure 1. Trends in Foreign Exchange Reserves in Bangladesh

This is happening basically for two reasons 1) Ready Made Garments (RMG) and 2) Remittances. From 2003 to 2011, there is a dramatic upward trend of forex reserves. But in 2012 the foreign exchange reserves decreases slightly due to political instability, indecisiveness of the government, and increasing payments of import bills. High import cost especially with respect to fuel import for rental power plants had put pressure on foreign exchange reserves. The reserves position of a country is determined for the most part by the nature of its transaction with the rest of the world and the corresponding flow of fund in or out of the country. On this ground trade balance is an important factor for determining a country's reserve position. For Bangladesh like many other developing countries foreign aid and remittance flow are two major factors in creating reserves balance.

The structure of the paper is as follows. After this introduction, section two presents the objectives of the study. Section three presents the literature review. Section four deals with determinants of the foreign exchange reserves where definitions of the variables and expected relation have been discussed. Section five shows data sources and methodology where statistical techniques for analysis have been discussed. Section six represents the findings and analysis of the study. Section seven deals with different diagnostic tests. Finally, section eight represents some concluding remarks and policy implications of the desired study.

## 2. Objectives of the Study

- Develop a regression model to show the relationship among these factors and Foreign Exchange Reserves and show the level of impact of these factors on Foreign Exchange Reserves.
- To find out the strength of various factors in influencing foreign exchange reserves.
- To indicate some important determinants to raise the amount of foreign exchange reserves and to examine how and to what extent these factors effective the size of foreign exchange reserves.
- Suggest some policy measures for overall improvement of Foreign Exchange Reserves based on empirical results.

## 3. Literature Review

The research on foreign currency reserves begins mainly from 80 decade. Researchers were focused primarily on identifying the effects that the Bretton Woods system, and its collapse, had on foreign reserves of the research papers in 60, 70 and 80's decades. At the end of 1995, the global reserves except gold were US\$ 991 billion (IFS, 2005). By the end of 2003, the reserves becomes US\$ 2224 billion (IFS, 2005), indicates that the global foreign exchange reserves has become more than doubled within very shortest possible time. This dramatic change in forex reserves encourages the researchers to make research what the determinants are and

which factors are keeping good contribution to increase forex reserves.

Heller and Khan (1978), Edwards (1985), Lizondo and Mathieson (1987), Landell-Mills (1989) and Lane and Burke (2001) were able to get some explanatory variables as a determinants of forex reserves through empirical research on international reserves. The determinants of reserves holding reported in the literature can be grouped into five categories: economic size, current account vulnerability, capital account vulnerability, exchange rate flexibility, and opportunity cost. In the literature per capita GDP is used as indicator of economic size. The vulnerability of current account can be captured by such measures as export and import. In the long run central bank will increase their reserve in response to a greater exposure to external shock. For this reason, the level of reserves should be positively correlated with an increase in both exports and imports. Capital account vulnerability increase with financial openness and potential for resident based capital flight from the domestic currency. Consequently reserves should be positively correlated with such variables. Exchange rate flexibility is usually important, it reduce the demand for reserves, since central banks no longer need a large stockpile of reserves to manage a pegged exchange rate. Because there is “fear of floating” flexibility is generally measured by the actual volatility of the exchange rate. There is an opportunity cost of holding reserves, because the monetary authority swaps high-yield domestic assets for low yield foreign ones. It corresponds to the difference between the yield on reserves and marginal productivity of an alternative investment. This variable is, however, likely reflecting measurement problems.

Mendoza (2004) viewed the precautionary analytical framework as a natural expansion of all previous theories. He showed in her studies that most Asian countries increase their level of reserves for self-assurance purposes in the aftermath of the Asian financial crisis. Similarly, Lizondo and Matheieson (1987) found that the debt crisis of the early 1980's in Latin America produced a structural break in the demand of reserves. Frenkel, in his 1978 seminal paper, argued that the marginal propensity to import (MPI) measures an economy's openness to external shocks and therefore would be positively related to foreign currency reserves if the reserves were held as a precautionary measure. Frenkel measured a country's MPI as the ratio of imports over GDP. Batten (1982) conducted an empirical study partly based on Frankel's model to determine the demand for foreign reserves under fixed and floating exchange rates. He identified four major determinants of reserve holding: the variability of international payments and receipts, the propensity to import, the opportunity cost of holding reserves and a scale variable measuring the size of international transaction. Eichengreen and Mathieson (2000) expounded a theory of the determinants of foreign exchange reserves portfolio composition for those countries that release such data. They estimated the demand for the level of reserve using three principal determinants: trade flows, financial flows, and existence of currency pegs. Theory found that

there was a “striking” stability over time in both the currency composition of reserves and also in the relationship between the demand for reserves and these principal determinants. Distayat (2001) build on his work and developed a reserve demand model compatible with the 2<sup>nd</sup> generation financial crisis.

Aizenman and Marion (2002) found that reserves holding for the 1980-1996 periods in the Far East countries are the outcome of several factors such as: international transactions, international transaction volatility, the exchange rate arrangement, political uncertainty and corruption.

The IMF (2003) studied a simple empirical model that incorporates various determinants of reserves holding. The model is estimated using a large panel that covers 122 emerging market economies with annual data from 1980 to 1996. In the study real per capita GDP, the population level, the ratio of import to GDP, and the volatility of the exchange rate are found to be statistically significant determinants of real reserves. Predicted values from this model over the 1992-2002 periods reveal that foreign reserves in Latin America are not excessive, while those in emerging Asia have increased more than warranted by the determinants since 2001. The IMF concludes that foreign exchange reserves in emerging Asia have reached a point where some slowdown in the rate of accumulation is needed.

Using data for Korea, Aizenman, Lee and Rhee (2004) found evidence of a break in the pattern of holding foreign reserves in the post 1997 period. The authors claimed that the self-assurance motive became stronger following the crisis. More specifically, they said that trade openness is significant in explaining foreign reserves before the crisis, but that it loses significance after the crisis. They argued that this was consistent with the increased relative importance of financial openness. To examine whether increased external financial exposure is a driving factor behind reserves build up in the post-crisis period, they considered foreigners fsequity positions and short-term external debts as additional explanatory variables. They found that coefficients on those variables significant after the crisis, supporting the view that Korea raised its level of reserves to increase its insurance against sudden stop of capital flows. Dooley, Folkents-Landay, and Garber (2004) argued that reserves accumulation reflects the intervention of Asian central banks who want to prevent their currency from appreciating against the US dollar in order to promote export led growth. However, using lagged export growth and deviations from predicted purchasing power parity in addition to the standard determinants, Aizenman and Lee (2005) found limited support for the mercantilist motives. Gosselin and Parent (2005) examined the issue of reserves accumulation by central banks in emerging-market economics. They found a structural break in the determinants for reserves in the aftermath of Asians financial crisis.

Romero (2005) estimated, reserves holding for China and India, and she examined which variables affect one country more than the other. She mentioned that, the Chinese government remains in tight control of the economy,

including reserves and the exchange rates. So, market oriented variables don't explain reserve holding for China but those are very much significant in the context of India. Prabhesh, Malathy and Madhumati(2007) analyzed the determinants of foreign exchange reserves for India from 1983 to 2005. They found that India's long-run foreign reserves are a function of current account vulnerability, capital account vulnerability, exchange rate flexibility and opportunity cost of holding reserves. They also mentioned that the reserves holding behavior is mainly influenced by the capital account vulnerability indicative of the self-insurance motive against residential base capital flights and less sensitive to its opportunity cost. Schgal and Sharman (2008) found the evidence for both precautionary as well as for mercantile motive behind holding reserves in India. They also found that the risky capital flows and the exchange rate volatility have positive impact on foreign reserves holding.

Delatte and Fouquau (2009) adopted a non linear approach to examine the dynamics of the foreign reserves holding and found evidence for the presence of a non linear behavior in the demand for foreign reserves. They identified the misalignment of real exchange rate and the level of the US real interest rate where two threshold variables that may explain properly the acceleration of foreign exchange reserves accumulation. Obstfeld et al. (2008) and Obstfeld et al. (2009) first argued that financial openness is a robust predictor of foreign exchange reserves and subsequently that a country's reserves holding just before the (2008) crisis, relative to their predicted holdings based on these financial motives can significantly predict exchange rate movements of both emerging and advanced countries in 2008. By doing research within 50 countries of the world Gantt (2010) found that the level of foreign exchange reserves is determined by a combination of trade variables (import, export), monetary aggregate (Money supply,  $M_2$ ) and characteristics of exchange rate regime.

Although literature reviewed here proposes several variables as determinants of foreign exchange reserves for many countries, but little had been said about reserves adequacy. A traditional measure developed, after the collapsed of Bretton Woods system, used to rules of thumbs, such as three months of import cover. Clearly, when India is holding over 20 months of import cover (IMF, 2005), that measure does not apply today. Neither do most of other measures proposed in the late 70's and early 80's literature. Reserves adequacy measures had been changed after the onset of the financial crisis in the 1990s. Calvo (1996) suggested that, a country's vulnerability to crisis should be measured, in part, by the size of its money supply, defined broadly, relative to its reserves holding, since broad money reflects a country's exposure to the withdrawal of assets. Greenspan (1999) expanded, the Gnidotti rule a previous reserves adequacy measure, which suggested that countries should hold enough reserves to be able to live without new foreign borrowing up to one year. Greenspan (1999) expanded this rule by adding a test that "the average maturity of a country's external liability should exceed a

certain threshold, such as three years".

In the context of Bangladeshi economy, research on the determinants of foreign exchange reserves has received little attention. Ali and Medhekar (2010) made a good study about multifold effects on real monetary external sectors determinants by taking data from 1971 to 2010 in the context of Bangladesh. He found that, foreign exchange reserve is directly related to GDP and depend on export, import, foreign aid and remittance in the context of Bangladesh economy. He also mentioned that international commitment, commercial transportation and transfer payment of the countries affects the reserves position and it can not be fully predetermined. Rezaulk (2011) analyzed the performance of various governments in Bangladesh with respect to maintaining an adequate level of foreign exchange reserves during their regimes. For this purpose, he measured the performance of the determinants of foreign exchange reserves in Erashad, AL and BNP regime. He found that reserve formation is closely to the policies adopted and performances attained in the external sector of the economy by the respective government. He also found that foreign aid is the strongest determinant of foreign exchange reserves. He predicted that if Bangladesh can sustain her increasing trend of remittance earnings, export earnings and foreign direct investment flows we can expect a further boost in its reserve level in the near future. This paper contributes to the literature by providing estimates of reserves function, using a broader set of explanatory variables and recent econometric techniques.

## 4. Data Sources and Methodology

### 4.1. Data Sources

We use annual time series data for the period of 1972-2011 for the ten variables, remittance (% of GDP), exchange rate. Inflation rate differential, unit price index of imports, unit price index of exports, home interest rate, broad money  $M_2$  (% of GDP), foreign aid (% of GDP) and per capita GDP in PPP dollar. Data in this study has been used extensively from the secondary sources. All the figures that were used in this study were collected from the following publications.

Bangladesh Economic Survey, various issues, published by the ministry of finance. Economic trends (monthly), published by the statistical department of the central bank of Bangladesh, official website of the central bank, ministry of finance and export promotion Bureau of Bangladesh, Bangladesh Bank annual report, published by Bangladesh Bank., Statistical Year Book, Published by the Bangladesh Bureau of Statistics, The world economic outlook 2010, published by International Monetary Fund, World Bank databank, official website of World Bank, Bangladesh Bank Bulletin, Bangladesh Arthanaitic Jarip, Bangladesh Arthanaitic Samikhaya, Asian Development Bank (ADB) database. We have also consulted published books, working papers, reports, research monographs, journals and research works that are relevant to the study.

#### 4.2. Methodology

A regression analysis is undertaken to determine the factors affecting the foreign exchange reserves. A total of three regression models are tested. We identify the three models as Model A, Model B, and Model C:

Model A: measures the effects of exchange rate, home interest rate, foreign aid, remittance, broad money ( $M_2$ ), inflation rate differential, UPI of import and export, and per capita GDP on the foreign exchange reserves.

Model B: measures the effects of exchange rate, home interest rate, foreign aid, remittance, broad money ( $M_2$ ), UPI of import and export, and per capita GDP on the foreign exchange reserves.

Model C: measures the effects of exchange rate, home interest rate, remittance, broad money ( $M_2$ ), UPI of import and export, and per capita GDP on the foreign exchange reserves.

##### Model A

In linear Model A, foreign exchange reserves (% of GDP) has been assumed to be a linear function of exchange rate, home interest rate, foreign aid(% of GDP), remittance(% of GDP), broad money  $M_2$ (% of GDP), inflation rate differential, UPI of import and export, and per capita GDP (PPP).

The linear model A is defined as follows:

$$Y_t = \beta_1 + \beta_2 EXC + \beta_3 EXO + \beta_4 FOA + \beta_5 GDP + \beta_6 HOI + \beta_7 IMP + \beta_8 INF + \beta_9 M_2 + \beta_{10} REM + U_t$$

Where,

$Y_t$  is foreign currency reserves in % of GDP (excluded gold) for period  $t$ , where  $t$  = sample year 1 to 39 over the period from July 1973 to July 2011 : July 1972 = 1 and July 2011=39

EXC is the exchange rate, FOA is the % of GDP of foreign aid, HOI is the bank rate that is called home interest rate, IMP is the Unit price index of imports (IMP) that is obtained on the base year of 1988-89, EXO is the Unit price index of exports that is obtained on the base year of 1988-89, REM is the % of GDP of remittance, INF is the inflation rate differentials which are calculated by subtracting the US inflation from Bangladesh inflation,  $M_2$  is the broad money ( $M_2$ ) as % of GDP, GDP is the per capita gross domestic product, PPP (current international US dollar).

##### Model B

In linear Model B, the inflation rate (INF) is excluded from the model A and the model is defined as follows:

$$Y_t = \beta_1 + \beta_2 EXC + \beta_3 EXO + \beta_4 FOA + \beta_5 GDP + \beta_6 HOI + \beta_7 IMP + \beta_9 M_2 + \beta_{10} REM + U_t$$

Where,

$Y_t$ , EXC, FOA, HOI, IMP, EXO, REM,  $M_2$ , and GDP are same as described above the linear Model A. Model C

Now we have excluded foreign aid from our linear model B and the model C is characterized as follows:

$$Y_t = \beta_1 + \beta_2 EXC + \beta_3 EXO + \beta_5 GDP + \beta_6 HOI + \beta_7 IMP + \beta_9 M_2 + \beta_{10} REM + U_t$$

Where,

$Y_t$ , EXC, HOI, IMP, EXO, REM,  $M_2$ , and GDP are same as described above the linear Model A.

In order to figure out the determinants of foreign exchange reserves in Bangladesh, we used the Ordinary Least Square (OLS) as method. The sample period for investigation in 1972-2011 the empirical analysis of this study employed annual secondary data, collected from different sources, which are time series data. Most time series data are non-stationary by their nature. If the data is non-stationary the ordinary least square may not be applicable. So for validity of OLS regression we have applied unit root test to check stationarity. To test the co-integration of variables, Engle Granger residual based co-integration approach has used since we have got same integration order. Our empirical analysis can be divided in three stages. The first stage, we used ADF unit root test to test the stationary. In the second stage, the test for co-integration is conducted using Engle and Granger (1987) procedure that is verifies the order of integration of the variables since the various co integration tests are valid only if the variables have the same order of integration and in the final stage, we operate different diagnostics tests for the better modeling. In testing particular function, attention will be given in following criteria.

1. Parameter estimates with an algebraic sign consistent with a priory expectation
2. Non-autocorrelation residuals are shown by *Durbin-Watson* statistics.
3. Confidence interval for the parameter not wide enough to conclude zero at a reasonable level.
4. For testing Heteroskedasticity we have used the *White Heteroskedasticity* test.
5. For test the Multicollinearity we have used *auxiliary regressions*.
6. To test the structural change of the model we have used the *Chow test*.
7. For testing specification error we have used the *Ramsey's RESET test*.
8. Percentage of variation in each function explained by the explanatory variables as indicated by the simple coefficient of determination ( $R^2$ ) as well as the adjust coefficient of determination ( $\bar{R}^2$ ).
9. To test the normality we have used *Jarque-Bera* test.

## 5. Findings and Analysis

### 5.1. Stationary Issues

A random time series  $Y_t$  is said to be stationary if its mean and variance constant over time and the value of covariance between two time periods depends only the distance between the two time periods and not on the actual time at which the variance is computed (Gujarti,1995).In order to check for time series properties stationary of the variables, the widely

applied unit root test such as Augmented Dickey–Fuller(1981) and Philips-Perron (1988) tests have been used.

We applied the ADF test to the exchange rate, home interest rate, foreign aid, remittance, broad money ( $M_2$ ), inflation rate, UPI of import and exports, per capita GDP and foreign exchange reserves series separately. We carried out the estimation of the models using the econometric software E-Views and test the presence of unit roots using the systematic procedure described in Enders (1995). The results of the Augmented Dickey-Fuller (ADF) test for the stationarity of the ten original series are presented in Table 1. As can be seen, each time series have at least one unit root except inflation rate differential and hence are non-stationary in their original form.

We now test the stationarity of the first difference of these series by applying the ADF test on the first difference series. The results are presented in Table 1. As can be seen, the results show that these series are stationary in their first difference form. This means all series are I(1) except inflation rate differential that is I(0).

Even if the nine variables series individually are I (1), it may be possible that a linear combination of the nine variables may be stationary. If we are modelling a linear relationship among the variables series, even if each of them individually are non-stationary (i.e. I (1)), as long as they are co-integrated, the regression involving the nine series may not be spurious. Thus, we now investigate whether the nine series are co-integrated and have a long run equilibrium

relationship.

We now employ the Engle and Granger (1987) procedure, which is based on testing for a unit root in the residual series of the estimated equilibrium relationship by employing the Augmented Dickey-Fuller test. Therefore, the null and alternative hypotheses are:

$H_0$ : The residual series has a unit root or (exchange rate, home interest rate, foreign aid, remittance, broad money ( $M_2$ ), UPI of import and export, per capita GDP and foreign exchange reserves series are not co-integrated)

$H_A$ : The residual series has no unit root or (exchange rate, home interest rate, foreign aid, remittance, broad money ( $M_2$ ), UPI of import and export, per capita GDP and foreign exchange reserves series are co-integrated)

Rejection of the null hypothesis would mean that the exchange rate, home interest rate, foreign aid, remittance, broad money ( $M_2$ ), UPI of import and export, per capita GDP and foreign exchange reserves series are co-integrated.

The results are presented in Table-2 and clearly show that all the least square residual series are stationary and hence the variables are co-integrated, indicating that there is long-run equilibrium relationship among exchange rate, home interest rate, foreign aid, remittance, broad money ( $M_2$ ), UPI of import and export, per capita GDP and foreign exchange reserves series.

**Table 1.** ADF test results for a unit root on the level and first difference of the original series

Variable	ADF test at level			ADF test at first difference			Status
	t-statistic	Critical value at 5%	Decision	t-statistic	Critical value at 5%	Decision	
EXC	-0.811570	-2.967767	Non-stationary	-6.363493	-2.967767	stationary	I(1)
EXO	2.504925	-2.941145	Non-stationary	-4.515393	-2.943427	stationary	I(1)
FOA	-1.218695	-2.941145	Non-stationary	-9.007575	-2.943427	stationary	I(1)
GDP	9.616029	-2.943427	Non-stationary	-3.721247	-2.943427	stationary	I(1)
HOI	-0.990202	-2.943427	Non-stationary	-5.879651	-2.943427	stationary	I(1)
IMP	0.968335	-2.941145	Non-stationary	-6.082325	-2.943427	stationary	I(1)
M2	1.406313	-2.945842	Non-stationary	-3.965535	-2.945842	stationary	I(1)
REM	1.507945	-2.941145	Non-stationary	-5.160532	-2.943427	stationary	I(1)
YT	-0.329.645	-2.941145	Non-stationary	-5.431964	-2.943427	stationary	I(1)
INF	-5.86466	-2.941145	stationary				I(0)

**Table 2.** Test for co-integration of all the variables series

Model Residuals	Data based value of the test statistic	Critical value at 5% level	Results
Constant and trend	<b>-5.866643</b>	<b>-2.943427</b>	<b>Reject <math>H_0</math></b>
Conclusion	The residuals series does not have a unit root. Hence, exchange rate, home interest rate, foreign aid, remittance, money supply( $M_2$ ), UPI of import and export, per capita GDP and foreign exchange reserves series are co-integrated.		

**Table 3.** Results of Linear Regression Models Forecasting Foreign Exchange Reserves

Variables	Model B			Model C		
	Coefficient	Std. Error	Pro.	Coefficient	Std. Error	Pro.
CONSTANT	12.00241	3.008518	0.0004	14.04276	2.471971	0.00000
EXC	-51.34161	12.51909	0.0003	-52.04222	12.58147	0.0002
EXO	-0.031019	0.010122	0.0046	-0.036584	0.009000	0.0003
FOA	0.261609	0.222624	0.2492			
GDP	0.026051	0.004427	0.00000	0.025316	0.004410	0.0000
HOI	-1.055174	0.186320	0.00000	-1.071851	0.186917	0.0000
IMP	-0.016035	0.012492	0.2091	-0.012506	0.012200	0.3132
M2	-0.358321	0.071658	0.00000	-0.367896	0.071629	0.0000
REM	0.411960	0.322247	0.2109	0.627100	0.266813	0.0253

Variables	Model B			Model C		
	Coefficient	Std. Error	Pro.	Coefficient	Std. Error	Pro.
F-Value	29.60582			33.22965		
Adjusted R <sup>2</sup>	0.857596			0.855846		

**5.2. Regression Results**

At the beginning we decided to operate regression analysis by taking three models A, B and C. As inflation rate differential is stationary at the level, we have rule out the variable INF and we will not go further regression analysis through model A

Results presented in table-3 show that exchange rate, home interest rate, exports, money supply and GDP significantly affect the foreign exchange reserves, but the sign of coefficient of imports and home interest rate are in opposite to what were expected in our hypothesis. The linear model B shows that these eight variables could independently explain about 85.76 percent of the foreign exchange reserves movements. With the exclusion of foreign aid, the linear model C can explain approximately 85.58 percent of the foreign exchange reserves movements, but the effect of remittance becomes significant, and six variables within seven variables become significant. If the coefficients of two models are observed, the effects of exchange rate, home interest rate, remittance, broad money (M<sub>2</sub>), UPI of import and export, and per capita GDP become significant in Model- C when inflation rate and foreign aid variables are excluded. However, it needs a careful analysis why the effects of imports (UPI) and home interest rate are opposite what we expected.

Finally, we expected that the sign of coefficient of HOI would be positive and we found it as negative. Because we know,  $F=F(r)$  and  $F'(r) < 0$ , where, F is the net outflow and r is the rate of interest. As domestic r increases net out flow will be decreased and FCR will be increased. So we expected a positive relationship between r and FCR and we got it as negative one. The probable cause of this incident may be that "To decrease net out flow F(r), rate of interest(r) have to increase"- is a necessary condition but not the sufficient one, because of 'other thing remain constant' (Investment environment, political instability, lack of infrastructural opportunities etc.).If other things are not favour, F(r) may increase as r increases and then foreign exchange reserves decreases. Moreover, the negative co-efficient of home interest rate implies that higher interest rate in Bangladesh does not attract foreign capital inflow to increase demand for local currency. Instead, capital may outflow from the country as investors may perceive it as the sign of economic difficulties; hence the demand for foreign currency increases. It is observed that central bank generally pursues conservative monetary policy to raise the rate of interest during the period of financial difficulties. Therefore, investors may like to shift their capital in a safer country. In addition, the BDT is freely convertible only for the current account transactions, but not for the capital account transactions. Funds transfer from capital investment accounts needs official approval of the central bank. As investment

capitals cannot flow in and flow out freely, a higher interest rate in normal economic period may not adequately attract the foreign capital.

Furthermore, the finding suggests that factors underlying the operation of IFE and PPP theories do not exist in Bangladesh although BDT has been made fully convertible and its exchange rate with USD supposed to be determined by the market forces, i.e., unrestricted demand and supply of both local of foreign currency. It shows that liberalization of the economy with unrestricted flow of funds in both local and foreign currencies has its potential negative impacts for the developing countries like Bangladesh where demand for foreign currencies is always high due to high import volumes relative to exports earnings. Therefore, inconsistency in the regression signs of interest rate and import are likely to be maintained even though local currency, BDT, has been made fully convertible and its exchange rate is freely floated on the market.

In general, it is assumed that import will decrease if import price index increases, therefore, foreign exchange reserve will increase. But in the context of Bangladesh imports are inevitable for the socio-economic development of the country. So in spite of increasing import price, it is not possible for the country to decrease its import. Rather, Bangladesh losses significant amount of forex reserve to import same things as before. For this reason, there is a negative relation between import price index and forex reserve. The results show that, as expected, the foreign aid has positive effect on the forex reserves. Although this variable has a positive relationship, we are not keeping this variable for further analysis (Model C) as it is statistically insignificant. As a reason to happen this, foreign aid is now contributing a little addition to GDP. In fiscal year 2009-2010, the total foreign aid was \$2228 million; in 2010-11 it became \$1760 million. 13% of total GDP was foreign aid in 80's decade which has been diminished substantially 5.9% in 1990, 3.3% in 1999, and 1% in 2011. There is a possibility to reduce this figure less than 1% in fiscal 2012-13.

In our model we get negative co-efficient of exchange rate, it implies that as exchange rate decreases forex reserves will increase as export will increase import will decrease. Because we know that there is a direct relation between exchange rate and imports while there is an inverse relation between exchange rate and exports. We get the following as a final model.

$$Y_t = 14.042 - 52.04 EXC - 0.037 EXO + 0.025 GDP - 1.0719 HOI - 0.0125 IMP - 0.368 M_2 + 0.6271REM$$

If EXC reduces 1 unit, foreign exchange reserves will increase 52.04% as a percentage of GDP. Again, if UPI of

export increases 1 unit, foreign exchange reserves decrease 0.037% as a percentage of GDP. From our model we can see that if we increase 1% of per capita GDP, forex reserves will increase, which makes up 0.025%, as a percentage of GDP. Forex reserves will go up 0.368 % as a percentage of GDP if broad money (M<sub>2</sub>) goes down 1%. Finally, there exists a strong relationship between forex reserves and remittance by which we observe if remittance increases 1%, forex reserves will increase 0.6271% as a percentage of GDP. To sum up the analysis, it can be concluded that exchange rate and remittance are the major determinants to determine forex reserves that are statistically and economically significant too.

## 6. Diagnostic Test

### 6.1. Ramsey Reset Test

We consider our model (*Model C*) as simple linear regression model and finally took only seven regressors. So we have to test whether to test there any kind of specification error. To test it we follow a general test of specification error, which is called Ramsey RESET test. By using *E-Views* we get following results:  
Here,

$$H_0 = \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 = 0$$

Again,  $F_{0.05(7,24)} = 2.455$ ; Where, 7 = Number of new regressors.

24= Number of parameters in the model.

0.05 = Level of significance

### 6.2. Multicollinearity Test

In these least squares regressions, the left hand side variable is one of the explanatory variables and the right hand side variables are remaining explanatory variables .For example, a general auxiliary regression for EXC is,

$$EXC = \beta_3 EXO + \beta_5 GDP + \beta_6 HOI + \beta_7 IMP + \beta_9 M_2 + \beta_{10} REM + \epsilon_t$$

If  $R^2$  from this artificial model is high, above 0.80, say, the implication is that a large portion of the variation in EXC is explained by variation in the other explanatory variables. As  $R^2$  from our artificial model is not high, less than 0.80, say, a small portion of the variation in EXC is explained by the variation in other explanatory variables that is there is *no Multicollinearity* in our model.

Table 4. Test of specification error

Model	Data based value of the test statistic	Critical value at 5% level	Results
Constant and trend	2.188295	2.455	Accept $H_0$
Conclusion	Therefore, F-critical >F-calculated. Evidence does not support to reject the null hypothesis, and we accept null hypothesis. So, we can conclude that there is no specification error in our model.		

Table 5. Multicollinearity Test(Auxiliary Regressions)

Model	Expected $R^2$	Artificial Model $R^2$	Decision
	0.80>	0.720491	Absence of Multicollinearity
Conclusion	Therefore, 0.720491<0.80. We see that our artificial model $R^2$ is less than 0.80. So; we can conclude that there is no presence of Multicollinearity.		

### 6.3. Test of Autocorrelation (Durbin-Watson Test)

The Durbin-Watson ‘d’ test is appropriate for detecting the first order autocorrelation. The estimated Durbin-Watson ‘d’ statistic is 2.017331. So, we have to test the autocorrelation, as our sample size is 39, number of explanatory variables are  $K=7$  and  $\alpha=5\%$ ; the  $d_L = 1.104$ (lowerbound of d) and  $d_U = 1.932$ (the upper bound of d) .As computed  $d=2.017331$ , therefore we see that  $d_U < d < 4 - d_U$  that is

$1.932 < 2.017331 < 2.068$ . So there is no autocorrelation in our model.

Legend,

$$H_0: \text{no positive autocorellation}$$

Or,

$$H_0: \text{no negative autocorellation}$$

Table 6. Autocorrelation test (Durbin-Watson ‘d’ statistic)

Model	Critical upper value of Durbin-Watson( $d_U$ )at 5%	$d_U < d < 4 - d_U$	Results
	1.932	1.932<2.017331<2.068	Accept $H_0$
Conclusion	Since, the ‘d’ statistic is greater than $d_U$ and less than $(4 - d_U)$ . So, we do not reject null hypothesis of showing no positive autocorrelation. In the above model there is no autocorrelation.		

Table 7. Test for Heteroskedasticity

Model	Obtained $\chi^2 (n \cdot R^2)$	Critical value at different significant level.	Decision
	37.070826	49.802(5%)	No Heterskedasticity
		46.059(10%)	No Heterskedasticity
		53.203(2.5%)	No Heterskedasticity
		57.342(1%)	No Heterskedasticity
Conclusion	Obtained $\chi^2 <$ Critical value of $\chi^2$ . So, our model is free from Heteroskedasticity at 5%, 10%, 2.5% and 1% level of significance. Finally, we can conclude that there is no Heteroskedasticity.		



**6.4. Test for Heteroskedasticity( White Heteroskedasticity Test)**

To test Heteroskedasticity, we have used the White Heteroskedasticity test. By using E-views we found following result.

**6.5. Chow Breakpoint Test (Structural Stability Test)**

Structural stability can be examined through several

methods. However, we have used the Chow test. To apply the chow test, the data is divided into two parts at a priori date and two regressions over the sub periods are compared to the full sample regression using F-ratio. We have divided the observations into two sub group. One is covering from 1973 to 1985 and another is covering from 1986 to 2011.

$$H_0: \text{no structural change}$$

$$H_A: \text{structural change}$$

Table 8. Chow Breakpoint test (structural stability test)

Model	F-Calculated value	Critical value at 5% level	Results
Constant and trend	1.861670	2.395	Accept $H_0$
Conclusion	Therefore, F-critical >F-calculated. Evidence does not support to reject the null hypothesis, thus we can say that null hypothesis of “No structural change” is accepted. That is our model is found structurally stable over time.		

**6.6. Test for Normality**

The classical normal linear regression model assumes that each  $U_1$  is distributed normally. If the distribution of the residuals is not normal, than the obtain t-ratios are substandard and inferences are not valid. So test for normality is very important.

**6.6.1. Visual Examination and Jarque-Bera Test**

A residual is the difference between the observed and model predicated values of the dependent. The shape of the histogram should approximately follow the shape of the normal curve.

The Jarque-Bera Test of normality is an asymptotic or large sample test. Though, our sample is not large enough for validity of the model. This test has been used for normality test. For the test at first we have to compute the skewness and kurtosis measures of the OLS residuals by using the following statistic:

hypothesis that the residuals are normally distributed.

**7. Conclusions and Policy Implication**

A sound level of forex reserves indicates how much strong of foreign sector of a country. Basically, there is no alternative to keep substantial amount of foreign exchange reserves in a country if the government want to keep currency stable and to avoid fluctuation of exchange rate. In the absence of sound level of forex reserves, speculation attack currency and devalue it forcefully. Bangladesh is a developing country with low level income. Its foreign exchange reserves are not attractive as neighboring south Asian countries. Much research has been done on the topic of determination of forex reserves by Asian countries. Although there is no conclusive evidence in the literature as to which variables determine forex reserves, the result of this study seem to be consistent with the findings of previous works.

The main purpose of this study is to identify the determinants of foreign exchange reserves by estimating an appropriate international reserves function. After testing exchange rate, home interest rate, foreign aid, remittance, broad money supply( $M_2$ ), inflation rate differential, import, export and GDP as candidates for the threshold variables, we identified exchange rate, home interest rate, remittance, broad money supply( $M_2$ ), UPI of import and export and per capita GDP as threshold variables that may determine the foreign exchange reserves. The major findings of the paper states that foreign currency reserves linearly depend on exchange rate, home interest rate, remittance, broad money supply( $M_2$ ), UPI of import and export and per capita GDP. The study also finds that foreign aid is not a significant determinant of foreign reserves for the sample data. Because, in recent years, many developed and international organizations have reduced their considerable amount of aid due to various causes such as the global economic recession, various unfeasible condition by donor countries, unwanted existing corruption of the country, and so on. As a result, the amount of aid has been anchored by less than 1% of GDP in year of 2012. There were several issues left unexplored in this paper due to data constraints. In particular it would be

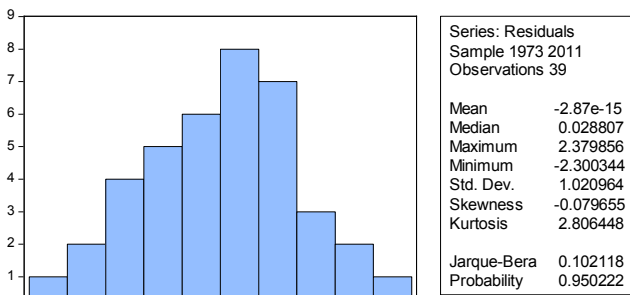


Figure 2. E-Views output residuals histogram and summary statistic.

$$JB = n \left[ \frac{S^2}{6} + (K - 3)^2/24 \right]$$

Where S and K are the skewness and kurtosis respectively.

By using E-Views we got the skewness and kurtosis of the model which are ‘-0.079655’ and ‘2.806448’ respectively and the JB value is 0.102118. Since this JB statistics follow the chi-square distribution and the critical value is ‘5.991’ at 5% level of significance with 2 df. So, we can not reject the null

interesting to examine relationship between the political instability and level of reserves perspective Bangladesh.

As a future step to this research, it would be useful to have a more rigorous framework in which to characterize the potential determinants of forex reserves. Another area of research could be to examine the interaction between monetary policy of govt. and the forex reserves accumulation. One can verify this with increase sample size or re-specified the model. Again one can re-examine the relation by taking more explanatory variables in the model. Despite the limitations and complexity of economic relation with the help of this paper govt. can get an indication to make its monetary policy. To change it foreign exchange reserve any govt. can consider its exchange rate, home interest rate, remittance, broad money supply ( $M_2$ ), UPI of import and export and per capita GDP as the dominant factors but not as only factors.

Foreign exchange reserve position is also significantly related with the behavior of exchange rate. Measures to reduce balance of trade deficit and current account deficit are required. To keep the foreign exchange rate stable, the macro economic environment must be conducive to maintain relatively stable price levels. Fiscal and monetary discipline is an essential precondition for price level stability. Independent and professional behavior of Central Bank of Bangladesh and role of government is very vital in order to create an environment conducive for the price level and exchange rate stability. The political stability ensures commitment toward the consistent policies.

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