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Nominal Exchange Rate Dynamics for the Taka

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Abstract. Error correction modeling is used to model the nominal exchange rate for the Bangladeshi taka. Based on existing trade volumes and trade practices, the bilateral exchange rate of the taka with the dollar is analyzed. Annual frequency data are utilized for the study. The sample data cover the four decade period from 1976 to 2015. Results indicate that a balance of payments modeling approach performs more reliably than a monetary balances approach.

Keywords. Regional economics, Business cycles, Economic indicators.
JEL. F31, O53.

1. Introduction

Currency market values are difficult to model (Uddin *et al.,* 2013). In many developing countries, exchange rate fluctuations form the nucleus of ongoing economic debates. In such cases, empirical evidence can prove important. Error correction models are often useful for analyzing nominal exchange rates, because this approach allows examination of long-run and short-run exchange rate dynamics.

The objective of this study is to analyze the time series behavior of the nominal taka / dollar exchange rate using annual data from 1976 to 2015. The taka is the national currency of Bangladesh. Since the United States dollar is commonly utilized to carry out international trade transactions of Bangladesh with rest of the world, the taka / dollar exchange rate is selected for the analysis. The research follows an error correction procedure similar to that employed by Fullerton & Lopez (2005) for the Mexican peso / United States dollar exchange rate. The analysis employs traditional balance of payments and monetary constructs (Dornbusch, & Fischer 1980; Baillie, & Selover 1987).

The study is organized as follows. The next section provides a brief review of related literature. The theoretical models undergirding the econometric analysis are then introduced, followed by a discussion of the data, and empirical results. The final section concludes and summarizes the study.

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2. Literature Review

Exchange rates are affected by many macroeconomic variables. Some of the major factors influencing exchange rate dynamics include national price levels, interest rates, real output levels, money supplies, and international trade balances (Isard, 1987; Hopper, 1997). Exchange rates, in turn, influence international prices of goods and services and, consequently, volumes of exports and imports (Makin, 2009).

Whenever the balance of payments registers a purchase of a foreign asset or a sale of a domestic commodity abroad, this implicitly indicates that there is a change in the demand for, or in the supply of, a foreign currency. The exchange rate is the value at which the supply and the demand for the foreign currency in terms of the local currency equilibrates. Makin (2009) notes that the exchange rate is based on relative movements in the supply and demand for currencies arising from external account transactions such as imports, exports, and foreign investment flows. Therefore, changes in balance of payments can cause fluctuations in the exchange rate between the domestic and foreign currencies.

Monetary factors also play significant roles in exchange rate behavior (Baillie & Selover, 1987). According to the monetary approach, the equilibrium exchange rate changes due to variations in money supply, income, interest rates, and money demand. Expectations of asset holders concerning future exchange rates are influenced by beliefs regarding future monetary policy (Mussa, 1976). From this perspective, the equilibrium rate is directly related to the instruments of monetary policy. The monetary model also implies that speculation may be a significant factor affecting exchange rates (Bilson, 1978).

Gross domestic product (GDP) may also be related to exchange rate fluctuations. Dritsakis (2004) presents evidence that there is a causal relationship between exchange rates and economic growth in Greece. Price levels decrease with the increase of economic growth (real gross domestic product growth) and the decline of the price level (relative to price levels in other countries) results in appreciation of the domestic currency. As another example of this phenomenon, East Asia experienced high per capita GDP growth and real currency appreciations in the period from 1973 to 1995 (Ito *et al.,* 1999).

Hoffman & MacDonald (2009) note that real exchange rates and real interest rates have economically significant relationships. Higher interest rates attract foreign capital and cause exchange rates to appreciate. Because interest rates affect the behavior of exchange rates, it is often an important variable category for analyzing exchange rate dynamics.

Purchasing Power Parity (PPP) helps explain the evolution of exchange rates over time. Inflation in the domestic country leads to depreciation of the national currency, other things equal. Exchange rate models based on PPP tend to be valid for the long run (Sarno & Taylor, 2002; Makin, 2009). However, the PPP relationship often fails to adequately represent exchange rate behavior in the short run (Edison, 1987). Rogoff (1996) notes that both long-run and short-run forces affect exchange rate dynamics. Therefore, models that take into account both long-run and short-run exchange rate dynamics can be useful.

Granger (1981) provides a framework for specifying econometric models of cointegrating and error correction relationships. Studies using cointegration and error correction approaches have found that long-run and short-run factors significantly affect financial variables (Engle & Granger, 1987; Modeste & Mustafa, 1999). There may also be benefits to incorporating both long-run and short-run factors into models of exchange movements for currencies such as the taka.

In Bangladesh, inflation, GDP growth, interest rates, and current account balances have been found to influence the exchange rate (Chowdury & Hossain, 2014). Foreign exchange reserves and monetary variables have also been documented as affecting real exchange rates in Bangladesh (Uddin, Quaosar & Nandi, 2013). It should be noted that the exchange rate system of Bangladesh changed from a fixed rate to a managed float in 1979 and from managed floating to clean floating by creating a fully convertible current account in 2003. Interestingly, these changes in the exchange rate regime are not found to have impacted the value of Bangladeshi currency in statistically significant ways (Priyo, 2009).

Nominal exchange rate models based on balance of payments and monetary constructs can be estimated within error correction frameworks (Fullerton, Hattori, & Calderon, 2001; Fullerton & Lopez, 2005). Relatively little research exists on the long-run and short-run dynamics of the nominal exchange rate of Bangladesh. This study analyzes the behavior of the nominal taka/dollar exchange rate using annual data from 1976 to 2015 within an error correction framework.

3. Theoretical Framework

This study analyzes annual frequency exchange rate data of Bangladesh using an approach similar to that employed by Fullerton & Lopez (2005) to model the Mexican peso / US dollar exchange rate. The approach incorporates several different variables that have proven helpful in analyzing exchange rate dynamics and examines the effects of both long-run and short-run forces on the exchange rate (Rogoff, 1996). Two basic frameworks are employed: a balance of payment approach depicting the effect of international reserves on exchange rate dynamics and a monetary approach. Equations (1) and (2) correspond to the balance of payments approach (Dornbusch & Fisher, 1980).

$$s_t = a_0 + a_1 (p - p^*)_t + a_2 (r - r^*)_t + a_3 IR_t + u_t \quad (1)$$
$$ds_t = b_0 + b_1 d(p - p^*)_t + b_2 d(r - r^*)_t + b_3 dIR_t + b_4 u_{t-1} + v_t \quad (2)$$

Equation (1), which captures long-run equilibrium dynamics, shows the nominal taka/dollar exchange rate (s) as a function of national price level (p) differences, interest rate (r) differentials, international liquid reserves (IR), and a stochastic error term (u). The variables s, p, and IR are expressed in natural logarithms while r is expressed as a percentage. Asterisks denote variables corresponding to the United States and t is a time subscript. All the other explanatory variables correspond to Bangladesh. Slope coefficients represent the effects that the explanatory variables have on the taka / dollar exchange rate.

In Equation (1), a_1 is hypothesized to be positive. That is because an increase in the Bangladeshi price level relative to the United States price level is expected to reduce the value of the taka relative to the dollar, thus resulting in a higher taka / dollar exchange rate. The coefficient a_2 is hypothesized to be negative. An increase in domestic interest rates relative to foreign interest rates attracts foreign capital and causes the domestic currency to appreciate, thus decreasing the exchange rate, s. According to orthodox theory, rising international reserves increase the value of the domestic currency, which results in a negative value for a_3.

The short-run behavior of the exchange rate is represented by Equation (2). This is also the error correction equation. In this equation, the nominal taka/dollar exchange rate, price level, interest rate, and international liquid reserves variables are first-differenced and a one period lag of the stochastic error term (u_{t-1}) is included. Here, d is the difference operator and v is a white noise random disturbance term. Changes in the taka/dollar exchange rate can be affected by short-run and long-run forces. Long-run dynamics are incorporated into Equation (2) through the lagged residuals, u_{t-1}, from Equation (1).

The following hypotheses are advanced for the price and interest rate differential coefficients in Equation (2): $b_1 > 0$ and $b_2 < 0$. As in the long-run equation, the rationale for these hypotheses is that higher relative price levels in Bangladesh lead to an increase in the taka/dollar exchange rate, s, while higher relative interest rates lead to a decrease in s. Also, as previously mentioned, liquid reserves are expected to have a negative effect on exchange rate, hence, $b_3 < 0$. The error correction coefficient, b_4, measures the speed of adjustment to any deviation from long-run equilibrium. The coefficient b_4 is, accordingly, hypothesized to be negative because deviations from equilibrium will be followed by compensating adjustments in subsequent periods.

The second framework considered is based on the monetary approach of exchange rate determination (Baillie, & Selover, 1987).

$$s_t = c_0 + c_1 (p - p^*)_t + c_2 (r - r^*)_t + c_3 (m - m^*)_t + c_4 (y - y^*) + w_t \tag{3}$$

$$ds_t = f_0 + f_1 d(p - p^*)_t + f_2 d(r-r^*)_t + f_3 d(m-m^*) + f_4 d(y-y^*) + f_5 w_{t-1} + z_t \tag{4}$$

In Equation (3), slope coefficients c_1, c_2, c_3 and c_4 capture the response of the nominal exchange rate to movements in national price levels, interest rates, national money supplies (m), and real gross domestic products (y), respectively. The exchange rate, price, money supply, and gross domestic product variables are expressed in natural logarithms. Equation (4) depicts the short-run behavior of the nominal exchange rate. w_t represents the long-run error term and z_t is the short-run random disturbance. w_{t-1} is the one-year lag of the long-run error term and f_5 represents the rate at which disequilibria from prior periods dissipate.

Expected coefficient signs for Equation (3) are $c_1 > 0$, $c_3 = 1$, and $c_4 < 0$ due to the following reasons. Higher domestic price levels relative to the foreign price level cause depreciation of the domestic currency. Moreover, the response of the exchange rate to the money supply differential is hypothesized to be unit-elastic (Baillie & Selover, 1987). A higher money supply typically leads to inflation, which tends to decrease the domestic currency value. A rise in inflation also reduces real output, when nominal output is held constant. Hence, lower real output is associated with domestic currency depreciation and a higher exchange rate s, other things equal.

There is some ambiguity associated with the sign of c_2. According to conventional theory, higher interest rates attract foreign capital and cause the domestic currency to appreciate. If that is the case then c_2 is expected to be less than 0. However, in the sticky price model of Dornbusch (1976), $c_1 > 0$ and $c_2 = 0$. Alternate model structures have other signs for c_2. According to Kim & Mo (1995), under a flexible price framework, $c_2 > 0$.

The hypotheses for Equation (4) are largely similar to those advanced for Equation (3). Increases in both the domestic price level and the domestic money supply relative to those of the foreign country decrease the domestic currency value. Conversely, higher relative interest rates and real output levels in the home country tend to increase the domestic currency value. Furthermore, f_5 is expected to be negative because deviations from equilibrium will be followed by offsetting adjustments in subsequent periods. Therefore, expected signs for Equation (4) are $f_1 > 0$, $f_3 > 0$, $f_4 < 0$, and $f_5 < 0$. However, there is some ambiguity with respect to the sign of f_2. Dornbusch (1976) indicates that $f_2 < 0$, while Kim & Mo (1995) conjectures that $f_2 > 0$.

An autoregressive distributed lag (ARDL) modeling approach is used to establish the exact form of the model specification. A bounds testing procedure is applied to determine whether the variables in Equation (1) are cointegrated (Pesaran, & Shin, 1998; Pesaran *et al.,* 2001). This approach has been used to analyze the effect of exchange rate volatility on US exports to the rest of the world (De Vita & Abbott, 2004). The advantage of the bounds testing approach is that it does not require all of the potentially cointegrated variables be I(1), but rather allows for cases in which the variables are I(0), I(1), or a mix of the two. Moreover, its small sample properties are relatively favorable (Narayan, 2005).

The ARDL specification of Equation (1) is shown in Equation (5). The optimal number of lags for each variable can be selected using the Akaike Information Criterion or the Schwarz Bayesian Criterion (Enders, 2010).

$$s_t = \alpha_0 + \sum \Upsilon_i s_{t-i} + \sum \alpha_{1i} (p - p^*)_{t-i} + \sum \alpha_{2i} (r - r^*)_{t-i} + \sum \alpha_{3i} IR_{t-i} + w_t \quad (5)$$

In Equation (5), i is an index for lags and w_t is an error term.

In Equation (6), long-run coefficients are calculated using the estimated α_{ji} parameters, where j is an index identifying the explanatory variables employed in the model. The long-run coefficients are then substituted into Equation (1) and the residuals, u_t, are calculated. The lagged residuals, u_{t-1}, will be included in the short-run error correction equation if a conintegrating relationship exists.

$$a_j = \sum \alpha_{ji} / (1 - \sum \Upsilon_i) \quad (6)$$

A bounds test is conducted to determine whether the variables in Equation (1), for the balance of payments approrach, are cointegrated (Pesaran *et al,* 2001). For this test Equation (7) is estimated, where d denotes the first-difference and v is a random error term.

$$ds_t = \rho_0 + \sum \theta_i ds_{t-i} + \sum \rho_{1i} d(p - p^*)_{t-i} + \sum \rho_{2i} d(r - r^*)_{t-i} + \sum \rho_{3i} d(IR)_{t-i} + \rho_4 s_{t-1} + \rho_5 (p - p^*)_{t-1} + \rho_6 (r - r^*)_{t-1} + \rho_7 IR_{t-1} + v_t \quad (7)$$

The null hypothesis is that there is no cointegration. An F-test can be used to evaluate the null hypothesis, which can be formally stated as $H_0: \rho_4 = \rho_5 = \rho_6 = \rho_7 = 0$. There is one set of (lower-bound) critical values for the case where all variables are I(0) and another set of (upper-bound) critical values for the case where all variables are I(1) (Pesaran *et al,* 2001). When the calculated F-statistic is larger than the upper bound, then null hypothesis can be rejected, which indicates that there is cointegration. If the F-statistic falls between the upper and lower critical values, then the conclusion of the test is indeterminate.

Equation (8) shows the short-run error correction equation specification. Short-run departures from the long-run equilibrium can happen due to various types of economic and non-economic shocks. When those shocks occur, the exchange rate is hypothesized to respond in a manner that allows the equilibrium to eventually be re-attained.

$$ds_t = \beta_0 + \sum \delta_i d_i s_{t-i} + \sum p_{1i} d(p - p^*)_{t-i} + \sum p_{2i} d(r - r^*)_{t-i} + \sum p_{3i} d(IR)_{t-i} + \varphi u_{t-1} + \varepsilon_t \quad (8)$$

The coefficient for the error term, u_{t-1}, is expected to be negative, and indicates the rate at which a short-run departure from equilibrium will dissipate. The time required for complete adjustment to the long-run equilibrium increases as the value of the error term coefficient approaches zero.

In order to determine whether the variables in Equation (3), for the monetary approach, are cointegrated, an ARDL model is estimated and the bounds testing procedure is again applied (Pesaran & Shin, 1998; Pesaran *et al.,* 2001). The ARDL specification of Equation (3) is shown in Equation (9), where i is an index for lags, p is the optimal number of lags for the dependent variable, q_j is the optimal number of lags for each explanatory variable, and x_t is an error term.

$$s_t = \mu_0 + \sum \eta_i s_{t-i} + \sum \mu_{1i} (p - p^*)_{t-i} + \sum \mu_{2i} (r - r^*)_{t-i} + \sum \mu_{3i} (m - m^*)_{t-i} + \sum \mu_{4i} (y - y^*)_{t-i} + x_t \quad (9)$$

In Equation (10), long-run coefficients are calculated using the estimated μ_{ji} parameters, where j is an index identifying the explanatory variables considered in the model. The long-run coefficients are then substituted into Equation (3) and the residuals, w_t, are calculated. The lagged residuals, w_{t-1}, will be included in the short-run error correction equation if a cointegrating relationship exists.

$$c_j = \Sigma\, \mu_{ji} \,/\, (1 - \Sigma\, \eta_i) \tag{10}$$

For the bounds test Equation (11) is estimated, where d denotes the first-difference and v is a random error term. The null hypothesis is no cointegration, hence, H_0: $\rho_5 = \rho_6 = \rho_7 = \rho_8 = \rho_9 = 0$. Calculated F-statistics can be compared against the critical values presented in Pesaran *et al.* (2001) to determine whether cointegration is present.

$$\begin{aligned} ds_t &= \rho_0 + \Sigma\, \theta_i\, ds_{t-i} + \Sigma\, \rho_{1i}\, d(p - p^*)_{t-i} + \Sigma\, \rho_{2i}\, d(r - r^*)_{t-i} + \\ &\Sigma\, \rho_{3i}\, d(m - m^*)_{t-i} + \Sigma\, \rho_{4i}\, d(y - y^*)_{t-i} + \Sigma\, \rho_5\, s_{t-1} + \rho_6\,(p - p^*)_{t-1} + \\ &\rho_7\,(r - r^*)_{t-1} + \rho_8\,(m - m^*)_{t-1} + \rho_9\,(y - y^*)_{t-1} + v_t \end{aligned} \tag{11}$$

Equation (12) is the estimated short-run error correction equation. Short-run departures from the long-run equilibrium can happen due to a variety of factors. The coefficient for the error term, w_{t-1} is expected to be negative, and indicates the rate at which a short-run departure from equilibrium will dissipate.

$$\begin{aligned} ds_t &= \beta_0 + \Sigma\, \delta_i\, ds_{t-i} + \Sigma\, \rho_{1i}\, d(p - p^*)_{t-i} + \Sigma\, \rho_{2i}\, d(r - r^*)_{t-i} + \\ &\Sigma\, \rho_{3i}\, d(m - m^*)_{t-i} + \Sigma\, \rho_{4i}\, d(y - y^*)_{t-i} + \varphi\, w_{t-1} + \varepsilon_t \end{aligned} \tag{12}$$

The following section describes data and empirical results. Annual-frequency data covering the 1976 to 2015 sample period are used to analyze the behavior of the nominal taka/dollar exchange rate. Two models are developed to investigate nominal exchange rate dynamics within an error correction framework. Those models are based on balance of payments and monetary constructs (Fullerton, Hattori, & Calderon, 2001). Autoregressive distributed lag (ARDL) models are estimated and bounds testing is conducted to determine whether cointegration exists among the variables included in each model.

4. Data and Empirical Results

Data for domestic (Bangladesh) and foreign (United States) variables are collected from the International Monetary Fund database *International Financial Statistics 2013* and from the website of the International Monetary Fund (IMF). Annual data from 1976 to 2015 are collected for the taka / dollar exchange rate and for the independent variables employed in the balance of payments and monetary construct equations. Variable definitions and data sources are provided in Table 1. Real gross domestic products (GDP) for both countries are the proxy variables for real incomes. Because data on certificate of deposit interest rates for the United States are truncated in 2010, non-jumbo deposit interest rates are used for 2011 to 2015.

Table 1. *Variable Definitions and Data Sources*

Variable	Definition, Units, and Sources
s	Natural logarithm of the nominal exchange rate (taka/dollar). Source: 2013 IMF *International Financial Statistics CD-ROM* and IMF Website.
p	Natural logarithm, Bangladesh GDP implicit price deflator, 2005=100. Source: 2013 IMF *International Financial Statistics CD-ROM* and IMF website.
p*	Natural logarithm, United States GDP implicit price deflator, 2005=100. Source: 2013 IMF *International Financial Statistics CD-ROM* and IMF website.
r_{cd}	3-6 month scheduled bank fixed deposit rate, Bangladesh. Source: 2013 IMF *International Financial Statistics CD-ROM* and IMF website.
r_{cd}*	3-month Certificate of Deposit rate, United States. Source: 2013 IMF *International Financial Statistics CD-ROM* and IMF website.
IR	Natural logarithm, liquid international reserves, Bangladesh. Millions US dollars. Source: 2013 IMF *International Financial Statistics CD-ROM* and IMF website.
m	Natural logarithm, M2 money supply, Bangladesh, Millions of national currency

	(Taka). Source: 2013 IMF *International Financial Statistics CD-ROM* and IMF website.
m*	Natural logarithm, M2 money supply, United states, billions of dollars. Source: 2013 IMF *International Financial Statistics CD-ROM* and IMF website.
y	Natural logarithm, Bangladesh real GDP, 2005 base year. Billions national currency (Taka). Source: 2013 IMF *International Financial Statistics CD-ROM* and IMF website.
y*	Natural logarithm, United States real GDP, 2005 base year. Billions of dollars. Source: 2013 IMF *International Financial Statistics CD-ROM* and IMF website.
u	Balance of payments approach equilibrium error term.
w	Monetary approach equilibrium error term.
v	Balance of payments approach white noise random disturbance.
z	Monetary approach white noise random disturbance.
d	Difference operator.
t	Time period index.
*	Denotes foreign country variable, United States.

Several studies based on the application of time series methodologies have been completed using relatively few observations (Shiller & Perron 1985; Hakkio & Rush 1991). Research in this area indicates that empirical analyses conducted for short time spans should use lower numbers of time lags to avoid pronounced losses in test power (Zhou, 2001). This issue is examined below.

The ARDL balance of payments models are summarized in Tables 2 and 3 and monetary construct models are summarized in Tables 4 and 5. The ARDL approach is not appropriate to use for variables that are integrated of an order greater than one (Pesaran *et al.* 2001). Augmented Dickey-Fuller unit root tests indicate that all the variables included in the two models are either I(0) or I(1). Those results mean that the data are suitable for analysis within an ARDL framework.

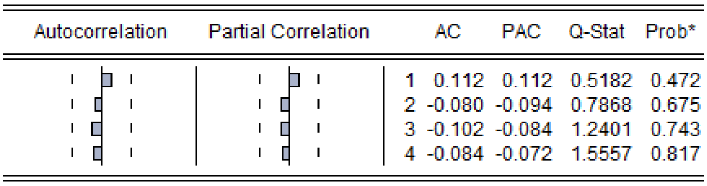
Table 2. *ARDL Balance of Payment Exchange Rate Estimation Results*

ARDL(2, 1, 0, 2) Equation Long-Run Coefficients

Variable	Coeff.	Std. Error	t-Statistic	Prob.
c	6.2200	1.8564	3.3506	0.0023
p - p*	1.6840	0.6179	2.7252	0.0108
r - r*	-0.0409	0.0304	-1.3474	0.1883
IR	-0.2162	0.2103	-1.0278	0.3125

R-squared	0.9969	Mean dependent var	3.7407
Adjusted R-squared	0.9961	S.D. dependent var	0.4963
S.E. of regression	0.0311	Akaike info criterion	-3.9022
Sum squared resid	0.0280	Schwarz criterion	-3.5144
Log likelihood	83.1420	Hannan-Quinn criter.	-3.7642
F-statistic	1177.091	Durbin-Watson stat	1.7628
Prob(F-statistic)	0.0000		

Chi-squared Autocorrelation Function Q-test for Higher Order Autocorrelation



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.112	0.112	0.5182	0.472
		2	-0.080	-0.094	0.7868	0.675
		3	-0.102	-0.084	1.2401	0.743
		4	-0.084	-0.072	1.5557	0.817

ARDL Bounds Test

Test Statistic	Value	k
F-statistic	8.3494	3

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.37	3.20
5%	2.79	3.67
2.5%	3.15	4.08
1%	3.65	4.66

Note: Bounds test critical values are from Narayan (2005).

The Akaike information criterion is utilized for lag length selection in developing the ARDL models for the taka / dollar exchange rate. A maximum of three lags of each variable is considered for inclusion in the final specifications. The minimum values of the Akaike information criterion and the Hannan-Quinn criterion correspond to an ARDL (2, 1, 0, 2) balance of payments model and an ARDL (2, 3, 0, 0, 0) monetary construct model. The first number in parentheses is the number of dependent variable lags included in the final specifications and the subsequent numbers are the lag orders for each of the explanatory variables. The Appendix reports alternative models selected on the basis of the Akaike information criterion when the maximum number of lags considered is restricted to one or two.

Table 2 reports estimated long-run elasticities plus diagnostic statistics for the ARDL (2, 1, 0, 2) balance of payments model of the taka / dollar exchange rate. For the model presented in Table 2, the Akaike information criterion and Hannan-Quinn criterion indicate that model performance is best with a maximum of one lag. Furthermore, the same specification (2, 1, 0, 2) is selected regardless of whether the maximum lag order is set at two or three. A Chi-squared autocorrelation function test indicates that serial correlation is not problematic. The calculated F-statistic for H_0: $\rho_4 = \rho_5 = \rho_6 = \rho_7 = 0$ is 8.35, which exceeds the 5-percent critical value for the upper bound computed by Narayan (2005). This confirms that the variables employed are cointegrated.

According to Table 2, the long-run coefficient signs align with the hypothesized signs. The price elasticity of the exchange rate is 1.68, which implies that, as the domestic price level increases by 1% relative to the United States price level, the domestic currency depreciates 1.68%. This estimate is smaller than the coefficient of the relative price levels, 2.42%, indicated by Meerza (2012) in a separate study of the taka per dollar exchange rate. Chowdhury & Hossain (2014) report that the coefficient of the inflation rate in the exchange rate model is 0.71. That suggests that the inflation rate and the exchange rate are positively correlated in Bangladesh and, as hypothesized, an increase of the domestic price level relative to the USA price level will increase the exchange rate. Mark (1990) also finds that there is a positive relationship between the domestic price level and the exchange rate.

Moreover, higher domestic interest rates tend to attract foreign investment. The interest rate coefficient is -0.04, which indicates that a 1-point increase in the Bangladesh-US interest rate differential will lead the taka to appreciate by 4% against the dollar. That is greater in absolute value than the -0.0005 estimate reported by Priyo (2009) in a previous exchange rate study for Bangladesh. The coefficient sign corroborates conventional economic theory, which holds that, as the domestic interest rate rises relative to foreign interest rates, more investors will invest in domestic financial securities, leading to domestic currency appreciation.

Furthermore, the international liquid reserve elasticity of the exchange rate is -0.22, which indicates that, if international liquid reserves increase by 1%, then the taka appreciates relative to the dollar by 0.22%. Uddin *et al.* (2013) estimates that the foreign exchange reserve elasticity of the exchange rate is -0.0975, which implies that a 1% increase of foreign exchange reserves results in a relatively small appreciation of the taka by only 0.0975%. In both studies, an increase of foreign exchange reserves occurs as a result of net inflows denominated in foreign currencies, and leads to appreciation of the domestic currency value. Although the sign and magnitude of the international reserve coefficient in Table 2 seem plausible, it is not significantly different from zero at the 5% level.

Additionally, CUSUM and CUSUMSQ tests are carried out to determine whether the estimated parameters remain stable or change significantly over time. The calculated CUSUM statistics are inside the 5-percent critical bounds as shown in Figure 1. Figure 2 shows that the CUSUMSQ statistics exceed the 5-percent critical bounds very slightly for a small subset of the time periods considered but otherwise remain well inside the bounds. These results indicate that the estimated parameters are reasonably stable over the time.

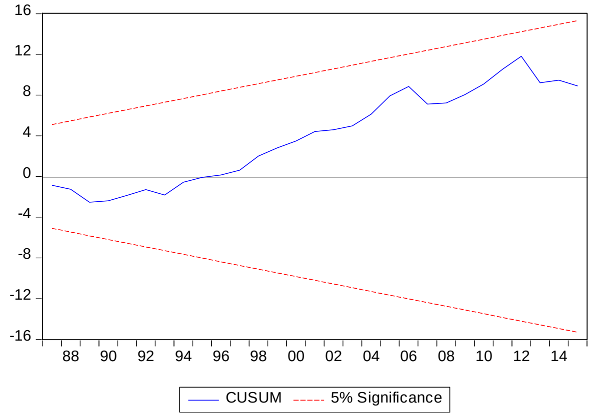


Figure 1: *CUSUM Results for Balance of Payments Exchange Rate Equations*

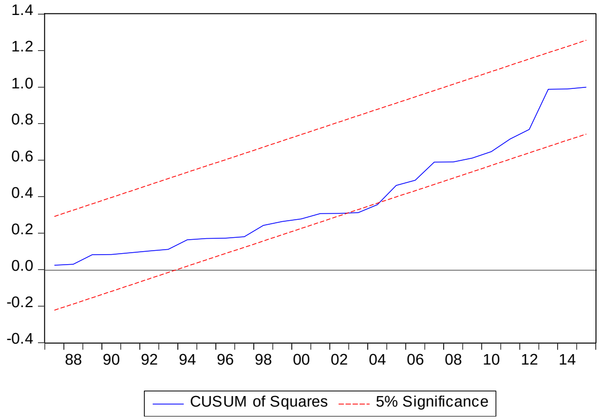


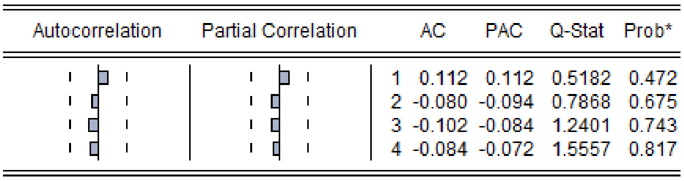
Figure 2: *CUSUMSQ Results for Balance of Payments Exch. Rate Equations*

Short-run error correction estimation results for the ARDL (2, 1, 0, 2) balance of payments model are summarized in Table 3. A chi-squared autocorrelation function Q-test indicates that serial correlation is not problematic. The coefficient of the lagged exchange rate is 0.28, considerably lower than the 1.41 response documented by Uddin *et al.* (2013). This parameter estimate in Table 3 suggests that short-run inertial forces are relatively subdued for the sample period utilized in this study. The computed t-statistic for it exceeds the 5% critical value.

Table 3. *Balance of Payments Error Correction Estimation Results*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
c	0.0006	0.0141	0.0406	0.9679
d(s(-1))	0.2801	0.1302	2.1513	0.0394
d(p-p*)	-0.1244	0.0725	-1.7163	0.0961
d(r-r*)	-0.0022	0.0034	-0.6278	0.5347
d(IR)	-0.0124	0.0159	-0.7808	0.4408
d(IR(-1))	-0.0433	0.0153	-2.8227	0.0082
U_t(-1)	-0.0955	0.0268	-3.5585	0.0012
R-squared	0.6874	Mean dependent var		0.0426
Adjusted R-squared	0.6269	S.D. dependent var		0.0489
S.E. of regression	0.0299	Log likelihood		83.3254
Sum squared resid	0.0277	Durbin-Watson stat		1.7586
F-statistic	11.3593	Prob(F-statistic)		0.0000

Chi-squared Autocorrelation Function Q-test for Higher Order Autocorrelation



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.112	0.112	0.5182	0.472
		2	-0.080	-0.094	0.7868	0.675
		3	-0.102	-0.084	1.2401	0.743
		4	-0.084	-0.072	1.5557	0.817

The short-run price differential coefficient is -0.12, indicating that a 1% increase of the domestic price level relative to the United States price level will cause the taka to appreciate by 0.12% against the dollar. This outcome is counterintuitive. However, Meerza (2012) also documents a similar, albeit more elastic, relationship in the short-run between the exchange rate and the price differential in a separate study of the taka. The parameter estimate in Table 3, however, fails to satisfy the 5% significance criterion. The short-run link between the inflationary gap and the taka / dollar exchange appears weak, at best.

The interest rate coefficient is -0.002, which indicates that a 1 point increase in the domestic-foreign interest rate differential decreases the exchange rate by 0.2%. This outcome is less, in terms of absolute value, than the -0.77% effect reported by AbuDalu *et al.*, (2008) in a short-run exchange rate model for the Singapore dollar. The negative sign of the interest rate parameter estimate reported in Table 3 aligns with the hypothesis. Although the t-statistic falls below the standard significance threshold, this outcome is economically plausible. An increase in the domestic interest rate relative to the foreign interest rate tends to attract investment, which increases foreign currency inflows, and leads to appreciation of the domestic currency.

As hypothesized, the short-run coefficient of contemporaneous liquid international reserves (IR) is -0.012 and that for liquid international reserves (IR) with a one-period lag is -0.043. When liquid reserves increase by 1%, then the domestic currency value appreciates by 0.012% in the first year, and by 0.043% in the second year. This outcome makes sense because the increment in foreign exchange reserves appreciates the currency value of the taka. The estimated effects are greater in absolute value than the -0.002% impact of international reserves reported by Ahmed *et al.,* (2012) in a study of the bilateral Pakistani rupee exchange rate. That may reflect the relative sizes of the two economies and the greater volume of international trade generated each year in Bangladesh.

As hypothesized, the sign for the error correction parameter (u_{t-1}) is less than zero. The value of the error coefficient is -0.09, implying that 11 years (1 / 0.09) are needed for short-run departures from equilibrium to fully dissipate. This is substantially slower than the speed of adjustment documented by Meerza (2012). According to that study, 7 years (1/0.14) are needed for short-run departures from equilibrium to fully dissipate. Both studies indicate that short-run deviations from the long-run taka/dollar equilibrium exchange last for fairly long periods of time. That may reflect a variety of institutional factors that reduce market flexibility in this growing economy (WB, 2017).

Next, an ARDL (2, 3, 0, 0, 0) model is estimated for the taka / dollar exchange rate using the monetary approach (Baillie & Selover, 1987). Table 4 reports estimated long-run elasticities with diagnostic statistics for this ARDL model. The lag structure is selected on the basis of Akaike, Schwarz, and Hannan-Quinn information criteria. Autocorrelation Q-statistics for the first four lags indicate that serial correlation is not problematic. The calculated F-statistic for H_0: $\rho_5 = \rho_6 = \rho_7 = \rho_8 = \rho_9 = 0$ is 3.14, which is higher than the 5-percent critical value for the upper bound computed by Narayan (2005). That confirms that the variables of the model are cointegrated.

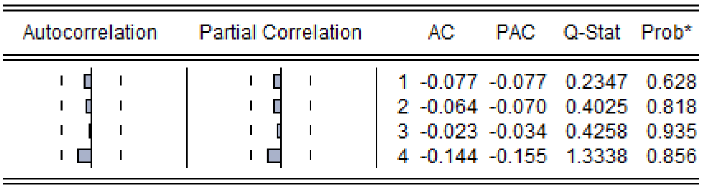
Table 4. *ARDL Monetary Exchange Rate Estimation Results*

ARDL(2, 3, 0, 0, 0) Equation Long Run Coefficients

Variable	Coeff.	Std. Error	t-Statistic	Prob.
c	-6.4816	1.3726	-4.7219	0.0001
p - p*	0.1359	0.1568	0.8665	0.3938
r - r*	0.0027	0.0065	0.4093	0.6856
m - m*	0.5036	0.0636	7.9151	0.0000
y - y*	-0.6231	0.1621	-3.8435	0.0007

R-squared	0.9965	Mean dependent var	3.7686
Adjusted R-squared	0.9954	S.D. dependent var	0.4720
S.E. of regression	0.0322	Akaike info criterion	-3.8110
Sum squared resid	0.0279	Schwarz criterion	-3.3756
Log likelihood	80.5041	Hannan-Quinn criter.	-3.6575
F-statistic	859.0523	Durbin-Watson stat	2.2510
Prob(F-statistic)	0.0000		

Chi-squared Autocorrelation Function Q-test for Higher Order Autocorrelation



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Autocorrelation    Partial Correlation        AC     PAC    Q-Stat  Prob*

                                         1 -0.077 -0.077  0.2347  0.628
                                         2 -0.064 -0.070  0.4025  0.818
                                         3 -0.023 -0.034  0.4258  0.935
                                         4 -0.144 -0.155  1.3338  0.856
```

ARDL Bounds Test

Test Statistic	Value	k
F-statistic	3.1369	4

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.20	3.09
5%	2.56	3.49
2.5%	2.88	3.87
1%	3.29	4.37

Note: Bounds test critical values are from Narayan (2005).

According to Table 4, the price level elasticity of the exchange rate is 0.14, which implies that 1% increases in Bangladeshi inflation relative to United States inflation increase the taka / dollar exchange rate by 0.14%. This estimate is larger than the 0.002% estimate reported by Priyo (2009), but substantially smaller than the 2.42% obtained by Meerza (2012). The positive sign of the price coefficient corroborates the null hypothesis based on conventional economic theory. An increase in domestic prices relative to inflation in the foreign country leads to depreciation of the domestic currency. The computed t-statistic does not, however, exceed the 5% critical value. On the basis of impulse-response analysis, Mark (1990) also reports evidence that the long-run dynamic relationship between nominal exchange rates and relative price levels can be weak.

The estimated interest rate coefficient sign runs counter to the null hypothesis discussed above. When the domestic interest rate increases, foreign currency inflows are also expected to increase. However, the interest rate coefficient is 0.003, which indicates that a 1 percentage point increment in the domestic-foreign interest rate differential causes the domestic currency value to depreciate by 0.3%. The estimated outcome is counter-intuitive because, as the interest rate increases, foreign currency inflows are predicted to result in appreciation of the domestic currency. However, the computed t-statistic does not standard significance criterion. One plausible interpretation of the interest rate coefficient in Table 4 is that this variable has no discernible long-run impact on the exchange rate in Bangladesh within a monetary model specification. Some other studies of exchange rate dynamics in Bangladesh also report positive interest rate coefficients that are statistically indistinguishable from zero (Priyo, 2009; Chowdhury & Hossain, 2014).

The money supply (M2) elasticity of the exchange rate is 0.5, which indicates that a 1% increase in the money supply of Bangladesh relative to the money supply of the United States results in depreciation of the taka relative to the dollar by 0.5%. *Uddin et al.,* (2013) find that a 1% increase in the money supply results in a real depreciation of the taka by 0.52% in Bangladesh. This outcome is logical according to economic theory, since an increase in money supply results in inflation and inflation tends to diminish the domestic currency value. In addition to the alignment of the sign of the money supply coefficient with the stated hypothesis for it, the computed t-statistic for M2 satisfies the standard significances criterion.

An increase in real output in Bangladesh with respect to real output in the United States is expected to cause the taka to appreciate relative to the dollar. In Table 4, the output elasticity of the exchange rate is -0.62, which indicates that if domestic output increases by 1% with respect to foreign output, then the domestic currency appreciates by 0.62%. Nieh & Wang (2005) find that the coefficient on output with a lag of one period is -0.783 in an exchange rate model developed for Taiwan. Hooper & Morton (1982) note that the output elasticity of the exchange rate is -1.46 in a model of dollar exchange rate determination in the United States.

CUSUM and CUSUMSQ tests are carried out to examine parameter stability. Figure 3 indicates that the calculated statistics stay within the 5-percent critical bounds for the CUSUM test. Figure 4 indicates a fair degree of parameter stability, though the calculated statistics do exceed the 5-percent bounds over a subset of the sample period that corresponds to the transition away from the managed float exchange rate regime. This suggests that monetary model long-run parameters are relatively less stable than those of the balance of payments approach for Bangladesh.

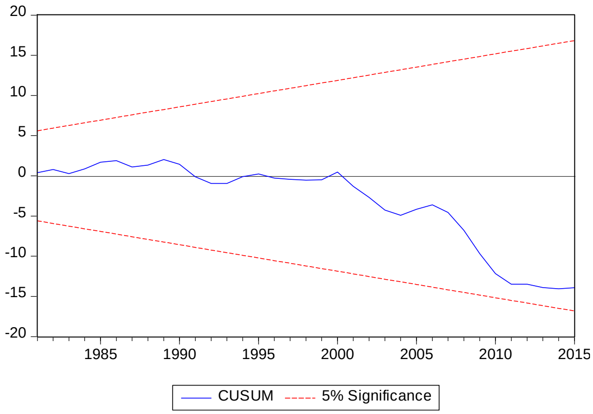


Figure 3: *CUSUM Results for Monetary Framework Exch. Rate Equations*

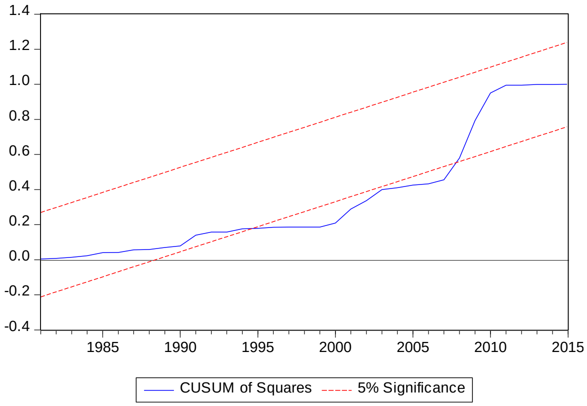


Figure 4: *CUSUMSQ Results for Monetary Framework Exch. Rate Equations*

Table 5 displays the results for the short-run error correction equation based on the monetary approach. Chi-squared Q-statistics for the residual autocorrelation function indicate that serial correlation is not problematic for the residuals associated with Table 5. The coefficient of the lagged exchange rate is 0.54, which indicates that a 1% increase in the exchange rate is associated with a 0.54% increase in the exchange rate in the following year. This outcome is smaller than the 1.41% response documented by Uddin *et al.,* (2013) for the taka per United States dollar exchange rate. The 0.54 estimate in Table 5 implies that the inertial component of taka/dollar bilateral exchange rate has subsided substantially and become more stable in recent years. The standard deviation for this coefficient in Table 5 is relatively small, reflecting a fairly reliable autoregressive relationship.

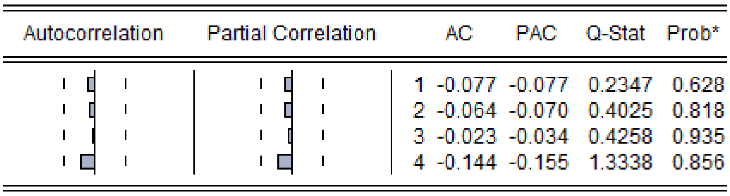
Table 5. *Monetary Model Error Correction Estimation Results*

Dependent Variable: d(s)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.007903	0.015590	0.506929	0.6162
d(s(-1))	0.537939	0.160027	3.361554	0.0023
d(p-p*)	-0.302083	0.087680	-3.445287	0.0018
d(p-p*(-1))	0.020785	0.091217	0.227861	0.8214
d(p-p*(-2))	0.170853	0.091070	1.876061	0.0711
d(r-r*)	0.003398	0.003733	0.910132	0.3705
d(m-m*)	0.195467	0.094326	2.072243	0.0476
d(y-y*)	-0.335159	0.282066	-1.188232	0.2447
W_{t-1}	-0.543508	0.126803	-4.286223	0.0002

R-squared	0.680860	Mean dependent var	0.044394
Adjusted R-squared	0.589677	S.D. dependent var	0.048342
S.E. of regression	0.030966	Akaike info criterion	-3.904063
Sum squared resid	0.026849	Schwarz criterion	-3.512218
Log likelihood	81.22517	Hannan-Quinn criter.	-3.765919
F-statistic	7.466981	Durbin-Watson stat	2.152590
Prob(F-statistic)	0.000027		

Chi-squared Autocorrelation Function Q-test for Higher Order Autocorrelation



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.077	-0.077	0.2347	0.628
		2	-0.064	-0.070	0.4025	0.818
		3	-0.023	-0.034	0.4258	0.935
		4	-0.144	-0.155	1.3338	0.856

The coefficients for the contemporaneous, one-year and two-year lags of the price sum to -0.11, which indicates that a 1% increase in the domestic price level relative to the foreign price level leads to a 0.11% appreciation in the domestic currency value. This outcome contradicts the stated hypothesis. However, Meerza (2012) also finds that the coefficient of the inflation differential with a lag of one period is -0.35, which is fairly slow to the parameter value shown in Table 5. Even though reported in two separate studies covering different sample periods, a short-run negative relationship between the price level differential and the exchange rate is surprising. Additional research on this aspect of the currency market for the taka appears warranted.

The coefficient for the interest rate differential in Table 5 is 0.003. This unexpected outcome implies that, if the interest rate differential increases by 1 point, then the domestic currency depreciates by 0.3% within one year. Generally, an increase in the interest rate should attract investment flows that will appreciate the domestic currency value. This counter-intuitive outcome may have occurred due to political instability and sometimes excessive inflation observed in Bangladesh over the course of the sample period. Changes in the nominal interest rate reflect, among other things, changes in the expected inflation rate. In times of high inflation, the relationship between interest rates and expected inflation may be strong enough to result in a positive marginal effect of interest rates on the exchange rate rather than the hypothesized negative effect (Frenkel, 1976; Frankel, 1979). AbuDalu *et al.* (2008) obtains a similar result in an exchange rate model for Philippines. Bangladesh and the Philippines have both experienced some degree of economic instability and relatively high inflation at times in the recent past.

Table 5 indicates that the impact of the money supply differential on the exchange rate is 0.2, which implies that a 1% increase in the money supply of Bangladesh relative to the money supply of the United States results in depreciation of the taka relative to the dollar by 0.2%. That aligns with the basic monetary balance hypothesis. Evidence for other Asian economies also provide evidence in favor of that conjecture. The AbuDalu (2008) study of the Philippines peso documents that an increase in the money supply similarly leads to depreciation of that currency.

The real output differential on the exchange rate is negative as hypothesized. The coefficient of the real output differential is -0.34, which supports the accepted argument that an increase in relative real output will decrease relative inflation, holding other factors constant, and appreciate the domestic currency value. This outcome indicates that a 1% increase in relative real output will lead the domestic currency to appreciate by 0.34% against the dollar within one year.

As anticipated, the sign for the error correction parameter (w_{t-1}) is less than zero. The value of that coefficient is -0.54, which indicates that approximately 2 years are needed for any short-run departures from the currency market equilibrium to dissipate. The computed t-statistic satisfies the 5% significance criterion. This is substantially faster than the 7-year adjustment period that Meerza (2012) documents for the taka.

Meerza (2012) considers the effects of both the money supply and international reserves in one model, whereas, in this study, those variables are considered in two separate models. The estimated model based on the balance of payments approach examines the effects of international reserves on the exchange rate and the model based on the monetary approach analyzes the effects of the money supply on the exchange rate. It is not surprising, then, that the estimated adjustment period documented by Meerza (2012) for a model combining characteristics of these two approaches (7 years) is in between the estimated adjustment periods derived from Tables 3 and 5 (11 years and 2 years respectively).

The differences in the speed of adjustment between the two approaches in this effort may be partly attributable to the predictors included in those models. The exchange rate may respond more quickly to changes in the money supply than to changes in international reserves, which may account for the shorter adjustment period in the monetary model than in the balance of payments model. Moreover, the 2 years adjustment period reported in the monetary model estimates seems intuitively more plausible than the 11 years adjustment period suggested by the balance of payments model. However, the overall performance of the monetary model cannot be ascertained by examining the error correction term in isolation. The model based on the balance of payment approach exhibits more plausible econometric traits, overall, than the model based on the monetary approach.

According to the results obtained, nominal taka/dollar exchange rate dynamics are more plausibly analyzed using a balance of payments approach than with a monetary approach. The balance of payment equations appear to have better econometric and economic traits than those based on the monetary construct. Moreover, the diagnostic statistics for the models based on the balance of payments approach appear superior to those for the models based on the monetary construct.

5. Conclusion

In this study, ARDL models based on balance of payments and monetary approaches are estimated to study long-term and short-term taka/dollar exchange rate dynamics in Bangladesh. Prior to estimating the models, Augmented Dickey-Fuller unit root tests are carried out and indicate that all the variables included in the two models are either I(0) or I(1). Accordingly, the data are suitable for analysis within the ARDL framework. Both sets of bounds tests confirm that the variables of the models are cointegrated.

The bilateral taka / dollar exchange rate model based on the balance of payments approach has better econometric and statistical traits than the model based on the monetary constructs. Overall, the effect of inflation on the exchange rate is manifested primarily in the long-run rather than the short-run. The exchange rate model based on the balance of payments approach indicates that an increase in inflation results in depreciation of the domestic currency in the long-run. Conversely, increments in the interest rate and international reserves cause the taka to appreciate in both the long-run and short-run.

It is important to note that the macroeconomy of Bangladesh is still very young. While the results obtained herein indicate that inflation, interest rates, and international reserves affect taka/dollar exchange rate dynamics in statistically stable manners, additional empirical verification is recommended as more data become available. Beyond the information that can be gained from in-sample parameter estimation, it would further be useful to examine model out-of-sample simulation performance characteristics.

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Appendix: Historical Data

Table A1. *Exchange Rate, Price Index, and Interest Rate Data*

Year	Nominal Exchange Rate taka/$	Bangladesh GDP implicit price deflator, 2005 = 100	USA GDP implicit price deflator, 2005 = 100	Bangladesh 3-6 month scheduled bank fixed deposit rate, %	USA 3-month Certificate of Deposit rate, %
1976	15.40	10.209	35.965	6.75	5.27
1977	15.38	9.878	38.196	7.00	5.64
1978	15.02	12.884	40.877	7.00	8.22
1979	15.55	14.549	44.251	7.00	11.23
1980	15.45	23.331	48.242	8.25	13.07
1981	17.99	25.071	52.748	12.00	15.91
1982	22.12	27.923	56.019	12.00	12.27
1983	24.62	30.419	58.230	12.00	9.07
1984	25.35	35.011	60.297	12.00	10.37
1985	27.99	38.728	62.226	12.00	8.05
1986	30.41	41.634	63.482	12.00	6.52
1987	30.95	45.965	65.101	12.00	6.86
1988	31.73	49.107	67.380	12.00	7.73
1989	32.27	53.329	70.000	12.00	9.09
1990	34.57	56.343	72.590	12.04	8.15
1991	36.60	60.060	75.005	12.05	5.84
1992	38.95	61.847	76.715	10.47	3.68
1993	39.57	62.025	78.541	8.18	3.17
1994	40.21	64.364	80.213	6.40	4.63
1995	40.28	69.092	81.885	6.04	5.92
1996	41.79	72.018	83.380	7.28	5.39
1997	43.89	74.243	84.807	8.11	5.62
1998	46.91	78.159	85.728	9.30	5.47
1999	49.09	81.798	87.039	9.44	5.33
2000	52.14	83.317	89.020	8.69	6.46
2001	55.81	84.640	91.049	9.15	3.69
2002	57.89	87.344	92.446	7.91	1.73
2003	58.15	91.299	94.290	7.11	1.15
2004	59.51	95.170	96.882	5.80	1.56
2005	64.33	100.000	100.000	5.53	3.51
2006	68.93	122.023	103.072	5.99	5.15
2007	68.87	129.920	105.815	6.99	5.27
2008	68.60	140.133	107.891	7.55	2.97
2009	69.04	149.612	108.710	7.81	0.56
2010	69.65	160.301	110.038	7.21	0.31
2011	74.15	171.555	112.309	8.84	0.18
2012	81.86	185.615	114.379	10.22	0.12
2013	78.10	198.697	116.244	11.72	0.08
2014	77.63	211.698	118.153	9.80	0.08
2015	77.63	222.701	119.337	8.24	0.08

Note: The Bangldeshi GDP data in Column 5 of Table A2 are reported in nominal US$. Those data can be converted to nominal taka by multiplying them by the data in Column 2 of Table A1.

Nominal GDP measured in taka are used for for the parameter estimates reported in Tables 4 and 5.

Table A2. *Int. Reserves, M2 Money Supply, and Bangladesh Nominal GDP Data*

Year	Bangladesh liquid International Reserves (US$, Billions)	Bangladesh M2 money supply (Billions of national currency, Taka)	USA M2 money supply (Billions of dollars)	Bangladesh Nominal GDP (Billions of dollars)
1976	0.288920	17,000,000	1,153.50	6.977922
1977	0.232670	21,000,000	1,273.00	6.850455
1978	0.315230	27,000,000	1,370.80	9.745007
1979	0.386250	33,000,000	1,479.00	11.113826
1980	0.299650	40,000,000	1,604.80	18.173463
1981	0.138420	47,000,000	1,760.30	17.906615
1982	0.182620	52,000,000	1,917.20	16.353526
1983	0.524080	73,000,000	2,136.20	16.584484
1984	0.389910	100,000,000	2,320.90	19.321105
1985	0.336520	110,000,000	2,506.60	20.076456
1986	0.409090	130,000,000	2,744.30	20.805327
1987	0.843150	160,000,000	2,842.90	23.512439
1988	1.046060	180,000,000	3,006.30	25.210526
1989	0.501460	210,000,000	3,171.40	27.598389
1990	0.628650	230,000,000	3,289.60	29.021984
1991	1.278240	270,000,000	3,390.50	30.196175
1992	1.824600	300,000,000	3,445.40	30.691142
1993	2.410810	330,000,000	3,499.90	31.683093
1994	3.138700	390,000,000	3,514.90	33.676200
1995	2.339670	440,000,000	3,661.00	37.864449
1996	1.834620	490,000,000	3,837.60	39.799952
1997	1.581460	530,000,000	4,052.70	41.171337
1998	1.905410	600,000,000	4,395.50	42.672564
1999	1.603640	687,394,000	4,660.00	44.753921
2000	1.485960	820,000,000	4,945.50	45.471040
2001	1.275030	1,200,000,000	5,466.80	45.430210
2002	1.683210	1,300,000,000	5,808.30	47.193125
2003	2.577890	1,500,000,000	6,093.60	51.690456
2004	3.172440	1,700,000,000	6,436.70	55.952445
2005	2.767240	2,000,000,000	6,698.20	57.625836
2006	3.805600	2,400,000,000	7,094.20	69.974902
2007	5.183430	2,800,000,000	7,521.80	79.831567
2008	5.689280	3,200,000,000	8,269.20	91.644606
2009	10.218900	3,900,000,000	8,552.30	102.125145
2010	10.564300	4,700,000,000	8,848.90	114.506676
2011	8.509530	5,500,000,000	9,692.30	122.549562
2012	12.031200	6,400,000,000	10,490.90	127.937943
2013	17.564340	6,539,666,000	11,068.50	152.180538
2014	21.785400	7,412,483,000	11,718.70	173.006570
2015	27.023380	8,381,142,000	12,401.50	193.923741

Table A3. *Bangladesh Real GDP, USA Nom. GDP, and USA Real GDP Data*

Year	Bangladesh real GDP, 2005 base year (Billions of dollars)	United States Nominal GDP (Billions of dollars)	United States real GDP, 2005 base year (Billions of dollars)
1976	0.000684	1,824.58	50.732
1977	0.000693	2,030.12	53.150
1978	0.000756	2,293.75	56.113
1979	0.000764	2,562.20	57.901
1980	0.000779	2,788.15	57.795
1981	0.000714	3,126.85	59.279
1982	0.000586	3,253.18	58.073
1983	0.000545	3,534.60	60.701
1984	0.000552	3,930.92	65.192
1985	0.000518	4,217.48	67.777
1986	0.0005	4,460.05	70.257
1987	0.000512	4,736.35	72.754
1988	0.000513	5,100.43	75.697
1989	0.000518	5,482.12	78.316
1990	0.000515	5,800.53	79.908
1991	0.000503	6,130.37	81.733
1992	0.000496	6,539.27	85.241
1993	0.000511	6,878.70	87.581
1994	0.000523	7,308.70	91.116
1995	0.000548	7,664.05	93.595
1996	0.000553	8,100.15	97.148
1997	0.000555	8,608.48	101.507
1998	0.000546	9,089.12	106.023
1999	0.000547	9,665.70	111.050
2000	0.000546	10,289.70	115.589
2001	0.000537	10,625.30	116.699
2002	0.00054	10,980.20	118.774
2003	0.000566	11,512.30	122.095
2004	0.000588	12,277.00	126.721
2005	0.000576	13,095.40	130.954
2006	0.000573	13,857.90	134.448
2007	0.000614	14,480.30	136.845
2008	0.000654	14,720.20	136.436
2009	0.000683	14,417.90	132.627
2010	0.000714	14,958.30	135.937
2011	0.000714	15,533.80	138.312
2012	0.000689	16,244.60	142.024
2013	0.000766	16,663.15	143.347
2014	0.000817	17,348.08	146.828
2015	0.000871	17,947.00	150.390

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