EMPIRICALLY EXPLORING THE IMPACT OF INTEREST RATE AND ANNUAL CPI DIFFERENCE ON EXCHANGE RATE

SUHAIB AAMIR¹, MUHAMMAD YASIR², MOHSIN ULLAH³ AND SALMAN AHMAD⁴

¹Department of Management Sciences, COMSATS INSTITUTE OF IT, ATTOCK CAMPUS
suhaibaamir@gmail.com

²Department of Management Sciences, COMSATS INSTITUTE OF IT, ATTOCK CAMPUS
yasirfw@hotmail.com

³Department of Management Sciences, COMSATS INSTITUTE OF IT, ATTOCK CAMPUS
mohsin_cecos@yahoo.com

⁴Department of Management Sciences, Edwards College, Peshawar
salmanaahmad@gmail.com

ABSTRACT. This paper examines the relationship and the impact of interest rate and CPI difference from one year to another on the exchange rate of the home country. This particular study has been conducted in the context of Pakistan which serves to be the home country, and the empirical findings are made in relation to China, Japan, UK and USA. The study uses the panel data concerning the exchange rate, interest rate and CPI difference for all the five countries ranging from the first quarter of 1991 (Q1) to the last quarter of 2011 (Q4). The results of the study validate the conjecture of the literature that in the long-run, inflation affects the exchange rate in a positive way, while interest rate prevailing in a country has a negative impact on the exchange rate. The results of the panel data regression on the cumulative data of all the countries, with fixed-effect and random-effect shows that the relationship prevails but both the CPI difference and interest rate affects the exchange rate to a very insignificant level. Comparatively, the results of LSDV, which involved evaluating the coefficients on the country-specific level, shows that interest rate and CPI change has significant impact on the exchange rate.

Keywords: Exchange rate determination, interest rate and exchange rate, inflation and exchange rate

Introduction
In today’s era of globalization, exchange rate is termed to be of crucial importance for any economy due to the involvement of the international transactions among the countries. Countries, union of countries and continents have come closer as a result of the trend of globalization across the globe. To address the dynamics and determinants of exchange rate there is a vast pool of literature available concerning the exchange rate. Exchange rate has been studied as a macro variable in different empirical studies against a variety of determinants (interest rate, PPP, foreign reserves, monetary base, GDP, inflation etc.), both in the short-run and long-run (Meese and Rogoff, 1988; Evans and Lyons, 2002; Drazen and Hubrich, 2006; Ichiue and Koyama, 2011). In his study, Suthar (2008) has defined foreign exchange as:

“Foreign exchange rate is the price of a unit of foreign currency in terms of the domestic currency.”

The focus of the research in this study is on the exchange rate determination in between Pakistan and China,
Pakistan and Japan, Pakistan and United Kingdom (UK), and Pakistan and United States (US). In all the cases, for exchange rate US Dollar (USD) is considered to be the base currency. The exchange rate of Pakistan with these four countries has been taken due to the fact that Pakistan since its inception has bilateral trade agreement with all these countries especially US and UK. Pakistan heavily imports variety of consumer goods from all these countries, with some products and services being exported to them. Apart from trade these countries have been funding and supporting many projects in Pakistan, and have established a number of non-profit organizations. Pakistani Rupee (PKR) as compared to Chinese and Japanese currency is not internationally traded and is thus isolated. This isolation of Pak Rupee can give the chance of exploring the factors of exchange rate in an easy manner. Although in Pakistan, the political turmoil, terrorism, natural catastrophes, sectarianism, unemployment, safety and security play a vital role in determining the exchange rate, foreign reserves, international trade, imports and exports, trade-sanctions, and foreign direct investment (FDI); the study is limited to the two variables which are CPI and Interest rate prevailing in these countries.

In this paper, an effort has been made to find the empirical evidence concerning the trend of exchange rate in Pakistan in the long run with Chinese, Japanese, British and American currency. Results of this study would enable the policy makers and practitioners to be in better position to devise policies, make judgments and economic decisions based on the behavior of exchange rate and the associated risks in the long-run. Developing economies try to adopt the policy of obtaining high economic growth, price level stability and reduction in the volatility of exchange rate, which are termed to be the three separate points of a triangle that cannot be achieved simultaneously (Suthar, 2008).

The structure of the paper is arranged in five sections. Following the section of introduction, section 2 presents the literature review concerning the exchange rate, inflation with proxy of consumer price index (CPI) and the interest rate; section 3 is about the methodology of the research study; section 4 provides empirical results of the exchange rate behavior against two of the determinants studied in this paper in the long-run. Discussions about the results follow in section 5. The final section of the paper wraps up the study by providing the conclusions.

**Literature Review:** It is of utmost importance for any country to choose the most appropriate exchange rate system as per the crucial implications it would have on the economic policy both at the domestic and international level (Heller, 1978). As identified by Heller (1978), this choice of exchange rate in a country depends upon the economic characteristics of that country, and the factors that are relevant to it are: a country’s size, openness, financial integration degree, inflation and the foreign trade pattern. The presumption, which has been validated in Heller’s study was concerning those countries whose divergence of the inflation rate is higher as compared to the average of the rest of the world, have a tough time to maintain the fixed exchange rate over a longer period of time (Obstfeld and Rogoff, 1995; Goyal and Arora, 2012; Engle et al., 2007). Chiu (2008), in his study has determined the behavior of exchange rate in the long-run against “Purchasing Power Parity (PPP), productivity differential, foreign reserves and monetary base”. These factors turned out to be having strong driving for the exchange rate in the long-run. PPP has been referred to as the relative prices of items (goods and services) traded between the countries. Literature has two way studies concerning the proposition of PPP, one relating to the violation of this proposition (Balasa, 1964; Samuelson, 1964; Engle & Granger, 1987) and the other supporting it (MacDonald, 1994; MacDonald & Moore, 1996).

Looking at the relationship, for the effects of interest rate differential on the exchange rate, in the theory, Hacker et al. (2010, 2012) state that this relationship tends to be negative in the short-run and positive in the long-run. The relationship is negative in the short-run because ceteris paribus, the inflow of capital to the domestic country increases when there is a rise in the interest rate as compared to the off-home country which appreciates the domestic currency. On the other hand, the positive relationship holds true for the effect of interest rate on the exchange rate in the long-run is explained by the comprehension that when the interest rate in the domestic country increases, it raises the chances of an increase in the inflation of that country as compared to the foreign one, which depreciates the domestic currency. Depreciation of the domestic currency increases the trade balance of the domestic country and decreases the foreign trade balance, which brings on a rise in the domestic interest rate and a fall in the foreign interest rate (Hacker et al., 2012; Hacker et al., 2010). The hypothesis that the exchange rate is determined by the purchasing power parity (PPP) based on the relationship between exchange rates and prices, was disclosed in the study of Manzur (1990). This hypothesis in its absolute form mentions that exchange rate is the ratio of home prices to foreign prices, and in the relative form it is stated as the change in the exchange rate equal to the differential of the inflation (Manzur, 1990). Looking back at the history of PPP, Manzur (1990) has stated that the first principle regarding the PPP theory was presented in the 16th century and not during 1920s by the Cassel. In the tracks of PPP history, the other striking name is of Balassa (1964), who first identified the hypothesis of systematic bias for the
measurement of equilibrium exchange rate in the absolute PPP.

Balsa (1964) argued that the relative prices of the non-traded goods rises as a result of the low productivity growth in this sector as compared to the traded goods. As per the theory of Balsa this hypothesis is termed as the productivity bias hypothesis. Frenkel (1981) argued that the determination of exchange rate stems out of the ‘asset market theory’, and provides with the essential difference between exchange rate and state-defined price levels. In his study, Manzur (1990) found that the PPP hypothesis holds true in the long-run but the same prediction is not held true in the short-run. Pakistan being a developing Asian country is classified to be a small open economy that is heavily reliant on the import of consumer goods in order to meet the national demand for those products and services (Akbari and Rankaduwa, 2006). Due to the openness of the Pakistan’s economy to foreign trade, there is no immunity in it against the external price shocks, for instance when there is appreciation or depreciation of the exchange rate or price changes for the imported goods (Janjua, 2007). Since 1982, Pakistan Rupee (PKR) has been un-pegged from the Pound Sterling, and has been deregulated and shifted to managed floating exchange rate. The linkage of Pakistani rupee has been made with the currency basket that is trade-weighted (Ahmad, 1998).

Srikanth and Kishor (2012) in their study have concluded that the exchange rate between US Dollar and Indian Rupee is significantly determined by the variables such as the lagged value of the exchange rate for the last year between US Dollar and Indian Rupee, balance of the current account, relative supply of money, interest rate differential and index of industrial production. Multiple regressions were used in their study to assess the relative importance of the identified independent variables on the exchange rate as the dependent variable. Due to spurious regression, Augmented Dickey Fuller Test (ADF) was employed in order to check the stationarity of the variables by taking the first and in some cases the second differencing of the variables. Considering other factors, the interest rate within a country is considered to be an important element of its economic growth. The interest rate prevailing in Pakistan is termed to be the highest on global arena, which makes the banking and financial sector of Pakistan attractive. The high interest rate saved the banking sector in specific and the overall economy in general to the spread of financial crisis in 2007. In their study, Chen and Hsing (2005) have identified the factors that influence the exchange rate using the VAR model in Korea. From their study they have obtained the empirical evidences which are consistent with the theory of exchange rate. Among other factors, interest rate differential between the US and Korea have negative reactions to the exchange rate. The study of Frankel (1979), which is normally known as the model of real interest rate differential (RID), takes into account the relationship between monetary fundamentals and the exchange rate. Furthering with the discussion of interest rate by dividing them into short-term and long-term interest rate, it is stated that “...the short-term interest rates are designed to capture liquidity or real effects of monetary policy while the long-term interest rates are designed to capture expected inflation effects” (Yuan, 2011).

Research Methodology: In this study the behavior of exchange rate in Pakistan has been examined with the Chinese Yuan (CNY), Japanese Yen (JPY), British Pound Sterling (UKP), and US Dollar (USD) against two factors that are the inflation differential and interest rate differential. The exchange rate for all the currencies is determined in the national currency of Pakistan that is Pakistani Rupee. Inflation differential has been computed using the differential of Consumer Price Index (CPI) differential that has been used as a proxy for the Purchasing Price Parity. The study period that has been used in this study ranges from the first quarter (Q1) of 1991 to the last quarter (Q4) 2011. Quarterly data for the entire variables from all the five countries has been utilized in this study, due to the non-availability of monthly data concerning certain variables in specific countries. In this study, panel data regression has been used in order to express the influence in relative terms of the following independent variables on exchange rate of PKR/CNY, PKR/JPY, PKR/UKP and PKR/USD. Panel data regression has been used in this study because the data obtained is both of the time-series and cross-sectional format. As per the time-series arrangement the data ranges from 1991Q1 to 2011Q4, and for the cross-sectional arrangement the data is available country wise for exchange rate, interest rate and CPI. Panel data regression involving fixed-effect (fe), random-effect (re), and least square dummy variable model has been used. There were a total of 420 observations used in this study, out of which 84 observations pertain to each of the country. Data has been sorted on the basis of each country.

Data for all the variables, countries and years was obtained from the International Monetary Fund’s (IMF) International Financial Statistics (IFS). Organizing of the data was done using Microsoft Excel, and for the purpose of regression and data analysis, Stata 11 was used. All the documentation has been attached in the annexure. For panel data regression with fixed effect and random effect, we have:

$$ex_{it} = \alpha + \beta_1IRD_{it} + \beta_2IFD_{it} + \omega_{it} \rightarrow eq.1$$
Where:
- $\alpha_i$ ($i=1,...,n$) is the unknown intercept.
- $ex_{\text{rate},it}$ is the dependent variable with $i$ referring to entity and $t$ referring to time.
- $IRD_{it}$ and $IFD_{it}$ represent the two independent variables (Interest rate and CPI).
- $\beta_1$ and $\beta_2$ are the coefficients for independent variables,
- $u_{it}$ is the error term.

For panel data regression with least square dummy variable model (LSDV), we have:

\[
ex_{\text{rate},it} = \alpha_i + \beta_1 IRD_{it} + \beta_2 IFD_{it} + \gamma_1 D_1 + \ldots + \gamma_n D_n + \omega_{it} \rightarrow eq.2
\]

Where:
- $\alpha_i$ ($i=1,...,n$) is the unknown intercept.
- $ex_{\text{rate},it}$ is the dependent variable with $i$ referring to entity and $t$ referring to time.
- $IRD_{it}$ and $IFD_{it}$ represent the two independent variables (Interest rate and CPI).
- $\beta_1$ and $\beta_2$ are the coefficients for independent variables,
- $u_{it}$ is the error term.
- $D_n$ is the entity $n$. Since they are binary (dummies) thus n-1 entities included in the model.
- $\gamma_n$ is the coefficient for the binary repressors (entities).

The hypotheses that are developed and tested in this study are based on the critical review of the literature concerning the impact of interest rate and inflation on exchange rate. The two hypotheses in the alternate form are given below:

H$_1$: There is significant negative impact of interest rate on exchange rate.
H$_2$: There is significant positive impact of CPI difference on exchange rate.

**Empirical Results and Discussion:** The results presented here are for the variables identified and mentioned above using the multiple regression models. The results encompass data of 84 quarters for all the five countries, relating to all the variables used in the regression model. The results for each of the country along with their results and graphical presentation are presented below. The very first graph presents the trends of exchange rate, which is the dependent variable, in terms of Pak Rupees for all the countries.

From the figure 1, it can be seen that there has been much volatility in between the exchange rate of Pak Rupee (PKR) and UK Pound Sterling (UKP) over the period of 20 years. Similarly there has been much volatility in between the exchange rate of Pak Rupee (PKR) and US Dollar (USD) over the same period. There has been less
volatility in between PKR and Chinese Yuan (CNY), and almost negligible variation between the exchange rate of PKR and Japanese Yen (JPY). Thus, all the four countries show different volatility in terms of their currency to the Pak Rupee (PKR).

Amongst the panel data regression models, the fixed-effect is the first regression model which is run on the data. The fixed-effect panel data regression provides the following results.

<table>
<thead>
<tr>
<th>Fixed-effects (within) regression</th>
<th>Number of obs = 420</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group variable: nation</td>
<td>Number of groups = 5</td>
</tr>
<tr>
<td>R-sq: within = 0.2910</td>
<td>Obs per group: min = 84</td>
</tr>
<tr>
<td></td>
<td>avg = 84.0</td>
</tr>
<tr>
<td>between = 0.0066</td>
<td>max = 84</td>
</tr>
<tr>
<td>overall = 0.0411</td>
<td></td>
</tr>
<tr>
<td>corr(u_i, Xb) = -0.1840</td>
<td>F(2,413) = 84.74</td>
</tr>
<tr>
<td></td>
<td>Prob &gt; F = 0.0000</td>
</tr>
</tbody>
</table>

| ex_rate                  | Coef. | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|--------------------------|-------|-----------|-------|-----|----------------------|
| cpi_change               | .9760769 | .2101412 | 4.64  | 0.000 | .5629972 - 1.389157  |
| discount_r-e_cons        | -3.864832 | .2990943 | -12.92| 0.000 | -4.452769 -3.276895 |
| sigma_u                  | 47.91341 | 1.656124 | 28.93 | 0.000 | 44.65793 - 51.1689  |
| sigma_e                  | 39.832549 | 14.126402 | 2.72  | 0.009 | 14.126402 - 65.5757  |
| rho                      | 0.88827866 | (fraction of variance due to u_i) |

F test that all u_i=0:  F(4, 413) = 632.51    Prob > F = 0.0000

Table 1: Fixed-effects (within) regression

The panel data regression model with fixed-effect states that the model developed and used in this particular regression was acceptable. This is evident from the value of Prob > F, which is less than 0.05, and states that the model is acceptable and that the value of all the coefficients used in the model are different from zero. The value of corr(u_i, Xb), which is -0.184, states that the errors u_i are correlated with the regressors in the fixed effect model. The rho, which is the interclass correlation, portrays that 88.82% of the variation is due to the differences across the panels. T-values are highly significant for both the CPI and the interest rate, and shows high degree of relevance to the exchange rate. The two-tail p-values show that for both CPI and interest rate the values are less than 0.05, therefore the null-hypotheses would be rejected. Thus, the hypotheses in their alternative form are accepted that CPI difference has positive impact on the exchange rate, whereas interest rate has a negative impact on the exchange rate. The coefficient of CPI difference states that when there is one unit change in CPI, then on the average, there is a change of 0.976 in the exchange rate. While, for the interest rate, when there is a unit change in the interest rate, then there is -3.864 change in the exchange rate on the average. The coefficient of determination, R-squared for the overall data is 0.0411, which states that only 4% of the variation in the exchange rate is determined by interest rate and CPI change.

The result of panel data regression with random-effect which was used on the data after the fixed-effect provides the following results.
The results from the panel data regression model with random-effects present the following results. First of all, the acceptance of the model is checked. For that purpose the value of Prob>chi2 is a check, which is less than 0.05, on the basis of which we accept the results of this model. To check the correlation across the units, the value of corr(u_i, x) is checked, which in the case of random-effect states that the differences across the units are uncorrelated with the regressors. The two-tail p-values in the case of random-effect portrays that each coefficient is different from zero, and that these coefficients have significant effect on the dependent variable. Interpretation of the coefficient in the case of random-effect regression model is complex as it includes both the within-entity and between-entity effects. On the average, when there is one unit change in CPI difference across the time and the country, then it affects the exchange rate with 0.972 units. Whereas, one unit change in the interest rate across the time and the countries, on the average bring a change of -3.855 in the exchange rate. The coefficient of determination provided by the regression model with random-effect has the same value as the regression model with the fixed-effect. Thus, the value of R2 for the overall data shows low variation of only 4% in the exchange rate, determined by the interest rate and exchange rate.

In order to check for the preference of either of the fixed-effects regression model or the random-effect regression model, the Hausman test is used. In Hausman test, the null hypothesis states that the preferred model is the random-effect, while the alternative hypothesis prefers the fixed-effect model (Green, 2008).

Table 2: Random-effects GLS regression

| ex_rate | Coef. | Std. Err. | z   | P>|z| | [95% Conf. Interval] |
|---------|-------|-----------|-----|------|----------------------------|
| cpi_change | .9724316 | .2104878 | 4.62 | 0.000 | .5598831 1.38498 |
| discount_r_e | -3.855391 | .2992 | -12.89 | 0.000 | -4.441182 -3.26897 |
| _cons | 47.87384 | 15.36044 | 3.12 | 0.002 | 17.76794 77.97974 |
| sigma_u | 34.087519 |
| sigma_e | 14.126402 |
| rho | .85343139  (fraction of variance due to u_i) |

Table 3: Hausman Test Results

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Test: Ho: difference in coefficients not systematic

\[ \text{chi2}(2) = (b-b') \cdot [(V_{b-V_B})^{-1}](b-b) \]

= 0.99

Prob>chi2 = 0.6107

(V_{b-V_B} is not positive definite)
The Hausman test result states that the random-effect model is preferable as the null-hypothesis is accepted, based on the value of Prob>chi2, which is greater than 0.05. Following the panel data regression with both fixed-effect and random-effect, and Hausman test, the next regression model that is applied on the data is the least square dummy variable model (LSDV). LSDV model is another tool to check the impacts of the independent variables on the dependent variable by mediating the effect of independent variables over the countries. LSDV also provides a better understanding of the fixed effect, as the unobserved heterogeneity is controlled, and the pure effect of the independent variables is assessed.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Number of obs = 420</th>
<th>Number of obs = 420</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>540664.44</td>
<td>6</td>
<td>90110.74</td>
<td>F( 6, 413) = 451.56</td>
<td>F( 6, 413) = 451.56</td>
</tr>
<tr>
<td>Residual</td>
<td>82416.3131</td>
<td>413</td>
<td>199.555237</td>
<td>Prob &gt; F = 0.0000</td>
<td>Prob &gt; F = 0.0000</td>
</tr>
<tr>
<td>Total</td>
<td>623080.753</td>
<td>419</td>
<td>1487.06624</td>
<td>R-squared = 0.8677</td>
<td>R-squared = 0.8677</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adj R-squared = 0.8658</td>
<td>Adj R-squared = 0.8658</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Root MSE = 14.126</td>
<td>Root MSE = 14.126</td>
</tr>
</tbody>
</table>

| ex_rate      | Coef.    | Std. Err. | t   | P>|t| | [95% Conf. Interval] |
|--------------|----------|-----------|-----|------|----------------------|
| cpi_change   | .9760769 | .2101412  | 4.64| 0.000| .5629972 1.389157    |
| discount_r-e | -3.864832| .2990943  | -12.92| 0.000| -4.452769 -3.276895 |
| nation       |          |           |     |      |                      |
| 2            | -18.50877| 2.480261  | -7.46| 0.000| -23.38428 -13.63326  |
| 3            | 16.79026 | 2.862815  | 5.86| 0.000| 11.16276 22.41777   |
| 4            | 82.11015 | 2.232092  | 36.79| 0.000| 77.72247 86.49782   |
| 5            | 47.385   | 2.226303  | 21.28| 0.000| 43.0087 51.7613     |
| _cons        | 22.35808 | 2.0838    | 10.73| 0.000| 18.26191 26.45426   |

Table 4: Least Square Dummy Variable regression model

The value of the coefficients for the CPI change and the interest rate are the same as provided by the panel data regression model with fixed-effect, with the similar t-values and the p-values. The model is acceptable as the value of Prob>F is less than 0.05. The interesting measure which is provided by the LSDV model is the value of coefficient of determination, which is the $R^2$ that shows the amount of variation in exchange rate which is explained by the CPI change and the interest rate. The value of adjusted $R^2$ is 0.865. Keeping in mind the data used for this particular study along with the time-frame, variables and countries involved, the adjusted $R^2$ shows that 86.58% of the variation in the exchange rate is determined by change of CPI and interest rate. Comparing the coefficient of determination of the LSDV model and the coefficient of determination of fixed-effect and random-effect model, it can be concluded that the LSDV model provides significant variation in the exchange rate as per interest rate and CPI change as compared to the value of $R^2$ of fixed-effect and random-effect.

**Conclusions:** This paper has examined and analyzed the relationship of exchange rate, as a dependent variable, with the interest rate and inflation, which are the independent variables. The study involved panel data from five countries namely Pakistan, China, Japan, UK and USA. The results are aligned with the previous findings of the literature (Srikanth & Kishore, 2012; Hacker et al., 2010; Chen & Hsing, 2005) regarding the relationship of exchange rate and interest rate that interest rate negatively affects the exchange rate in the case of all the countries selected in the study. Similarly, the empirical findings related to the impact of inflation on exchange rate validate the previous findings of the researchers identified in the literature (Chiu, 2008; MacDonald, 1994; MacDonald & Moore, 1996; Manzur, 1990) that inflation prevailing in a country affects the exchange rate in a positive manner. This validation has been true both in the case of exchange rate determination by inflation in case of all the countries used in the study. According to coefficient of determination ($R^2$) provided by both the regression model with fixed-effect and random-effect, although the value is the same but is insignificant and shows a very low level variation of 4.11%
caused by interest rate and CPI in the exchange rate. This means that there are still other factors and variables which contribute to the determination of exchange rate. The coefficient of determination $R^2$ is significant in the case of LSDV regression model used, where the coefficients are separately evaluated for each of the country using dummy variables. The LSDV regression model shows that as per the $R^2$ 86.77% of the variation in exchange rate is determined by interest rate and CPI change. Further research can be conducted on adding a number of other variables into the regression model and determining the exchange rate in case of different countries.

REFERENCES


