Testing for the Uncovered Interest Rate Parity (UIP) in Developing Countries: The Case of Rwanda

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Abstract
The aim of this paper is to assess the link between interest rates and exchange rates in Rwanda under the framework of uncovered interest rate parity (UIP) hypothesis.The parity condition states that the difference between the interest rates of two countries is equal to the expected depreciation between the countries' currencies. The paper uses data spanning the January 2004 to December 2016 period. The paper uses the spot exchange rate, risk premium, deposit interest rates as domestic variables while the USA deposit rates are used as foreign interest rates. Due to its desirable properties especially in terms of handling rational expectations models, the Generalized Method of Moments (GMM) is used to estimate the UIP equation for Rwanda before carrying out several others diagnostic tests to assess the robustness of results. Empirical results show that interest rate differentials, risk premium and the intercept are statistically not significant. These results imply that the UIP condition does not hold for Rwanda under the period of study, which is consistent with other empirical findings in developing countries.
The lack of empirical support for the UIP hypothesis in Rwanda may open up arbitrage opportunities for investors with rational expectations.Indeed, the Modelling and forecasting team should review the UIP equation in the Forecasting and Policy Analysis System (FPAS) macro-model so as to give more attention to non-interest sensitive determinants of exchange rate dynamics in Rwanda.
Keywords: Uncovered Interest rate Parity (UIP), Generalized Method of Moments (GMM)
JEL Classification: C2, E4, E6, F2, F4

1. Introduction

The degree of financial market integration is significantly increasing across the globe and is at present creating cross-global investment opportunities and risk diversification.

The investors could exploit such opportunities by investing in high-yield currencies or by borrowing in low-yield currencies. The return from such a strategy is not only driven by interest rate differentials but also by currency movements. After all, investors with a stake in foreign currencies need to convert foreign to domestic money or vice versa at some point in time.

If uncovered interest rate parity (UIP) held, it would not be possible to exploit interest rate differentials profitably on average. UIP claims that high-yield currencies depreciate while low-yield currencies appreciate so that exchange rate movements precisely offset interest rate differentials. Though interest rate differentials and exchange rate movement remain key factors determining capital movement across countries, the study by John Havey (2004) showed that the exchange rate spread across many developing economies are not only driven by interest rate differentials but also by the status of foreign direct investments, public deficits, current account deficits, terms of trade and aid shocks.

Moreover, the study by Nuwagira W. (2016) about exchange rate and external sector competitiveness showed that the exchange rate behavior in Rwanda determined by terms of trade, productivity, net foreign assets, degree of trade openness and government expenditure, the same factors constrain the effectiveness of monetary policy in developing economies. The UIP balances exchange rate pressures, creates favorable investment climate for both nationals and foreigners and reduces capital flight between economies.

The UIP condition holds under the assumptions of perfect capital mobility, risk neutrality, identical assets in terms of liquidity, maturity and negligible transaction costs. The studies conducted by Bansal and Dahlquist (2000), Flood and Rose (2002) and Frankel and Poonawala (2006) showed that developing economies are mostly characterized by incomplete institutional reforms, relatively volatile economic conditions, weaker macroeconomic fundamentals and shallow financial markets.

Despite these features, Rwanda religiously followed the economic liberalization program, privatized the financial sector to reduce repression thereby encouraging market determination of prices for financial services and entry of international players, which all helped to enhance market competition. In line with the economic liberalization program, the National Bank of Rwanda Act was revised in 1999 to grant the Central Bank independence to formulate and implement monetary policy, ensure financial sector stability and to ensure free capital movement required for successful financial integration (Consolate R.2008). These developments had effects on exchange rate dynamics over time.

Empirical studies about the validity of the UIP focused on industrialized countries and to some extent emerging markets rather than developing countries where international financial data are not available. In this context, uncovered Interest rate parity hypothesis has never been tested in Rwanda. Being one of the equations in

BNR's core macroeconomic model, there is need to examine the linkage between the interest rate and exchange rate under the UIP condition so as to assess whether exchange rate spreads between Rwanda and the rest of the world is to a large extent driven by interest rate differentials.

The aim of paper is to assess the validity of the UIP condition in Rwanda, using the conventional regressions analysis over the period 2004M1-2016M12.

The paper intends not only to bridge the gap in the literature attempting to test the validity of the UIP model in developing economies especially for Rwanda, but to also serve as an input to the BNR Modelling and Forecasting team to review its definition of the exchange rate equation in the core macroeconomic model.

This paper is structured into four sections after the introduction, a review of relevant literature is presented in section two while the third section discusses the methodology and data whereas, section four presents the results and discussions and the conclusion comes last.

2. Literature Review

The theory of uncovered interest rate parity was originally formed through the "law of one price" and "the purchasing power parity" which were both developed in the early 20th century. It states that the difference between the interest rates of two countries will be equal to the expected depreciation of their respective currencies. That means that if one county's interest rate rises by two percent, the other country's currency must be worth two percent less in relation to the country which raised their interest rate.

The UIP condition holds when after regression analysis, the intercept for the UIP equation turns out to be zero, the slope is positive, statistically significant and unity, implying that the investors should be indifferent between assets denominated in either domestic or foreign currencies.

A negative coefficient has a surprising economic interpretation. When the domestic interest rate is higher than the foreign interest rate, the domestic currency on average appreciates (rather than depreciates) to exactly offset the interest rate differential, as predicted by the UIP.

Many comprehensive surveys exist (Froot Lewis (1995), Enge(1996)) that list and discuss the explanations which economists have devised for the empirical failure of UIP. For most of the studies, the estimated coefficient is significantly smaller than one, falling below the value predicted by the UIP. For some other countries, the slope coefficient is negative, and this has been coined in the literature as the forward premium puzzle or forward discount bias, since it implies that the forward market systematically mispredicts the direction of currency movements.

Froot (1990) reports that the average estimate of the slope across a large number of studies is 0.88, which constitutes strong evidence against UIP.

Durcakova, Mandel and Tomsik (2005*)* test UIP between the Czech Krona and USD/EUR and get clear results that UIP in fact does not hold. The slope coefficient value results are in the area -1.6 to -3.9 and the intercept result is between 0.5 and 0.7.

They conclude by claiming that a lot of the interest rate differential is in fact countered by transaction costs and interventions of central banks to control their respective currencies.

Harvey, John (2004) looks in to the subject from a different view in relation to many others by mostly focusing on the capital flows between countries and examining if this is a cause for the UIP not to hold. He also looks at the risk premium and, as opposed to many others, views this as a small contributor to why UIP does not hold with regard to other more important factors including the just mentioned capital flows and restriction on these.

However, according to Diez de Los Rios and Sentana, (2007), some studies reject the null hypothesis that the slope coefficient is one; in fact, a robust result is that the slope is negative. This involves borrowing low interest currencies and investing in high interest rate ones known as "interest arbitrage'' and this practice constitutes a very popular currency speculation strategy developed by financial market practitioners to exploit this anomaly.

The empirical evidence for developed economies within the context of the UIP condition is generally unfavorable as exposed in the surveys of Froot and Thaler (1990), Taylor (1995), Lewis (1995) and the rejection of the UIP condition implies that rational expectations and/or risk neutrality assumptions do not hold. The UIP studies showed that many of developing markets begun liberalizing their financial accounts in the late 1980s and the early 1990s. However, their degrees of financial liberalization are still largely less than those observed in developed economies. The degree of financial liberalization has implications on both interest rate differentials and exchange rate dynamics.

3. Methodology

3.1 Theoretical model

Uncovered Interest Parity is a simple relationship between nominal interest rates and nominal exchange rates. Under the rational expectations and risk-neutrality assumptions, the difference between the forward and spot exchange rate will equal to the interest rate differential among home and foreign countries. Following the Chinn (2006) formulation, UIP can be driven from the equation below:

$$f_t^{(k)} - s_t = i_t - i_t^* \quad (1)$$

where $f_t^{(k)}$ is the logarithm of forward exchange rate for maturity *k* periods ahead, s_t is the logarithm of spot exchange rate at time t, i_t is the -period yield on the domestic instrument, and i_t^* is the corresponding yield on the foreign instrument. Note that equation (1) is also called covered interest rate parity (CIP).
Equation (1) holds regardless of investor preferences. However, if the investors or market participants are risk-averse, then the forward rate will differ from the expected future spot exchange rate by a premium that compensates for the perceived riskiness of holding domestic versus foreign assets (Chinn, 2006). Thus, the risk premium, η , is defined as:

$$f_t^{(k)} = E_t s_{t+1} + \eta_{t+1} \quad (2)$$

Assuming CIP holds, substitute Eq. (2) into Eq. (1):

$$E_t s_{t+1} + \eta_{t+1} - s_t = i_t - i_t^* \quad (3)$$

Rearranging Eq. (3) gives:

$$E_t s_{t+1} - s_t = i_t - i_t^* - \eta_{t+1} \quad (4)$$

Recall UIP is based on the joint hypothesis that market participants have rational expectations and that they are not risk-neutral. Therefore, the rational expectations assumption can be defined as:

$$s_{t+1} = E_t s_{t+1} + \varepsilon_{t+1} \quad (5)$$

Where s_{t+1} is the logarithm of future spot exchange rate, $E_t s_{t+1}$ is the expectations of spot exchange rate at time *t* conditional upon information available at time t, and ε_{t+1} is the rational expectations forecasting error realized at time *t + 1* from a forecast of the exchange rate made at time *t*. Substituting Eq. (5) into Eq. (4) will enable us to incorporate rational the expectations assumption into the UIP condition:

$$s_{t+1} - s_t = i_t - i_t^* - \eta_{t+1} + \varepsilon_{t+1} \quad (6)$$

Furthermore, applying the other crucial assumption, risk behavior,
$\eta_{t+1} \neq 0$ UIP gives the following relationship:

$$s_{t+1} - s_t = i_t - i_t^* + \eta_{t+1} + \varepsilon_{t+1} \quad (7)$$

In order to test Eq. (7), the standard UIP equation can be define as,

$$\Delta s_{t+1} = \alpha + \beta(i_t - i_t^*) + \phi\eta_{t+1} + \varepsilon_{t+1} \quad (8)$$

Where

Δs_{t+1} denotes the change in the exchange rate in logarithms, α , β and ϕ are the intercept and slope , respectively, $(i_t - i_t^*)$ denotes the interest rate differential, and country risk premium, ε_{t+1} is the forecasting error, realized at time *t +1* from a forecast of the exchange rate made at time *t*.

3.2. Empirical Model

Following the methodology used by Champika D (2011) and Anh Tuan Bui (2010), the GMM technique is used to estimate the UIP equation for Rwanda**,** GMM has some attractive features. First, it affords one the opportunity to specify distributional assumptions such as normal errors and the GMM estimation postulates the usage of two sets of population moment conditions in a way that minimizes the asymptotic variance among the moment estimators of the population mean. Second, the GMM estimator is relatively more advantageous and more efficient over all other estimators when dealing with the time series data as it allows to add more moment conditions by

assuming that past values (lagged values) of both dependent and independent variables are not correlated with the error term even though they are not included in the model (Hansen 2001).
Lastly, it is said that the GMM estimator is more suitable for models that are based on rational expectations. Since the model of this study is based on the rational expectations hypothesis, the use of the GMM helped to draw reliable inferences on interest rate-exchange rate linkage in Rwanda.

To highlight the difference between GMM and OLS, consider the following general linear regression model:

$$y_i = x'\beta + \dots + u_i \quad \text{(9)}$$

The OLS estimator $\hat{\beta} = \sum_{i=1}^{n} x_i y_i / \sum_{i=1}^{n} x_i^2$ is consistent for β given £ (u_i/X) =0

A regression model with the first lagged-dependent variable as a regressor can be specified as:

$$y_i = y_{i-1}\beta_1 + x'\beta_2 + \dots + u_i \quad \text{(10)}$$

If the model in equation (10) is chosen for parsimony, OLS estimators are likely to be inefficient .The one period lagged value of y_{i-1} provides the current information about y_i while the regression error is u_i though uncorrelated with x_i is correlated the past values of y_i. This makes the OLS estimators to be inconsistent. Therefore, the GMM estimator becomes consistent for β (Hansen, 1982). An instrument variable z that is correlated with y_{i-1} and uncorrelated with y_i gives consistent estimation.

This implies that £ (u_i / z) = 0 which gives the moment condition or population zero correlation condition as:

$$£[(z' y_i - x_i' \beta)] = 0 \quad \text{(11)}$$

Assuming UIP holds, substitute Eq. (8) into Eq. (10) modified UIP model become:

$$\Delta s_{t+1} = \alpha + \Delta s_t \beta_1 + \beta_2 (i_t - i_t^*) + \phi \eta_t + \varepsilon_t \quad \text{(12)}$$

Where α is the constant term, Δs_t is one period present value of Δs_{t+1} and ε_{t+1} is the error term at time t.
Researchers do not use the modified standard UIP regression equation (12) due to the absence of reliable data for the expected future exchange rate making it difficult to reach definitive conclusions about its validity. However, testing UIP normally involves combining it with the assumption that investors have rational expectations, then the actual spot rate can be regarded as an unbiased predictor of the future spot rate.

As a result, empirical studies often test the doctrine in the form stated in equation (12) where the actual ex-post change in the exchange rate at time 't' become a good proxy for the expected change in the exchange rate. Hence, the expected change between time t +1 and t transforms to observed change between time t and t – 1.
Following Hodrick (1987), Froot and Thaler (1990), Engel (1996), Chinn and Meredith (2002) and other researchers, we adhere to the UIP equation mathematically stated as:

$$\Delta E_t = f[\Delta(i - i^*)_t]$$

Where E is the nominal exchange rate of domestic country, i is the nominal interest rate of domestic country, i^* is the nominal interest rate of anchor country (USA) and Δ is the first difference operator. The UIP for Rwanda is therefore stated as:

$$\Delta E_{Rwt} = f[\Delta(i_{Rw} - i_{US})_t]$$

The empirical form of UIP equation (12) is given below:

$$e_{Rwt} = \alpha + \beta_1 e_{Rwt-1} + \beta_2 \text{int}_t + \phi \eta_t + v_t \text{ .... (13)}$$

Where

e_{Rwt} = [$\frac{e_{Rwt} - e_{Rwt-1}}{e_{Rwt-1}}$] is the change in Rwanda's nominal exchange rate at time t,

$\dot{\text{int}}_t = \dot{\text{int}}_{(Rw/US)t}$ = [$\frac{\text{int}_{Rwt}/\text{int}_{USt} - \text{int}_{Rwt-1}/\text{int}_{USt-1}}{\text{int}_{Rwt-1}/\text{int}_{USt-1}}$] is the interest rate differential between Rwanda and USA at time t, v_t is stochastic error term at time t.

The instrumental variables estimation can be obtained using Δe_{Rwt-2} = (e_{Rwt-2} - e_{Rwt-3}). These instruments will not be correlated with

$\Delta u_t = (u_t - u_{t-1})$, as long as u_t are not serially correlated with one and other.

Therefore, the UIP condition can be tested using the joint hypothesis of α = 0, β_2 =1, ϕ =0 and v_t is orthogonal to all information available at time *t*.

The acceptance or the rejection of UIP depends on the hypothesis testing, with the null hypothesis stated that: H0: *α =0,* β_2 *=1 and* ϕ =0. However, the related literature usually focus only on β_2 (the slope coefficient of interest rate differential) and according to them β_2 should be significant with a positive sign (Flood et al. 2002) for the UIP condition to be valid.

3.3. The Data and Econometric software

The study uses the RWF/USD spot exchange rates, deposit interest rate and risk premium for Rwanda as the domestic variables and the USA deposit rate as foreign deposit interest rate. Most of the data are obtained from the National Bank of Rwanda. All data series are in monthly frequency and span the period from January 2004 to December 2016. The E-Views software is used for the econometrics estimations**.**

4. Results and Discussion

Before running a conventional regression on the UIP condition, we test whether time series of interest rate differential, risk premium and change in exchange rate are stationary or not. Decisions were made following the null hypothesis (H0) of presence of the unit root and the alternative hypothesis (H1) of stationarity.

Using Augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) test results shown that interest rate differential, risk premium and expected change in spot exchange rate reject the null hypothesis, implying that both series have no unit root at 1% level of significance.

Since all series are I(0), we can estimate the UIP equation using OLS. However, owing to OLS weakness explained in the previous section, the use of OLS method cannot capture unobservable specific effects and lagged dependent variables. This problem can be overcome with the use of the generalized methods of moments (GMM) estimation method. The lagged values of the dependent variables are used as instrumental variables and Wald restriction Test is performed to assess robustness of the regression results. The results from the regressions are summarized in the following table:

Table1.GMM results for the UIP equation

Parameter	Estimate	Error	t-statistic	p-value
A	9.91	0.00	0.71	0.47
β_1	0.63	0.07	8.66	0.00
β_2	-0.0002	0.0008	-0.24	0.80
ϕ	-2.47	1.64	-1.50	0.13

The coefficients α, β_1, β_2 and ϕ are for intercept, lag of exchange rate, interest rate differential and premium respectively.

The results of the GMM estimation for Rwanda seem to support the previous empirical literature of the failure of the UIP in developing countries. The empirical results showed that the individual statistical significance of coefficients on interest rate differentials, risk premium as well as on the constant are strongly rejected at 5%, entails that the UIP condition does not hold for Rwanda under the period of study. The result is consistent with other empirical findings where non-interest rate factors determine exchange rate dynamics in developing countries.

The lagged value of the exchange rate has a crucial effect on predicted future exchange rate and prevailing exchange market conditions. The R-squared (R^2) and adjusted R^2 of 0.47 and 0.46 respectively are extremely low, implying that the variation in explanatory variables explain less magnitude of exchange rate.

The null hypothesis of weak restriction and weak instrument variables are strongly rejected given low probability values of the Wald restriction test (α_1 = 0, β_2 =1 and ϕ =0) and the Crogg-Donald test of weak instruments (4).

The Durbin-Watson test shows the value of 4.08, the estimates are not affected by heteroskedasticity and autocorrelation.

The lack of empirical support for the UIP hypothesis in Rwanda may open up arbitrage opportunities for the investors with rational expectations.

Conclusion and recommendation

This paper addressed the link between exchange rate changes and interest rate differentials in the uncovered interest parity framework in Rwanda during January 2004 to December 2016.

It is utilized RWF/USD as spot exchange rates, premium and deposit interest rate for Rwanda as the domestic and the USA as foreign deposit interest rate. The paper adopted the GMM estimation technique to test the presence of UIP accurately.

The overall test results show that UIP hypothesis within the given time frames in Rwanda is rejected, confirming the previous findings relating to practical situation of UIP condition in developing countries. The result is consistent with other empirical findings where non-interest rate factors determine exchange rate dynamics in developing countries. The lagged value of the exchange rate has a crucial effect on predicted future exchange rate and prevailing exchange market conditions.

The lack of empirical support for the UIP hypothesis in Rwanda may open up arbitrage opportunities for the investors with rational expectations.

The findings are relevant for the Modelling and forecasting team to review the UIP equation in the FPAS macro-model for Rwanda.

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