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Uncovered interest parity and behavior of interest differentials[1]

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Abstract

We analyze the relationship between exchange returns and interest rate differentials through Uncovered Interest Parity (UIP). We use a sample of 83 countries for 1980-2015 period, organizing the information into a panel data structure. The fixed-effects regressions show that the UIP is not fulfilled. However, we observe that the effect of interest rate differential on foreign exchange returns is non-linear. The non-linearity shape suggests that UIP have a lower bias in countries with high interest rate differentials, usually over 38 %. Even quartiles regressions show that the positive relationship between exchange rate returns and interest rate differentials would be observed when these variables experience high variations. These results are relevant for monetary and exchange policies design and for investment decisions on exchange markets.
JEL Classification: F31, F36, G15
Keywords: exchange returns, interest parity, differentials

Paridad de tasas de interés y comportamiento de los diferenciales de tasas de interés

Resumen

En este artículo analizamos la relación entre los retornos cambiarios y diferenciales de tasas de interés a través de la Paridad Descubierta de Tasas de Interés (UIP). Usamos panel de datos para 83 países entre 1980 y 2015. Las regresiones por efectos fijos demuestran que la UIP no se cumple, pero el impacto del diferencial de tasas de interés sobre los retornos cambiarios es no lineal. La forma de la no linealidad sugiere que la UIP es menos sesgada en países con diferenciales de tasas de interés superiores al 38 %. Las regresiones por cuartiles demuestran que la relación positiva entre los retornos cambiarios y los diferenciales de tasas de interés se observaría cuando estas variables experimentan variaciones elevadas. Estos resultados son relevantes para el diseño de la política monetaria y cambiaria, y para decisiones de inversión en mercados cambiarios.
Clasificación JEL: F31, F36, G15
Palabras clave: retornos cambiarios, paridad de tasas, diferenciales

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1. Introduction

Exchange markets have been extensively researched in the last three decades. However, the academic community interest has increased because different facts have affected the behavior and development of the foreign exchange market. Along with the evident volatility of these markets, there are other stylized facts such as the economic and financial integration processes of several countries and the uncoupling of interest rates; the latter being one of the main attractions in this area.

Several researches based on Uncovered Interest Parity (UIP) have analyzed the exchange market behavior. The UIP indicates that the exchange return is fully explained through the difference between local and foreign interest rates. However, a wide empirical literature has rejected its validity arguing that the interest rate differential only explains a fraction of the exchange returns (Mussa, 1984; Frenkel, 1981). Moreover, other empirical studies have shown that UIP suffers the forward discount bias, result that attributes a negative effect of interest rate differential on exchange returns (Froot, 1990; Lewis, 1995; Bacchetta and Van Wincoop, 2010; Olmo and Pilbeam, 2011; Bacchetta, 2013; Bhatti, 2014, Gallí, 2019). Such a fact would be concentrated mainly in developed markets.

Despite of persistent rejection of UIP, the debate is still open. More recent studies have shown evidence somewhat more favorable to this short-term equilibrium condition. Such works has shown that UIP would be valid or less biased in emerging markets (Bansal and Dahlquist, 2000; Bekaert, Wei and Xing, 2007; Lothian and Wu, 2011). These markets would experience higher exchange returns and interest rate differentials, which they would support UIP compliance (Baillie and Kilic, 2006; Lothian, Pownall, and Koedijk, 2013). This point open a relevant gap for empirical researches because the interest rate differential level could have a non-linear effect on exchange returns. The lack of consensus observed in the empirical evidence shows that the interest rate differential would have a non-persistent effect on exchange returns, moving from the forward discount bias when these interest rate differentials are low towards the UIP validity when are higher.

Therefore, the aim of our research is to analyze the relationship between the significant variations for exchange returns and interest rate differentials through UIP. Our research contributes to the empirical evidence through two points. First, we analyze a possible non-linear relationship between exchange returns and interest rate differentials. At this point we focus the analysis on possible forward discount bias presence when the interest rate differentials are low, and the trend to UIP fulfillment when these are high. Finally, we analyze the UIP bias magnitud when the variations of interest rate differentials and exchange returns are higher as a way of evaluating the possible forward discount bias reduction.

To achieve this objective we use a sample of 83 countries between 1980 and 2015. We use fixed-effects estimator, which rules out UIP validity and compares the relationship between exchange rate returns and interest rate differentials across different countries. The fixed-effects panel data regressions demonstrate the nonlinear effect of interest rate differential on exchange returns. Non-linearity is U-shaped, which shows that forward discount bias is concentrated in countries with low interest rate differentials, while this bias is lower as this differential increases. For differentials that exceed 38 %, it is possible to observe a lower bias of UIP condition, especifically a positive relationship between exchange returns and interest differentials. Our results suggest that the positive relationship described by UIP intensifies as exchange returns and interest rate differentials experience higher variations. Even the quartiles regression show similar results. These results are relevant for policymakers because establish a threshold values that allows to identify the economies according to their levels of interest rate differentials and even risk premium, and quantify the effects of monetary policy on their currencies path. Furthermore, investors and consulting firms can generate predictions on future exchange returns based on the results we will indicate later.

This article is structured as follows. After this introduction, section 2 presents the theoretical and empirical evidence about UIP and its relationship with interest differential behavior. This section also points out the research hypotheses. Section 3 presents the data and analysis methodologies used, while section 4 shows the results obtained. Finally, section 5 groups the conclusions of this article.

2. Theortical framework and hypothesis

2.1. UIP and relationship between the exchange return and interest rate differentials

The UIP is an equilibrium condition for exchange market and has been widely studied by several researchers. The UIP indicates that the expected depreciation of exchange rate $[E(e_{t+k})-e_t]/e_t$ equals to difference between the local it and foreign interest rate i_t*, where $E(e_{t+k})$ is the expected exchange rate for the $t+k$ period and et is the spot exchange rate. In this way, the exchange rate would be in equilibrium if the interest rate differential fully explains the exchange return. Usually, this relationship has been tested through the following regression model:

$$\frac{E(e_{t+k}-e_t)}{e_t} = \alpha + \beta_1(i_t - i_t*) + \varepsilon_t \tag{1}$$

According to this specification, UIP would be valid if the model parameters (1) are $\alpha = 0$, $\beta_1 = 1$ and ε_t is a non-autocorrelated residue. However, an extensive empirical evidence has shown that the UIP is not met. This empirical literature has pointed out that the UIP prediction is biased because the interest rate differential only explains a fraction of the exchange returns (Mussa, 1984; Frenkel, 1981; Froot and Thaler, 1990). Even Froot and Thaler (1990) and Froot (1990) argue that the most common result is an interest rate differential that affects negatively the subsequent direction of exchange rate, i.e. 1<0. This result is usually known as forward premium puzzle or forward discount bias, and would be common in foreign exchange markets of developed countries (Fama, 1984; Mussa, 1984; Hodrick, 1987; Froot and Frankel, 1989; Froot, 1990; Lewis, 1995; Engel, 1996; Bacchetta and Van Wincoop, 2010; Olmo and Pilbeam, 2011; Bacchetta, 2013; Bhatti, 2014). Other studies that analyzed the prior periods to Bretton Woods, where lower exchange rate volatility was observed, found similar results to forward premium puzzle (McFarland, McMahon and Ngama, 1994; Phillips, McFarland and McMahon, 1996; Choudhry, 2013). Omer et al. (2013) warn dependence between currencies explains these results and would be closely related to the existence of negative interest rate differentials.

More recent researches provides a different vision and that would validate the UIP. Initial studies on this subject found that 1 is close to 1 when the estimation is based on long-term interest rates (Chinn and Meredith, 2004, 2005; Bekaert, Wei and Xing, 2007). Herger (2018) analyzed the currencies of France, Netherlands, Belgium and Germany and demonstrated UIP was a valid condition while exchange rates were related to investments in bills of exchange during the gold standard period. However, the actual debate on this line was deepened to a greater extent due to a more detailed analysis about interest rate differentials behavior. Aggarwal (2013) studied the exchange markets of Japan, Australia and the United States between 1992 and 2005 and found favorable evidence for UIP. This research argues that higher interest rate differentials lead to a risk premium that explain better the exchange rate behavior. According to Yung (2017), this premium of each exchange market, would contribute to explaining more than half of the exchange rate variations. Lothian and Wu (2011) support this vision using an extensive sample of years and countries. Their results validate UIP, especially in periods when interest rate differentials are high. The authors add that 1 becomes negative otherwise. Other empirical studies also support this view (Chaboud and Wright, 2005; Lambelet and Mihailov, 2005; Sarno, Valente and Leon, 2006; Baillie and Kilic, 2006; Lothian, Pownall, and Koedijk, 2013, Ismailov and Rossi, 2018). However, Bansal and Dahlquist (2000) and Frankel and Poonawala (2010) warn that the interest rate differential has a different behavior between developed and emerging countries. Their works reveal that there is less bias for UIP in emerging countries, while the forward discount bias would be observed more frequently in developed markets. Li, Ghoshray and Morley (2012) and Lothian (2016) add that the higher premium adjustment is more evident in emerging markets, where indeed interest rate differentials are comparatively higher than developed markets. Nunes and Piloiu (2017) indicate higher interest differentials reflects higher sistematic risk in exchange markets.

The debate described by the empirical literature validate UIP in countries that experience higher exchange returns and interest rate differentials, leaving this theory as a mechanism relates significant variations of these variables. This fact is observed mainly in emerging markets. While the forward discount bias is associated with low interest rate differentials, which are common in developed countries. These conditions allow us to argue that the relationship between the exchange rate returns and interest rate differentials has a non-linear shape, where the UIP bias decreases as such spreads increase. Even, Aggarwal (2013) warns that UIP could be valid with significant and higher variations both positive and negative. Therefore, we propose two research hypotheses regarding the relationship between exchange returns and interest rate differentials through UIP. So:

H1: The interest rate differential has a non-linear effect on exchange rate return.
H2: The UIP bias is lower when exchange rate returns and interest rate differentials experience higher variations.

3. Data and methods

3.1. Data

The research' data was extracted from the World Developing Indicators (WDI) of the World Bank. The information was organized in a panel data for 83 countries between 1980 and 2015. Table 1 shows the variables description.

The exchange return (EXRET), measured by the annual percentage change of the exchange rate, is the dependent variable of this paper. The exchange rate is quantified as the value of US dollar in terms of the local currency. This measure is widely used by several international studies (Fama, 1984; Domowitz and Hakkio, 1985; Baillie and Bollerslev, 1990a; Lewis, 1995; Engel, 2016). The interest rate differential (DIF) is measured by the difference between the 30-days interbank rates in country i and the US rate. Both variables are used to specify the UIP, theory that will be used for exchange rates valuation.

The analysis also includes dummy variables that adopt the value 1 in the years of the Asian (1997-1998), subprime (2008-2009) and European (2012-2013) crises. These variables allow controlling extreme events over foreign exchange market.

Table 1. Variables

Variables		**Description**
EXRET	Annual exchange return	Annual percentage change of the nominal exchange rate
DIF	Interest rate differential	Difference between 30-day interbank rate of country i and the United States
ASIA	Dummy Asia	Dummy equal to 1 between 1997 and 1998, and 0 otherwise
SUB	Dummy Subprime	Dummy equal to 1 between 2008 and 2009, and 0 otherwise
EUR	Dummy Eurozone	Dummy equal to 1 between 2012 and 2013, and 0 otherwise

Source: Own elaboration

3.2. Econometric methodology

In this section we present the econometric models used in this research. Preliminarily, we will evaluate the UIP validity using the model (1), which will be estimated by a fixed-effects panel data regression:

$$EXRET_{it} = \alpha + \beta_1 DIF_{it} + \eta_i + \eta_t + \varepsilon_{it} \tag{2}$$

Where $EXRET_{it}$ is the exchange return of the country i in the period t, which is controlled over the interbank interest rate differential (DIF_{it}). Additionally, η_i represent the individual fixed effects, η_t are the temporal effects and ε_{it} is a random disturbance. According to (1) and (2) the exchange market will be in equilibrium if $\alpha = 0$, $\beta_1 = 1$ and ε_t is a non-autocorrelated residue. However, if η_i and η_t are significant, the UIP condition is not valid because would exist idyiosincratic and temporal unobservable factors that explain exchange returns behavior.

To evaluate the hypothesis H1, where we test a possible non-linear effect of the interest rate differential on exchange returns, we will use the following regression:

$$EXRET_{it} = \alpha + \beta_1 DIF_{it} + \beta_2 DIF_{it}^2 + \eta_i + \eta_t + \varepsilon_{it} \tag{3}$$

Where $EXRET_{it}$ is the exchange return of the country i in the period t, which is controlled over the interbank interest rate differential (DIF_{it}). We note that DIF_{it}^2 is the quadratic value for the interest rate differential, where β_2 is the parameter that captures its possible non-linear effect on exchange return. In addition, we have that η_i represent the individual fixed effects, η_t are the temporal effects and ε_{it} is a random disturbance.

To evaluate hypothesis H2 we will estimate the regression (2) through two complementary ways. First, we will use a quartiles regression (QR), where the exchange returns are classified by quartiles to visualize their relationship with the interest rate differentials. Our interest is to analyze this relationship on their extreme quartiles (Q1 and Q4). Second, we will use a pooled data regression (POLS) where we analyze the effect of the absolute value of interest rate differentials on the absolute value of exchange returns. In this case, we have increasingly ordered the absolute values of the interest rate differentials by quartiles. In this way, Aggarwal (2013) indicates that the 1 increase shows the lower UIP bias according to exchange rate returns or interest rate differentials experience higher changes. In all these models we will test the hypothesis $H_0: \ \alpha = 0$ and $\beta_1 = 1$, which validates the UIP (see UIP1 in Table 3, UIP2 in Table 4 and UIP3 in Table 5). If this hypothesis is not support, we will observe the UIP bias, which will reduce if β_1 is not negative or close to 1.

Finally, models (2) and (3) include dummy variables to capture the effects of Asian, subprime and European crises on exchange rate returns. All these models were estimated through robust variance to control heteroskedasticity patterns.

4. Empirical results

4.1. Descriptive and correlational analysis

Table 2 presents the descriptive statistics, where the sample of countries was divided according to income level. On average, the exchange return is 19.46 %, which shows that most of the exchange fluctuations would be concentrated in quartiles 3 and 4. In addition, there is a clear heterogeneity between countries. Low and low-middle income countries exhibit exchange returns of 38.16 % and 24.20 % respectively, while upper-middle and high-income countries have returns that are below of sample average. This pattern for exchange returns is also seen in the quartiles for each type of country, where are visible the lower exchange returns from high-income countries and higher returns from low-income countries. Interest rate differentials have a similar pattern to the exchange returns. In fact, it is observed that its correlation with foreign exchange returns is positive and significant, which would according to UIP. The average interest rates differential is 17.56 %, where the low-income countries show values above the average, while the low-middle (7.36 %), upper-middle (5.26 %) and high (-0.02 %) income countries are below the average. Likewise, interest rate differentials are concentrated in quartiles 3 and 4, which also indicates that countries experience high spreads episodes. An idea that is also displayed in the quartile 4 values for each type of country.

It should be noted that for estimation process, both exchange rate returns and interest rate differentials are stationary variables. The unit root test is significant at 1 % in all cases.

Table 2. Statistical summary.

Variable	**Countries according to income level**				**Full sample**
	Low	**Low-middle**	**Upper-middle**	**High**	
A. Dependent variable: Exchange returns (%)					
Mean	38.16	24.20	12.27	3.22	19.46
Standard deviation	428.17	51.04	64.00	24.30	141.88
Quartile 1	-1.02	-0.85	-1.84	-3.09	-1.14
Quartile 2	5.40	4.07	4.22	0.10	3.28
Quartile 3	15.93	13.74	14.18	5.44	12.73
Quartile 4	321.90	234.26	80.06	39.39	244.18
Pesaran Unit root test	(-9.34)***	(-8.21)***	(-7.15)***	(-8.53)***	(-21.65)***
B. Financial fundamental: Interest rate differential (%)					
Mean	57.64	7.36	5.26	-0.02	17.56
Standard deviation	558.31	12.37	8.28	3.46	145.61
Quartile 1	1.49	1.31	0.81	-2.09	0.05
Quartile 2	3.90	4.40	3.87	-0.08	2.87
Quartile 3	8.77	8.42	7.95	1.76	7.10
Quartile 4	467.02	65.21	33.71	9.91	52.79
Correlation w/EXRET	0.03	0.46***	0.88***	0.14***	0.28***
Pesaran Unit root test	(-4.55)***	(-5.04)***	(-9.38)***	(-6.26)***	(-9.79)***

Superscripts ***, ** and * indicate significance at 1 %, 5 % and 10 %, respectively.

Source: Own elaboration

4.2. Non-linear effect of interest rate differentials on exchange return

In this section we present the econometric analysis results. Table 3 presents the model (2) results, which was estimated through pooled (POLS) and fixed-effects panel data (FE) regressions. Wald and F-test correspond to global significance tests for these models. In the latter case, the Hausman test reports the significance for the individual and temporal fixed-effects on regression (2) estimation. So, it result support the statistical relevance of the fixed-effects estimator. This model presents a preliminary UIP analysis. Its results are not originals because UIP is not met. The F-test denoted by UIP1, that indicates under null hypothesis $H_0 : \alpha = 0$ and $\beta_1 = 1$, is rejected in all cases. Even these findings coincide with fixed-effects existence because idiosyncratic factors also explain the exchange returns. This result is consistent with other empirical studies (Hodrick, 1987; Froot, 1990; McFarland, McMahon and Ngama, 1994; Lewis, 1995; Engel, 1996; Phillips, McFarland and McMahon, 1996; Bacchetta and Van Wincoop, 2010; Olmo and Pilbeam, 2011; Choudhry, 2013; Bhatti, 2014). However, we note that UIP bias is relatively lower in low-middle income countries and increases in high-income countries. This result also agrees with other studies (Bansal and Dahlquist, 2000; Frankel and Poonawala, 2010; Li, Ghoshray and Morley, 2012; Lothian, 2016, Nunes and Piloiu, 2017).

Table 4 presents the model (3) results through pooled (POLS) and fixed-effects (FE) regression. The Hausman test corroborates the fixed-effects estimator is better than random-effects estimator. The similar way, the F-test denoted by UIP2, that indicates under null hypothesis H0: =0 and 1=1, is rejected in all cases and support that UIP condition is not met. Despite this, FE estimator is appropriate econometric tool to capture the difference in the exchange returns and interest rate differentials between countries. We observe that the 2 parameter is positive and significant. This fact indicates that the interest rate differential (DIF) has a non-linear effect on exchange return (EXRET), which validates our hypothesis H1. The non-linearity shape suggests that for lower interest rate differentials, the UIP is not met and the forward discount bias predominates over exchange rates behavior. In high-income countries we observe the higher forward discount bias predominance, as these countries present low exchange returns and interest rate differentials. On the other hand, for higher interest rate differentials, we observe a positive relationship between differentials and exchange returns. In any case, there are threshold values that separate these effects. Critical values described in Table 4 were obtained by maximizing the exchange returns of the model (3) with respect to DIF variable, only when the parameters 1 and 2 are significant. In this way, critical values are obtained from the expression –(1/22). In low-middle and upper-middle income countries, where this bias is lower, the threshold values for interest rate differentials fluctuate between 38.43 % and 40.62 % according to estimation. The threshold values existence for interest rate differentials would allow policymakers, such as central banks and ministries, to identify the possible effects of monetary policy on exchange rates and economy. Even for investors, it provides guidelines that would allow them to analyze the effects of interest rate differentials changes on their investments in currencies.

Table 3. UIP regression analysis.

Coefficients	**Low income**		**Low-middle income**		**Upper-middle income**		**High income**	
	POLS	**FE**	**POLS**	**FE**	**POLS**	**FE**	**POLS**	**FE**
α	0.1921	0.1182	0.0103	0.0408	0.0949	0.0997	0.0091	0.0091
	(0.96)	(0.58)	(0.74)	(2.51)**	(2.70)***	(2.81)***	(2.33)**	(2.31)**
β_1	1.9870	3.3937	1.3166	0.8931	0.2713	0.2631	-0.3666	0.0842
	(0.97)	(1.33)	(12.78)***	(5.44)***	(43.32)***	(38.16)***	(-3.31)***	(0.52)
Sample	688	688	609	609	518	518	482	482
F-test /Wald test	(0.94)	(0.94)	(163.35)***	(71.20)***	(76.85)***	(79.98)***	(10.96)***	(10.96)***
R square	0.03	0.04	0.21	0.23	0.78	0.79	0.12	0.13
Country effects	No	Yes	No	Yes	No	Yes	No	Yes
Temporal effects	No	Yes	No	Yes	No	Yes	No	Yes
Hausman test	–	(3.89)***	–	(3.82)***	–	(5.24)***	–	(3.09)***
UIP1 Test	(1.99)**	(2.30)**	(8.56)***	(4.13)***	(29.67)***	(19.34)***	(19.08)***	(38.17)***

Superscript ***, ** and * indicate significance at 1 %, 5 % and 10 %, respectively.

Source: Own elaboration

Table 4.

Coefficients	**Low income**		**Low-middle income**		**Upper-middle income**		**High income**	
	POLS	**FE**	**POLS**	**FE**	**POLS**	**FE**	**POLS**	**FE**
α	0.1735	0.0648	0.0011	0.0094	0.0414	0.0783	-0.0008	-0.0012
	(0.85)	(0.29)	(0.05)	(0.77)	(1.98)**	(1.77)*	(-0.19)	(-0.29)
β_1	3.2753	6.3820	-0.0578	-0.0635	-0.0977	-0.1287	-0.1420	-0.1260
	(0.95)	(1.54)	(-4.38)***	(-3.15)***	(-15.93)***	(-13.85)***	(-1.74)*	(-1.77)*
β_2	5.1115	10.7839	0.0752	0.0814	0.1228	0.1584	0.1622	0.1833
	(0.46)	(0.92)	(2.07)**	(2.59)***	(9.35)***	(8.12)***	(5.56)***	(5.06)***
DIF critical value	–	–	38.43 %	39.01 %	39.79 %	40.62 %	43.77 %	34.37 %

Coefficients	Low income		Low-middle income		Upper-middle income		High income	
	POLS	FE	POLS	FE	POLS	FE	POLS	FE
Sample	688	688	609	609	518	518	482	482
Ftest/Wald test	(0.58)	(1.30)	(82.25)***	(16.70)***	(95.58)***	(70.55)***	(21.26)***	(12.95)***
R square	0.01	0.02	0.21	0.20	0.82	0.82	0.18	0.19
Country effect	No	Yes	No	Yes	No	Yes	No	Yes
Temporal effects	No	Yes	No	Yes	No	Yes	No	Yes
Hausman test	–	(4.27)***	–	(3.98)***	–	(4.73)***	–	(4.29)***
UIP2 Test	(3.07)***	(4.55)***	(5.05)***	(2.01)**	(91.05)***	(22.37)***	(28.37)***	(42.75)***

Superscript ***, ** and * indicate significance at 1 %, 5 % and 10 %, respectively.

Source: Own elaboration

Table 5 shows the model (2) results through pooled data and quartiles regressions. So, these regressions would show the relationship between Q1 (lower variations for exchange returns) and Q4 quartiles (higher variations for exchange returns) with interest differential. In addition, pooled data regressions evaluate the effect of absolute value of the interest rate differentials on absolute value of the exchange returns. The regressions have been classified in quartiles (Q4 and Q1), ordered by absolute values of interest rate differentials. The idea is to observe the UIP behavior according to magnitude of variations of these variables, regardless of the sign of change. Once again, our results support that UIP is not met. UIP3 test that evaluates the null hypothesis $\alpha = 0$ and $\beta_1 = 1$ is rejected at 1 % in each pooled data and quartile regression. But, according the positive values of β_1, we confirm that UIP bias is lower. The pooled data regression for quartile 1, which groups together the lowest absolute values of the interest rate differentials, presents a positive and not significant parameter equal to 0.0348; while the regression for quartile 4, which groups the highest absolute values of the interest rate differentials, has a significant parameter equal to 0.2682. The regressions by quartiles, which are grouped in quartiles according to the values of exchange returns, show a similar result. The UIP bias is reduced as the exchange returns and interest differentials show higher variations. These results validate hypothesis H2, which corroborates the trend to reduce UIP bias when its fundamentals undergo significant variations.

Table 5. Pooled and quartile regressions for UIP.

Coefficients	Pooled regression			Quartile regression		
	Full sample	Quartile 1	Quartile 4	Quartile 1	Intraquartile	Quartile 4
α	0.1304	0.0310	5.1780	-0.0220	0.1037	0.0817
	(2.52)**	(9.21)***	(1.27)	(-8.52)***	(10.78)***	(16.12)***
β_1	0.2719	0.0348	0.2682	0.2463	0.3163	0.5627
	(14.03)***	(0.32)	(2.10)**	(54.33)***	(1.79)*	(96.03)***
Sample	2297	1491	486			
F test/Wald test	(96.75)***	(0.10)	(8.99)***			
R square	0.07	0.05	0.13	0.10	0.19	0.27
UIP3 Test	(75.10)***	(70.49)***	(30.76)***	(45.66)***	(48.74)***	(64.93)***
Country effect	No	No	No	No	No	No
Temporal effects	No	No	No	No	No	No
Dummy income	Yes	Yes	Yes	Yes	Yes	Yes

5. Conclusions and discussion

The foreign exchange markets continue to be a permanent and attractive research focus for many researchers. Its relationship with economic policy, particularly monetary policy, makes this market a relevant factor for the economic growth and financial development of countries.

Several researches have studied the exchange market behavior through the UIP, and although most of the empirical evidence has ruled out its validity, the debate still remains open. Even more so if we consider that the most recent studies have provided favorable evidence to UIP through a deeper analysis on interest rate differentials behavior. More specifically, these studies argue that UIP would be met when interest rate differentials are high. The implications of these results would be relevant for the monetary policy design.

Our research addresses and deepens this research area, analyzing the UIP according to behavior of exchange rate returns and interest rate differentials. The results and implications of our research can be summarized in two points. First, our estimates show that interest rate differentials have a non-linear effect on exchange rate returns, specifically this relationship has a U-shape. Although not nonlinearity is not a rule, this suggests that when interest rate differentials are low the UIP is not meet. The forward discount bias predominates on exchange rates behavior, as seen in high-income countries, which are mostly developed countries. In addition, a lower UIP bias was observed when interest differentials experience higher variations, mainly in low-middle and upper-middle-income countries. But this fact does not guarantee the UIP compliance. In fact, the threshold values of interest rate differentials fluctuate between 38.43 % and 40.62 %. Second, the UIP bias is lower when exchange rate returns and interest rate differentials experience higher variations, regardless of the variation sign.

The threshold value existence for the effects of interest rate differentials on foreign exchange returns and the partial reduction of UIP bias in relation to higher interest rate differentials have important implications for policymakers and investors. Policymakers, such as central banks and ministries, from these results could identify the possible effects of monetary policy on exchange rates and the economy behavior. Even for investors, it provides parameters that, on the one hand, allow them to analyze the effects of changes in interest rate differentials on their foreign currency investments, and on the other, to make a better assessment of the risk associated with interest rates.

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