An Analysis of Purchasing Power Parity using Ricardian Model Regarding Real Exchange Rate, Inflation and Import of Bangladesh with Reference to 1972-2016

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Abstract

This paper tests purchasing power parity (PPP) with a version of Ricardian model which hypothesizes that there exists an association between real exchange rate and inflation in Bangladesh. The broad objective of this study is to investigate the causes of change in price of the goods in the case of Bangladesh by employing the Johansen long run testing approach to cointegration. Based on Ricardian model, Johansen long run cointegrating equation is developed for Bangladesh over the period 1972-2016. The Johansen multivariate cointegration technique is used in this paper to test the existence of a long-run equilibrium relationship among the variables such as real exchange rate, inflation and import. The augmented Dickey-Fuller test has been adopted to examine the stationarity, or otherwise, of the time series data. Error correction model (ECM), model is also developed to test the short run dynamics of real exchange rate function. Cumulative sum (CUSUM) and cumulative sum of square (CUSUMQ) have been used to test the stability of the model. The results show that there is a long run relationship among real exchange rate, inflation and import. The results from ECM show that speed of adjustment in real exchange rate function is moderate in Bangladesh. The plots of CUSUM and CUSUMQ indicate the instability of the model. Supportive evidence has been found that real exchange rate, inflation and import might account for deviations from PPP in Bangladesh within the analyzed period. The real exchange rate must respond to a number of real factors in the long run and nominal factors in the short run.

Keywords: Ricardian Model; Purchasing Power Parity; Johansen Long Run Cointegrating Equation; Real Exchange Rate-inflation Association; Instability

1. Introduction

On the basis of technological differences, the Ricardian model explains the difference in comparative advantage across the nations. It assumes all other factors to be similar across the countries. The supply side difference is actually the technological difference between two countries. In determining the trade and gains demand plays a crucial role and come in handy according to Ricardian model after opening up of trade.

Purchasing power parity (PPP) states that there would be no price discriminations of goods and services across the countries over time. It is affected by exchange rates. It determines the cost of things if parity did exist and if it were sold in local countries. It is used to adjust the price differences between countries. A wide range of goods and services must be considered for a meaningful price comparison. Exchange rates of PPP are stable with the span of time. However, market-based rates are harder to measure by PPP. It is also used to measure the real income of individuals across the countries.

The objective of this paper is to examine the impact of the real exchange rate changes on inflation and import in Bangladesh during 1972-2016 by employing the Johansen long run testing approach to
cointegration. Bangladesh floated with market based exchange rate, and it is determined on the basis of Bangladeshi Taka.

In such situation, the study seeks to evaluate whether there is any correlation among real exchange rates, inflation and import of Bangladesh during 1972-2016. Does PPP hold for Bangladesh? The study intends to examine the foresaid questions.

This study explores the relationship among real exchange rate, inflation and import in Bangladesh during the period 1972-2016. Unlike previous studies, this study employed unit root test, Johansen long run cointegrating test, ECM test, cumulative sum (CUSUM), and cumulative sum of square (CUSUMQ) test to test for long run relationships. The results of the Johansen long run cointegrating test suggest that there is a long run relationship among real exchange rate, inflation and import. This result is consistent with a number of earlier studies reviewed in the literature that was found real exchange rate, inflation and import to be co-integrated in the long run.

The rest of this paper is structured as follows. Section 2 provides a brief review of the relevant literature. Section 3 postulates a theoretical model that captures a Ricardian model. The empirical econometric results for the long run relationship among real exchange rate, inflation and import, as well as policy implications of the study are set out in Section 4. Section 5 presents some concluding remarks.

2. Literature Review

Islam (2013) tested PPP of Bangladesh and India using exchange rate and ratio of GDP deflator during the period 1971-2011. He used cointegration test to show the imposition of trade restrictions on the bilateral trade relationship.

Rogoff (1996) examined PPP on international goods market and found it highly integrated by employing cointegration test. It was found that nominal exchange rates were not affected by the relative domestic prices within a large buffer.

Balassa (1964) drawn a relationship of PPP, exchange rates and income level and has found positive correlation among the variables. This relationship provided guidance of national income and living standard for international comparison.

Manzur and Chan (2010) tested PPP and its justification for Euro. They employed unit root test and developed a regression model to test the forecasting accuracy of Euro exchange rates based on PPP with the aid of random walk model.

Al-Zyoud (2015) examined movement of Canadian dollar and US dollar exchange rates in the long run. This study showed that there is no long run relationship between exchange rates and PPP rate by employing Engle-Granger cointegration test and regression analysis. Actual exchange rates between US and Canada could be explained by the relative price movements.

Al-Gasaymeh and Kasem (2015) examined strong and weak form of PPP between Jordan and its other trading partner countries. They showed that there is weak PPP between Jordan and its major trading partner countries and there exists a long term cointegrating relationship between real exchange rate, domestic and foreign price level by employing Johansen cointegration test during 2000-2012 provided that real exchange rate is nonstationary.

Niu et al. (2016) tested the fluctuation of PPP by the effect of consumption expenditure growth, trade condition index, per capita income, FDI, and exchange rate. They tested it during the period 2000-2013 on the basis of panel fixed effect model of 62 countries. They found that PPP is mostly influenced by exchange rate.

Jayaraman and Choong (2013) investigated whether PPP theory holds under exchange rate regimes. They found exchange rate policy could be reformed under the guidance of PPP theory by employing Johansen and Pedroni cointegration tests and unit root test during the period 1980-2011.

Findreng (2014) examined relative PPP over the period 1999-2013 of Albania, Croatia, Bulgaria, Romania, Turkey, FYR Macedonia, and Germany and investigated real exchange rate by employing augmented Dickey-Fuller (ADF) test and Engle-Granger cointegration test. It was found that exchange rate and price level were not co-integrated and PPP results were ambiguous.
Sarno and Taylor (2002) assessed PPP as long run international parity condition impacted to real exchange rates by employing ADF and cointegration tests. The effects of real shocks seemed to be warranted on the long run equilibrium level.

Zaman and Bakshi (1999) explained PPP theory that changes in the ratio of inflation rate to the change of exchange rate between two countries by employing ADF and cointegration tests. They examined the long run relationship among PPP, inflation and exchange rates between Bangladesh and rest of the world.

Chowdhury (2004) found strong support for the validity of PPP that predicts nonlinear adjustments in real exchange rates. Nonlinear econometric techniques have been applied during the period 1994-2002 to examine PPP for Bangladesh and its trading partners such as India, Japan, US, and Euro area.

Beckmann (2011) examined PPP and found that reverting behavior in real exchange rate affected by nominal exchange rate, and shocks are significantly smaller by employing co-integrated VAR model and ESTR error correction models (ECMs) during the period 1973-2009 for Japan, France, Germany, UK, and USA.

Dornbusch (1985) examined PPP disparities on the basis of Ricardo-Harrod-Balassa-Samuelson model and found that there was a long run relationship among real price levels, interest rate, exchange rates, and real income by employing several statistical tools such as correlation and coefficient of variations.

Alexa et al. (2013) analyzed Ricardo’s model to see the major types of goods that Japan, USA, and the European Union export and also to test the validity of the assumptions. This analysis would help to choose the specialization on goods to take absolute advantage of factor of productions under the assumptions of perfect mobility.

Crownover et al. (1996) tested absolute PPP and found support for nominal exchange rate that equals the price ratio which does not contain a base period using new data.

Ocal (2013) tested PPP in Romania and found that PPP does not hold in Romania by employing Zivot-Andrews unit root test during 1991-2012.

Razmi (2011) developed a framework with a continuum of goods on the basis of Ricardian model and found that the trade balance of higher employment and profitability could be the consequence of diversification which is lead by suppression of real wage.

Jabara (2009) showed how changes in exchange rate affect the prices of imported goods of US using data during 1999-2008 by developing OLS estimation. This study examined that how import prices of US tend to show less change by dint of currency invoicing, pricing to market and cross border production.

Hakkio (1992) argued that currency (dollar) could be guided in the long run by PPP to a lesser extent in a short run as today’s dollar, relative to PPP is not unusually low, and in the near future there is no guarantee that it will rise in terms of value.

Ortega and Giovanni (2005) examined how exchange rate is affected by trade costs by applying Ricardian model during 1970-1997 and found strong evidence supporting technological differences affect exchange rate during the period.

Atkeson and Burstein (2006) showed that trade costs and imperfect market both affects pricing to market of the firm and aggregate levels according to Ricardian model of international trade and they also showed that trade costs are essential rather than pricing to market.

It has been seen that the literature of PPP is relatively bold but lacks any research to apply the Ricardian model to testify PPP for a country like Bangladesh. This paper attempts to fill this gap. Besides most of the papers examined PPP in accordance with real exchange rate and inflation only but this paper considered import also to justify PPP properly. This paper also intends to fill the gap of estimating the stability of the model by developing ECM model and using CUSUM and CUSUMQ test.

1.1. Objectives

The broad objective of this study is to investigate whether PPP holds in Bangladesh on the basis of Ricardian model by employing the Johansen long run testing approach to cointegration. The specific objectives of this study are:
i. To determine the potential effects in the relationship among real exchange rates, inflation and import.
ii. To estimate how real exchange rates respond to changes in inflation and import.
iii. To evaluate the stability of real exchange rates in Bangladesh during the period 1972-2016.
iv. To recommend policy guidelines to improve trade balance deterioration in Bangladesh.

2. Methodology

This research is descriptive in nature, and the data are quantitative in nature. Only the secondary data were used. Secondary data were collected from the world development indicators report, internal database and websites.

The Johansen multivariate cointegration technique is used to test the OLS model of a long-run equilibrium relationship among the variables specified in Equation (1) in this paper. One unit root test, i.e., the ADF test has been adopted to examine the stationary, or otherwise, of the time series data. ECM has been applied to estimate real exchange rates function and examine its stability in Bangladesh. Next, the structural stability of the ECM of real exchange rates has been examined. CUSUM and CUSUMQ of recursive tests have been used.

2.1. Theory and model

The Ricardian model focused on labor used to produce traded goods on the basis of comparative advantage. The main features of Ricardian model are that as primary input production uses only homogenous labor and dissimilarities across goods and countries in technology bring comparative advantage for producing goods. According to Ricardian model, supplies of goods are much more than that of demand for goods. It compares the equilibrium in autarky with free trade. It’s not so simple to extend to two or more goods and countries (Deardorff, 2007).

PPP allows the exchange rate to be equal to the purchasing power of each country’s currency by adjusting on the currency exchange rates between countries. It explains the relationships between changes in the exchange rate and inflation differentials between countries.

In accordance with Ricardian model and PPP theory, a relationship has been developed among real exchange rate, inflation and import to examine PPP in Bangladesh by imposing symmetry condition during 1972-2016 which is as follows:

$$r_t = \alpha + \beta_0 + \beta_1 \text{inf}_t + \beta_2 \text{imp}_t + \epsilon_t$$

Where \( r_t \) is the real exchange rate, \( \text{inf}_t \) and \( \text{imp}_t \) are the inflation and import, respectively (Jayaraman and Choong, 2013).

An ECM model has been developed to test the short run dynamics in the relationship between real exchange rate and its determinants. The ECM model is specified as:

$$\Delta \ln r_t = \alpha_0 + \alpha_1 \Delta \ln \text{inf}_t + \alpha_2 \Delta \ln \text{imp}_t + \Delta \ln r_{t-1} + \alpha_2 U_{t-1} + \epsilon_t$$

Where: \( U_{t-1} = \ln r_{t-1} - \beta_0 - \beta_1 \ln \text{inf}_{t-1} - \beta_2 \ln \text{imp}_{t-1} \)

Where \( \alpha_2 U_{t-1} \) is the error correction term, it is the residual from the cointegrating equation, \( \alpha_2 \) is the error correction coefficient and \( \alpha_3 \) are the estimated short run coefficients (Jammeh, 2012).

2.2. Econometric estimation

The ADF test has been applied to test the stationary of data, and it has been shown that all the variables are stationary at level. The null hypothesis of unit root at level can be rejected for real exchange rate, inflation and import. Table 1 has shown the econometrics result of ADF test.

All the variables used in this paper have been plotted to have initial glue about the properties of the variables. Figure 1 has showed a visual plot of all the variables.

Johansen long run cointegrating test has been proceeded to determine whether there is a long run co-integrated relationship among real exchange rate, inflation and import given that all the variables are stationary at level. The trace statistic has been suggested that there are at least two cointegrating
equations in the model (log likelihood 158.2978 and 166.1529, respectively). On the other hands, max-
Eigen value has been suggested that there is no cointegrating equation in the model. The results have
been shown in Table 2.

It has been revealed that there is a long run relationship among real exchange rate, inflation and
import and real exchange rate is negatively correlated to import which have been shown in Table 3.

Table 3 has been presented the first column of $\alpha$ matrix. The estimated adjusted coefficients ($\alpha$s)
have measured weak exogenenity among the variables. These coefficients have measured the speed of
the short run response to disequilibrium occurring in the model meaning that inflation and import are

**Figure 1:** Visual plots of the variables

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**Table 1: ADF unit root test**

<table>
<thead>
<tr>
<th>Variable</th>
<th>C (constant) and T (trend) in the equation</th>
<th>ADF statistics</th>
<th>Optimum lag</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>C and T</td>
<td>−3.974059</td>
<td>2</td>
</tr>
<tr>
<td>inf</td>
<td>C and T</td>
<td>−6.119012</td>
<td>0</td>
</tr>
<tr>
<td>imp</td>
<td>C and T</td>
<td>−4.880524</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Estimated (r=real exchange rate, inf=inflation, and imp=import).

**Table 2: Johansen test for cointegration**

<table>
<thead>
<tr>
<th>Hypothesized No. of CE (s)</th>
<th>Trace statistic</th>
<th>0.05 critical value</th>
<th>Eigen value</th>
<th>Hypothesized No. of CE (s)</th>
<th>Max-Eigen statistic</th>
<th>0.05 critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>None*</td>
<td>39.50164</td>
<td>29.79707</td>
<td>0.374508</td>
<td>None</td>
<td>20.17629</td>
<td>21.13162</td>
</tr>
<tr>
<td>At most 1*</td>
<td>19.32534</td>
<td>15.49471</td>
<td>0.306049</td>
<td>At most 1*</td>
<td>15.71020</td>
<td>14.26460</td>
</tr>
<tr>
<td>At most 2</td>
<td>3.615144</td>
<td>3.841466</td>
<td>0.080636</td>
<td>At most 2</td>
<td>3.615144</td>
<td>3.841466</td>
</tr>
</tbody>
</table>

Source: Estimated.*denotes difference is significant at 10% level.

**Table 3: Normalized cointegrating vectors and the corresponding adjustment coefficients**

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\beta$ coefficients</th>
<th>$\alpha$ coefficients</th>
<th>Standard error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>1.000000</td>
<td>−0.141936</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>inf</td>
<td>0.238939</td>
<td>−1.718926</td>
<td>0.05338</td>
<td>4.47624</td>
</tr>
<tr>
<td>Imp</td>
<td>−0.252118</td>
<td>−0.386655</td>
<td>0.01961</td>
<td>−12.8549</td>
</tr>
</tbody>
</table>
weakly exogenous with respect to real exchange rate. The estimated cointegrating vector has given below.

\[ r_t = 1.00 + 0.24 \inf_t - 0.25 \imp_t - 1.47 \]  
(3)

From Equation 3, it has been seen that there are positive coefficients for real exchange rate-inflation and negative coefficients for real exchange rate-import. Hence, there is a positive association between real exchange rate - inflation and negative association between real exchange rate - import meaning that if real exchange rate goes up, inflation goes up and if real exchange rate goes up, and import goes down vice-versa.

The ECM Stability test has been used to find out if the Ricardian model of real exchange rate is stable in Bangladesh during 1972-2016. The stability test has shown that the relationship among real exchange rate, inflation and import were not stable in Bangladesh during 1972-2016 in Table 4.

All the estimated parameters have been appropriately signed. The estimated F-statics have been statistically significant at 5% level meaning that the explanatory variables are jointly significant in explaining real exchange rate dynamics in Bangladesh. The R\(^2\) values have suggested a relative good fit for the data set. The estimated error correction terms have suggested the validity of equilibrium relationship among real exchange rate, inflation and import. The estimated coefficient values have suggested a moderate speed of adjustments meaning that the model corrects its previous period disequilibrium in a year (Table 4).

CUSUM and CUSUMQ tests have been preceded to evaluate the cointegration vector stability which has been shown in Figures 2 and 3.

In Figures 2 and 3, it has been shown that the real exchange rate model is not quite stable. If all the coefficient of ECM were stable, the CUSUM and CUSUMSQ plots will be under 5% critical bounds, but as figures have shown, the plot of CUSUM and CUSUMQ slightly crossed the bounds meaning that the model is almost instable.

3. Summary of Findings

One co-integrated equation has been found in the model. The equation has been retrieved by the normalized vector where positive association between real exchange rate – inflation and negative association between real exchange rate – import exist. Hence, if real exchange rate goes up, inflation goes up, and if real exchange rate goes up, import goes down. Besides, the results of the Johansen cointegration test among real exchange rate, inflation and import have indicated that there exists long run relationship among real exchange rate, inflation, and import for Bangladesh during 1972-2016.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficients</th>
<th>t-values</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.008821</td>
<td>1.12250</td>
<td>0.00786</td>
</tr>
<tr>
<td>D(r(−1))</td>
<td>0.156250</td>
<td>1.10456</td>
<td>0.14146</td>
</tr>
<tr>
<td>D(r(−2))</td>
<td>0.071107</td>
<td>0.39190</td>
<td>0.18144</td>
</tr>
<tr>
<td>D(inf(−1))</td>
<td>−0.559660</td>
<td>−2.83134</td>
<td>0.19767</td>
</tr>
<tr>
<td>D(inf(−2))</td>
<td>−0.068314</td>
<td>−0.47841</td>
<td>0.14280</td>
</tr>
<tr>
<td>D(imp(−1))</td>
<td>−0.358533</td>
<td>−1.89473</td>
<td>0.18923</td>
</tr>
<tr>
<td>D(imp(−2))</td>
<td>−0.023176</td>
<td>−0.13641</td>
<td>0.16990</td>
</tr>
<tr>
<td>R(^2)</td>
<td>0.695426</td>
<td>0.597118</td>
<td>0.701230</td>
</tr>
<tr>
<td>Adj. R(^2)</td>
<td>0.632719</td>
<td>0.514172</td>
<td>0.639719</td>
</tr>
<tr>
<td>Akaike AIC</td>
<td>−4.778998</td>
<td>0.360133</td>
<td>−2.275653</td>
</tr>
<tr>
<td>Schwarz SC</td>
<td>−4.448013</td>
<td>0.691117</td>
<td>−1.946578</td>
</tr>
<tr>
<td>F-statistic</td>
<td>11.09017</td>
<td>7.198861</td>
<td>11.40001</td>
</tr>
</tbody>
</table>

Source: Estimated (r=real exchange rate, inf=inflation, and imp=import)
Eventually, it could have been estimated that PPP does not hold for Bangladesh. ECM has showed moderate speed of adjustment in real exchange rate model in Bangladesh. The plots of CUSUM and CUSUMQ slightly have crossed the bounds meaning that the model is almost unstable.

**4. Conclusions and Policy Suggestions**

The rigorous econometric exercises have strongly rejected the validity of the PPP in Bangladesh because foreign investment and trade have little effect on the variation of PPP. Real exchange rate has influenced PPP greatly which is called the confounding effect. Foreign investment could improve the condition and also could improve the living standards because it could ease the price level of the country. The main determinants of real exchange rate are domestic and foreign prices. To stabilize price level both domestic and foreign, to monitor inflation and to enhance export policy makers should implement the appropriate real exchange rate policies in Bangladesh.

**References**