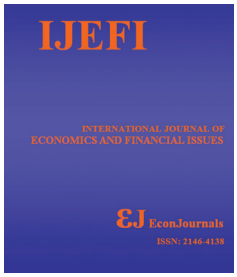

International Journal of Economics and Financial Issues

ISSN: 2146-4138

available at http: www.econjournals.com

International Journal of Economics and Financial Issues, 2016, 6(4), 1454-1459.

The Relationship between Exchange Rate and Inflation: An Empirical Study of Turkey

Abderezak Ali Abdurehman[1]*, Samet Hacilar[2]

[1]Department of Banking and Finance, PhD Student, Yildirim Beyazit University, Ankara, Turkey, [2]Scientific Programs Expert, Technological Research Council of Turkey (TÜBİTAK) and PhD Student, Yıldırım Beyazıt University, Ankara, Turkey.
*Email: 135202412@ybu.edu.tr

ABSTRACT

This paper investigates the relationship between inflation and exchange rate in Turkey. Unlike many empirical studies which make use of the US and Turkey inflation data to test the relationship between inflation and exchange rate in Turkey, this paper employed inflation data of Turkey and the United Kingdom. An ordinary least square (OLS) regression and a simple generalized autoregressive conditional heteroskedasticity (GARCH) model were used to understand the relationship between inflation and exchange rate. The results obtained from OLS regression indicate purchasing power parity (PPP) does not exist in Turkey. However, the existence of ARCH and GARCH in the relationship indicates that the deviations from PPP are not random and follow a certain pattern. Therefore, we conclude that the deviation of PPP might be attributed to certain factors such as transaction cost, government restriction, product specialization or other related factors.

Keywords: Exchange Rate, Inflation, Generalized Autoregressive Conditional Heteroskedasticity Model
JEL Classifications: C87, E31, F31

1. INTRODUCTION

For the last year, one of the most critical topics for Turkish economy was the foreign exchange rate. As it was the case for the other developing countries Turkish currency Turkish Lira depreciated against the developed countries' currencies; namely US Dollar, Euro, Pound, and Yen. For the 12-month period starting on 01/12/2014 and ending on 31/12/2015 USD, Euro, Pound and Yen have appreciated against Turkish Lira 30.28%; 10.78%; 25.24% and 25.37% respectively[1]. To talk about short-term movements in the exchange rate, daily news affecting economy may have some explanation power. However, if we look from a broad view there should be bigger (meaning factors having wider effects) and more general factors for exchange rate movements. These general factors can be listed as a differential in inflation rates, differential in interest rate, differential in income level, change in government controls and change in expectations of future exchange rates[2].

Among the factors listed, we believe that the differential in inflation rates has a special importance for Turkey. Turkey has suffered high inflation rates for a long time. After the 2001 crisis, by the serious steps taken to fight with high inflation, the country succeeded to decrease the inflation rate to one digit. Although the inflation rate has fallen, it remains one of the highest in the world. Despite remaining at one digit level, Turkey's inflation was 15th highest in the world at the end of 2014[3]. The high inflation and sudden increases in foreign money in the past years create the curiosity to investigate the recent relationship between them in the context of Turkey. In this paper, we try to find out if a relationship exists between differential in inflation rate and exchange rate. In addition, we will try to find out if historical data will help us determine relationship from the volatilities of inflation and exchange rate. The rest of the paper will go as follows; Section 2 explains the various papers related to the subject matter. Sections 3 will provide research methodology including economic and econometric models. Section 4 contains empirical results and discussions. Section 5 provides conclusions. The last section contains extensions and limitations of the paper.

1 www.tcmb.gov.tr
2 J. Madura "International Corporate Finance", 8th edition, 2006.
3 www.statista.com

2. LITERATURE REVIEW

Inflation may be one of the factors affecting exchange rate while it may also be the factor affected by the exchange rate. In literature, both views are tested and examined. One of the popular subjects is the pass-through effect of exchange rates on domestic prices. Choudri and Hakura (2001) worked on a large data set of 71 countries for the years 1979-2000. They found a pass-through, which is from exchange rate to prices. The pass-through gets higher for the countries with higher inflation meaning "higher inflation higher pass-through." Their findings are consistent with Taylor's (2000) paper, which inspired them. Edwards (2006) analysed the pass-through subject from an "inflation targeting" perspective. Edwards studied the relationship between the pass-through and the effectiveness of nominal exchange rates in regimes, which have inflation targeting. The results showed that countries with inflation targeting experienced decreasing pass-through effects of exchange rate changes to inflation.

For Turkey case, Central Bank experts Arslaner et al. (2014) worked on 1986-2013 data to see the exchange rate pass-through effects on inflation. The results showed that like other developing countries there is an exchange rate pass-through affecting inflation. The pass-through degree is higher in Turkey compared to developed countries. Another interesting finding is that the pass-through is higher for producer price index than consumer price index (CPI). The main factors for the pass-through are found to be past currency crises and the openness of the economy. Özçiçek (2007) studied on pass-through coefficients and found out that the crises have a significant effect on the pass-through coefficient. Özçiçek showed that for Turkey case the pass-through coefficient is low when the economic crises' data are excluded and the coefficient increases when the economic crises' data are included.

Albuquerque and Portugal (2005) studied the relationship between exchange rate and inflation volatilities. They used a bivariate GARCH model for test and found a relation between exchange rate and inflation variances. Berument (2002) examined the effects of foreign exchange rates on inflation. He found that the foreign exchange rate effects inflation. In addition, he tested the effects of CPI and producer price index separately. The results showed that the producer price index is affected by foreign exchange rate more than CPI. Bayraktar and Arslan (2003) worked on a 20-year data between 1980 and 2000 for Turkey to study the relationship between exchange rate, inflation and import. They found that the variables are cointegrated and there is a long-term relationship between these variables. Also, they used Granger causality test but the results showed there is not a Granger causality from inflation to exchange rate or vice versa. Gül and Ekinci (2006) reached a different conclusion when they used monthly data between January 1984 and December 2003. Their findings showed that there is a long-run relationship between nominal exchange rates and inflation, and a causal relationship between nominal exchange rates to inflation.

Some of the results support purchasing power parity (PPP) for Turkey while some do not. Aslan et al. (2010) analysed if PPP exists in the long-run for Turkey case. They used a large range of data covering 1953-1998. Their results showed there is not much evidence to support PPP exists for the period they analysed. Telatar and Kazdağı (1998) analysed long-run PPP for Turkish Lira and currencies of the major trade partners of Turkey. They used data for the years 1980-1993. Their findings did not show a relationship between exchange rates and prices. Alba and Park (2005) analysed if PPP exists between Turkish Lira and German Mark. For Turkish Lira and German Mark situation the findings showed that PPP exists especially for years closer to date the analyse was done. Özkan (2013) analysed PPP for Turkish Lira – Euro and Turkish Lira – US Dollar cases. The study showed that for the Dollar – Turkish Lira case the Dollar's purchasing power has an effect on the parity while for the Euro – Turkish Lira case the Turkish Lira's purchasing power has a greater effect.

In literature, while results change among papers the difference in results might be due to the countries compared and the data sets used. Also as it can be seen many studies focused on US Dollar, Euro or German Mark. Therefore, this study which compares Turkey and UK data might give some interesting information about PPP existence for Turkey. The paper will study the relationship between Turkish Lira and Pound. This paper will contribute to the literature on the relationship between inflation and exchange.

3. RESEARCH METHODS

The interrelationship between inflation and exchange rate could be seen either side, i.e., the pass-through effect of exchange to inflation, as well from the perspective of the effect of inflation on the exchange rate. This paper will focus on the second aspect, which is the effect of inflation on the exchange rate. At the start point to develop an economic model of the relationship between exchange rate and inflation, we will assume that CPI of home country (T) and the foreign country (The UK in this case) are the same. Then the two countries will have some level of inflation for a period. Let's name the inflation rate of home country I_T and an inflation rate of foreign country I_{UK}. Inflation will force the CPI of the home country CPI_T will be:

$$CPT_T(1+I_T)$$

For the foreign country, the inflation will also change the CPI which may become as given below:

$$CPI_{UK}(1+I_{UK})$$

In the case of $I_T > I_{UK}$, if the exchange rate does not change the consumers' purchasing power will be more for home country goods comparing to foreign goods. And in the opposite situation where $I_{UK} > I_T$, if the exchange rate does not change the consumers' purchasing power, will be more for foreign country goods comparing to home country goods. For both situations mentioned above an arbitrage will start because the PPP is violated. This arbitrage will return parity. PPP assumes that the exchange rate between the two countries will change to maintain the parity in purchasing power. So in a case of inflation and changing exchange rates it can be said that the foreign CPI for the home country consumers will be as shown below:

$$CPI_{UK}(1+I_{UK})(1+e_{UK})$$

Here the percentage change in the value of the foreign currency is shown as e_{UK}. This will show us the change needed to hold the PPP. If we equate the new CPI of a foreign country with the new price index of the home country, we will be able to find a formula for e_{UK}. This equation is shown below:

$$CPI_{UK}(1+I_{UK})(1+e_{UK})=CPI_{T}(1+I_{T}) \quad (1)$$

Solving the equation to find for e_{UK}, we obtain:

$$1+e_{UK}=\frac{CPI_{T}(1+I_{T})}{CPI_{UK}(1+I_{UK})}$$

$$e_{UK}=\frac{CPI_{T}(1+I_{T})}{CPI_{UK}(1+I_{UK})}-1 \quad (2)$$

Going back to our initial assumption that both CPI to be the same, CPI_{T} equal CPI_{U} they cancel, leaving:

$$e_{UK}=\frac{(1+I_{T})}{(1+I_{UK})}-1 \quad (3)$$

Equation (3) shows us the PPP relationship between the exchange rate and the relative inflation between two countries. Looking to the formula, we can say which way the exchange rate will go. For instance, when the inflation of foreign country is higher than home country inflation the e_{UK} becomes negative. Then we will expect the foreign currency will depreciate. *Vice versa*, if the inflation for the home country is higher than foreign country inflation then the e_{UK} becomes positive. So we will expect the home currency will depreciate (or foreign currency appreciate).

3.1. Description of Data

Monthly Inflation and exchange data of Turkey and UK for 10 years (from January 2005 up to December 2014) is used. The data for Turkish inflation is obtained from Turkish Statistical Institute, and inflation data of UK is obtained from Office for National Statistics of UK. The exchange rate data between Pound and Turkish Lira is obtained from Central Bank of the Republic of Turkey EDDS system. Table 1 provides the descriptive statistics of the data. The mean monthly inflation in Turkey between the study periods was 0.65% with standard deviation of 0.80 and skewness 0.45, whereas for the UK it was 0.21%, with a standard deviation of 0.36 and skewness of −0.56. The maximum monthly inflation was 3.27% for Turkey which was in October 2011, while the maximum monthly inflation for the UK was 1.04% in December 2010. The minimum inflation for Turkey was registered on June 2011, i.e., −1.43% and that of UK was −0.77% which is registered on January 2007.

3.2. Key Variables - Unit Root Test

The main explanatory variable in the paper is the inflation rate differential between Turkey and United Kingdom. The dependent variable is the realized change in the exchange rate Lira and Pound from (t) to (t+k). For conducting the time series analysis it was important to make sure that the variables are stationary. The stationary nature of the variables is studied using unit root test. The inflation rate differential was found non-stationary at the level, but its first difference was stationary. The unit root test is performed using Augmented Dickey-Fuller test (ADF) equation. The results are presented in Table 2. As can be seen from Table 2, the ADF probability is 0.000, which is below 0.05, indicating the first difference of the inflation differential is stationary. In addition, we can also see that the absolute value of the t-statistics, i.e., 11.19 is more than any of the critical value at 1%, 5%, and 10%, which are 3.49, 2.89, and 2.58 respectively. This also indicates that there is no unit root, and in another word the inflation differential first difference is stationary.

3.3. Econometric Models Used

3.3.1. Ordinary least square (OLS)

In this paper, a simplified econometric model will be used to apply regression analysis to historical exchange rates and inflation differentials. The particular focus is the exchange rate between Turkish Currency and United Kingdom Currency. The monthly percentage changes in the foreign currency value (e_{UK}) are regressed against the inflation differential that existed at the beginning of each month, as shown here:

$$e_{UK}=\beta_{0}+\beta_{1}\left(\frac{(1+I_{T})}{(1+I_{UK})}-1\right)+\mu \quad (4)$$

Where β_{0} is a constant, β_{1} is the slope coefficient, and μ is an error term. In the regression analysis, monthly data will be used for determining the regression coefficients. The hypothesized values of β_{0} are 0 and that of β_{1} is 1.0. These coefficients mean,

Table 1: Descriptive statistics

Statistical parameters	EXCHANGE	INFLATION_TURKEY	INFLATION_UK
Mean	2.698781	0.652353	0.214874
Median	2.575400	0.550000	0.250000
Maximum	3.700000	3.270000	1.040000
Minimum	2.223000	−1.430000	−0.770000
Standard deviation	0.388517	0.802784	0.362159
Skewness	1.209548	0.450783	−0.564358
Kurtosis	3.660283	3.303458	3.319688
Jarque-Bera	31.17800	4.486827	6.823651
Probability	0.000000	0.106096	0.032981
Sum	321.1549	77.63000	25.57000
Sum square deviation	17.81160	76.04654	15.47677
Observations	119	119	119

on average, for a given inflation differential, there is an equal offsetting percentage change in the exchange rate. The appropriate t-test for each regression coefficient requires a comparison to the hypothesized value and division by the standard error (SE) of the coefficient as follows:

$$\text{Test for } \beta_0 = 0 \; t = \frac{\beta_0 - 0}{\text{s.e of } \beta_0} \quad \text{Test for } \beta_1 = 1 \; t = \frac{\beta_1 - 1}{\text{s.e of } \beta_1}$$

After the calculations, the values of t-table is used in order to find the critical t-value. To say that the inflation differential and the exchange rate is different from what is stated by PPP theory the coefficients should differ significantly from expected.

3.3.2. Generalized autoregressive conditional heteroskedasticity (GARCH)

Literature indicates that exchange rates are very susceptible to volatility clustering, i.e., the tendency for large changes to be followed by another large change and vice versa. Though no relationship exists in the normal OLS it is possible that two variables to be related to their volatilities or the existence of a pattern in the deviation from the OLS model. For this purpose, a simple GARCH test is performed on the time series. In the analysis AR (1) MA (1) is found as the best fitting regression model and is given by:

$$R_t = \mu + \beta_0 \varepsilon_t + \beta_1 \varepsilon_{t-1} + \beta_2 \varepsilon_{t-2} \quad (5)$$

We use h_t to express the variance of the residuals of the ARMA regression model $R_t = m_t + \sqrt{h_t}\varepsilon_t$. In this expression, the variance of ε is one. The GARCH (1,1) Model Specification can be expressed as follows:

$$h_{t+1} = \omega_0 + \alpha \left(R_t - m_t\right)^2 + \beta h_t = \omega_0 + \alpha h_t \varepsilon_t^{\,2} + \beta h \quad (6)$$

In the GARCH (1, 1) Model Specification, the first 1 refers to how many autoregressive lags, or ARCH terms, appear in the equation while the second 1 refers to how many moving average lags are specified, which is often called the number of GARCH terms. Equation 6 is used to estimate the value of ω, α, and β. This model can work only in the condition that $\alpha + \beta < 1$ and the values of ω, α, and β are positive. The weights and long-run average variance are (1-α–β, β, α) and $\sqrt{\omega / (1 - \alpha - \beta}$ respectively.

Table 2: Unit root test

Null hypothesis: DINFLATIONDIFFERENTIAL has a unit root		
Exogenous: Constant		
Lag length: 10 (Automatic - based on SIC, Maxlag=12)		
	t-statistic	P*
Augmented Dickey-Fuller test statistic	−11.19586	0.0000
Test critical values		
1% level	−3.491928	
5% level	−2.88841 1	
10% level	−2.581176	
*Mackinnon (1996) one-sided P values		
Augmented Dickey-Fuller test equation		
Dependent variable: D(DINFLATIONDIFFERENTIAL)		
Method: Least squares		
Date: 11/11/15 Time: 02:47		
Sample (adjusted): 2006M012014M12		
Included observations: 108 after ad adjustments		

4. RESULTS AND DISCUSSION

4.1. OLS Model Results

As explained in the econometric model, the first estimation done is Equation 4. The estimation shows that there is no relationship between exchange rate and inflation observed. The explanatory variable has a coefficient different from one and constant near to zero but not significant. According to PPP, the value of β_1 is hypothesized to be one, and the value of β_0 to be zero. The value of β_1 is far from one, and at the same time, it was not also significant. The value of β_0 is close to zero, but it is not significant. In addition, the R^2 is very small which amounts to 2.6%. It implies that the inflation differential could explain only 2.6% of the deviations in the exchange. Taking into consideration all these facts on the basis of the OLS results we can conclude that the PPP is not supported in Turkey. That, the inflation differential between Turkey and the United Kingdom doesn't explain the TL/pound exchange rate. Like most previous empirical studies which have analyzed the PPP

Table 3: Estimated OLS model results

Dependent variable: EXCHANGEDIFFERENTIAL				
Method: Least squares				
Date: 11/11/15 Time: 13:16				
Sample (adjusted): 2005M022014M12				
Included observations: 119 after adjustments				
Variable	**Coefficient**	**SE**	**t-statistic**	**P**
C	0.003428	0.002943	1.164877	0.2464
DIXFLATIONDIFFERENTIAL	0.002450	0.001375	1.781120	0.0775
R^2	0.026399	Mean dependent variable		0.003376
Adjusted R^2	0.018077	SD dependent variable		0.032396
SE of regression	0.032102	Akaike info criterion		−4.023126
Sum squared residuals	0.120574	Schwarz criterion		−3.976418
Log likelihood	241.3760	Hannan-Quinn criterion		−4.004159
F-statistic	3.172387	Durbin-Watson stat		1.571588
Prob (F-statistic)	0.077488			

OLS: Ordinary least square, SE: Standard error, SD: Standard deviation

in the short-run, our results also could not find any relationship between inflation and exchange using simple OLS regression (Table 3).

4.2. GARCH Estimation

To determine the long-run tendency of deviation of the series from PPP, we examined its variance process using ARCH and GARCH Models proposed by Engle (1982) and Bollerslev (1986) respectively.

4.2.1. ARMA model results

In order to perform the GARCH analysis, we first estimated the best fitting ARMA model. Using Akaike info criterion, Schwarz criterion, and Hannan-Quinn criterion, we have found that ARMA (1,1) to be the best fit for the model. The ARMA (1,1) model is presented in Table 4.

4.2.2. GARCH model results

We can see estimated GARCH (1,1) Model results in Table 5. For the variance equation, the three variables are C, the intercept: ARCH (1), the first lag of the squared return: And GARCH (1), the first lag of the conditional variance. α and β which symbolizes the coefficients of ARCH and GARCH like in Equation 5are statistically significant at 5% levels. We can see that F-statistic is quite high and significant. From the results, we find evidence of both significant ARCH and GARCH effects for the PPP deviation

Table 4: Estimated ARMA model results

Dependent variable: EXCHANGEDIFFERENTIAL				
Method: Least squares				
Date: 11/11/15 Time: 14:26				
Sample (adjusted): 2005M032014M12				
Included observations: 118 after adjustments				
Convergence achieved after 8 iterations				
MA Backcast: 2005M02				
Variable	**Coefficient**	**SE**	**t-statistic**	**P**
C	0.003717	0.003388	1.097088	0.2749
AR(I)	−0.555688	0.112439	−4.942126	0.0000
MA(I)	0.900884	0.057658	15.62473	0.0000
R^2	0.150161	Mean dependent variable		0.003639
Adjusted R^2	0.135382	SD dependent variable		0.032407
SE of regression	0.030133	Akaike info criterion		−4.141282
Sum squared residuals	0.104421	Schwarz criterion		−4.070841
Log likelihood	247.3356	Hannan-Quinn criterion		−4.112681
F-statistic	10.15991	Durbin-Watson stat		2.009317
Prob (F-statistic)	0.000086			
Inverted AR roots	−0.56			
Inverted MA roots	−0.90			

SE: Standard error, SD: Standard deviation

Table 5: Estimated GARCH model results

Dependent variable: EXCHANGEDIFFERENTIAL				
Method: ML - ARCH (Marquardt) - Normal distribution				
Date: 11/11/15 Time: 15:10				
Sample (adjusted): 2005M03 2014M12				
Included observations: 118 after adjustments				
Convergence achieved after 4 iterations				
MA Backcast: 2005M02				
Pre sample variance: Backcast (parameter=0.7)				
GARCH=C(4)+C(5)*RESID(−1)²+C(6)*GARCH(−1)				
Variable	**Coefficient**	**SE**	**z-statistic**	**P**
C	0.006371	0.003984	1.599028	0.1098
ARCH(I)	−0.599066	0.088745	−6.750422	0.0000
GARCH(I)	0.945548	0.011849	79.79809	0.0000
R^2	0.137315	Mean dependent variable		0.003639
Adjusted R^2	0.122311	SD dependent variable		0.032407
SE of regression	0.030360	Akaike info criterion		−4.097980
Sum squared residuals	0.106000	Schwarz criterion		−3.957097
Log likelihood	247.7808	Hannan-Quinn criterion		−4.040777
Durbin-Watson stat	2.020277			
Inverted AR roots	−0.60			
Inverted MA roots	−0.95			

GARCH: Generalized autoregressive conditional heteroskedasticity, SE: Standard error, SD: Standard deviation

is found. More significantly the sum of ARCH (=−0.60) and GARCH (=0.95) effects equals 0.33. In other words, stationary variance requirement ($\alpha + \beta < 1$) is provided. This indicates the persistent or means reverting variance in the long run.

5. CONCLUSIONS

In this paper, we have tried to assess the relationship between exchange rate (represented by pound and lira rate) and inflation in Turkey. Though empirical tests of PPP in Turkey are prevalent most of them make use of the US and Turkey inflation as a dependent variable. We differed from this trend by using the UK inflation rate and thus the TL/Pound exchange rate. But our result does not deviate much from existing literature. We were not able to find PPP using OLS method. The existence of ARCH and GARCH in the relationship indicates that the deviations of PPP are not random and follow a certain pattern. Therefore, we conclude that the deviation of PPP might be attributed to certain factors such as transaction cost, government restriction, product specialization or other related factors.

6. POSSIBLE EXTENSIONS AND LIMITATIONS

In this paper, we limited our study to Turkey and UK data. The study could be extended considering other countries such as US, Japan, and the European Union. In this case, instead of only TL/Pound rate, it could further be studied using TL/Dollar, TL/Euro, and TL/Yen. This way it can give a broader idea and better understanding of the deviations and the reason behind it.

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