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The US Exchange Rate Behavior: An Advanced Test on Price Parity Theorem

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ABSTRACT

We researched a significant topic on exchange rate behavior by restating the test procedures in a novel manner and applying an appropriate econometric methodology to re-examine exchange rate behavior of the US economy. The central research question is: Do inflation differences across two economies fully account for exchange rate changes, if controls for non-parity factors are embedded while controlling for interest rate differences? The results affirm, for the first time, that price parity factor holds well while other factors - interest rates *and* non-parity factors – also affect exchange rates significantly. Our tests also identifies the time to equilibrium to be 0.139 (13.9%) per quarter to adjust to equilibrium value. In our view, these findings extend our knowledge of how the US dollar behavior is consistent with parity *and* non-parity theorems. Prior tests have been inconclusive on parity factors. The Malaysian Ringgit is heavily dependent on the US dollar exchange rate, and our findings thus have monetary policy implications for the Malaysia's regulators.

Keywords: Price parity, Exchange rate, Speed of adjustment, Non-parity factors, Interest rates, ARDL
JEL Classification: F23, F31, G12

INTRODUCTION

This research report provides new findings that, for the first time, affirm strong evidence supporting the two parity theorems as affecting the exchange rate. That is, both prices and relative interest rates have significant effects on the nominal exchange rate of the United States (US) currency. We used a very long time series covering 213 quarters. The novel idea tested in this report is to incorporate recently-suggested non-parity factors (Ho

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& Ariff, 2012) as control variables in the test model using the traditional parity factors, namely, inflation and interest rates. Several theories that exist in international finance literature predict how exchange rates are determined, although, to-date, there is little support in almost all studies for the prediction that inflation has a significant effect on exchange rate: some writers have termed this a 'puzzle' (Bergin, Glick, & Taylor, 2006).

This then calls for a novel approach to re-examine the exchange rate pricing behavior using a long-length time series and more up-to-date appropriate methodology. This paper explains this new approach, the appropriate models and the resulting findings. Given the heavy dependence of the Ringgit Malaysia (RM) on US exchange rate behavior, identifying the factors that determine exchange rate has monetary policy implications for the local economy. RM has depreciated at the rate of 5.1 per cent per annum since the onset of the Asian Financial Crisis; this underlines the importance of how price and interest rate differences could affect any currency.

The focus of this paper is on two major theories on exchange rate determination: Purchasing Power Parity (1918) or PPP on inflation and International Fisher Effect (1930) or IFE on interest rates. Despite the fact that these theories have been studied and tested, as well as entrenched in practical policy decisions at macro and micro-levels in a variety of contexts, there is still a lack of support for the theory-predicted results. (i) Does PPP factor affect exchange rate; (ii) Does interest rate (IFE) affect exchange rate; and (iii) Do PPP and IFE hold if controls for the already-known non-parity factors are embedded in our tests? We added to the traditional factors of parity conditions, the recently theorized and tested non-parity factors in this research.

The rest of the paper is organized into five sections. The next section is a very brief statement of the theories on exchange rate behavior from the vast literature on this topic. The third section provides a quick summary of the empirical literature that appears to suggest that there is still lack of evidence to support the PPP theory predictions. The data sources and tests are explained in the fourth section. The findings are reported in the fifth section and the paper ends with a summary in section 6.

EXCHANGE RATE THEORIES

Existing literature and respected financial press reports suggest large variation in several currency exchange rates under the free-floating system, which started in earnest in 1973 after the breakdown of the 1946 Bretton Woods Agreement. Thus, researchers have begun to re-examine the exchange rate behavior again, especially after the 2008-9 Global Financial Crisis (GFC) after which event, the volume in currency trades has jumped almost 60 per cent to the US$5.3 trillion a day. There is renewed interest on exchange rate determination in both theoretical and empirical literature. Under the monetarist

approach of exchange rate determination, PPP (Cassel, 1918) and IFE (Fisher, 1930) are assumed to fully explain how currency exchange rates are determined. Recent researchers have added a few non-parity factors, as explained before, to the parity factors from the monetary theories.

No evidence is available that PPP holds in the short-run although using a novel approach, one study (Manzur & Ariff, 1995) provides support for just long-run equilibrium. Meanwhile, there is ample support in the literature for IFE effect on the exchange rate (Edison & Melick, 1999). Hence, the literature relevant to this study is on inflation and interest rate differences, as well as known non-parity factors. Our review of literature that follows is limited to these factors.

Purchasing Power Parity

PPP suggests that the exchange rate is periodically affected by the relative price differences in traded goods/services across any two trading partner countries (Cassel, 1918). PPP is often said to have originated in earlier Spanish literature on inflation during the periods of gold importation from the New World. The theory examines the relationship between exchange rates across different countries. It asserts that inflation, measured as price differentials across any two trading countries, should be offset by exchange rate changes: it does not specify the time to equilibrium. Hence, any two identical goods produced in any two countries are said to have a similar base price, as stated by *the law of one price* for the same basket of goods traded across any two economies with different currencies.

Scholars in international finance and macroeconomics have found PPP's potential for a wide range of applications especially in the post-Bretton Woods era. It also provides a basis for international comparison of income and expenditure under an equilibrium condition, given an efficient arbitrage in goods traded. Most importantly, it is a theory for short-run as well as long-run exchange rate determination, whereby the authorities would set or steer a nominal exchange rate that satisfies international competition.

The relative version of PPP states that a country's currency will be adjusted based on the ratio of the rate of inflation and the trading partner's inflation rate. Subject to periodic fluctuations of real exchange rates, there is a possibility for the relative PPP to hold in the long-run but not the short-run, some arg.

This study used the relative version of PPP as in the following equation:

$$\ln E_{jt} = a_j + b_j ln\left(\frac{P_t^d}{P_t^f}\right)_{jt} + \mu_{jt} \qquad (1)$$

where, E is the Exchange rate of country over time period, is the Domestic prices and Foreign prices.

International Fisher Effect

A linkage between interest rate and inflation is postulated in the so-called *theory of interest* (Fisher, 1930) which predicts that the nominal interest rate is equal to the summation of real interest and expected

inflation rates dubbed the Domestic Fisher Effect. There is a further prediction that such a behavior will also lead to the interest rate differences between any two nations as a corresponding change in the nominal exchange rate. The relationship between interest rates and inflation is one to one, assuming a world of perfect capital mobility with no transaction costs involved: this effect is normally considered instantaneous. This hypothesis plays a crucial role, given the fact that, subject to the correlation between real interest rate and inflation, the nominal interest rate will not be fully adjusted after a change in the expected inflation (Levich, 2011). A large number of studies have been conducted on the IFE theory. The early studies go back to the 1980s. Yet, there is evidence of several mixed results concerning IFE.

As a general rule, the law of one price in the PPP holds, when there is equilibrium in foreign exchange market, deposits of all currencies possess an identical rate of return. Any change in a country's interest rate will create disequilibrium in its currency requiring long-term adjustments of the other country's exchange rate to restore the new equilibrium. In other words, the ratio of changes in exchange rates is determined by the ratio of domestic (superscript d) to foreign interest rate (relative interest rate, superscript f), as shown in the following equation:

$$\frac{E_{t+1}}{Et} = \left(\frac{1 + i_t^d}{1 + i_t^f} \right) \qquad (2)$$

Accordingly, IFE states that the interest rate differences across countries are unbiased predictors of any future changes in the spot nominal exchange rates. Tests on this theorem suggest that the interest rate differences are correlated significantly with exchange rate changes, although most tests show that, due to under-specification of the relationship, the explained variation in such tests is very low as shown by low R-squared values, which is also due to variable specification issues. Hence, there is also a need to re-examine if such test results are due to simpler methodology used in prior research.

Non-Parity Factors

There have been several important studies exploring if one or more non-parity factors is/are also relevant for exchange rate movements, given the lack of explanatory power of the monetary theorems with two parity conditions. Frankel and & Rose (1996) suggested trade balances, while Canzoneri, Cumby, and Diba (1999) suggested productivity changes as significant exchange-rate-relevant factors. Several other such factors were tested in the study identifying three key non-parity factors as being relevant to theory-building on exchange rates. Hence, this study incorporated these and other already-identified significant non-parity factors as the control variables in the tests of parity theorems.

Thus, it is believed that the introduction of a more fully-specified model will lead to robust results on exchange rate behavior compared to the existing US studies that

are limited to only the parity factors. Obviously, the differences in the behavior of US exchange rate may well be due to the changes in the underlying non-parity factors. Hence, the resulting findings may provide fresh insights into the very old issue of parity factors.

EMPIRICAL EVIDENCE ON PARITY THEORIES

Purchasing Power Parity

A seminal paper (Baharumshah & Ariff, 1997) showed that the purchasing power parity does not hold in the case of few currencies, including that of Malaysia. That finding is similar to the findings in most of the literature to-date, which prompts the question why. As the nominal prices are unstable or may also be sticky (i.e., prices take time to change; Dornbusch, 1976) and the nominal exchange rates are subject to wide fluctuations as the result of volatilities in flows of capitals, goods and services, the short-run equilibrium is often explained as not likely to hold. However, several empirical concerns have risen about this position in the literature. For example, if interest rates, which are also subjected to other effects, are holding in short-run, why is there lack of evidence for similar behavior for inflation? The mixed evidence in support of PPP equilibrium can be attributed to the models used for exchange rate determination and perhaps also to the sources of disturbances to real exchange rate.

A large number of studies in the late 1970s failed to validate a significant PPP relationship, mainly due to the non-stationarity nature of the residuals, as we have come to discover since the 1980s, given the advances in econometrics that identified non-stationarity as a factor introducing biased estimates. In particular, while these studies failed to confirm the unit root or the stationarity property of the residuals, the relationship between the respective variables (nominal exchange rates and relative prices) was mis-measured resulting in spurious regression parameters. The basic empirical studies on PPP before the 1980s were mostly concerned about the tests on absolute PPP with results rejecting the PPP hypothesis. The most influential study of this type (Frenkel, 1976) obtained estimates of respective coefficients that would not suggest a rejection of the null hypothesis, even considering that the sampled countries in the study were among high inflation economies.

Accordingly in the early1980s, research began to test for stationarity using a newly developed unit root test (Dickey-Fuller's ADF test). The ADF test, despite its revolutionary resolution of the problem, still failed to strongly support the presence of significant PPP in nearly all studies of unit root tests using cross country data for the free floating period, except a few studies on long-run PPP behavior, given that the real exchange rate deviations from its mean value are only temporary in nature. Such a failure was basically attributed to the limited power of the tests employed, especially in small samples using the simulation exercises (Levin & Lin, 1992).

Towards the end of 1980s, researchers attempted to overcome the problem of low power of tests by taking advantage of long horizon data. By using an error-correction model (Edison, 1987) researchers analysed the dollar-Pound Sterling data over 1890-1978 and found slightly higher degree of significance for PPP. Consistent with that study, a large number of other studies in the early 1990s attempted to test for PPP reliability over longer time horizons (something we also did in this study), while also using a number of recently-developed yet applied new and sophisticated methods such as cointegration, variance decompositions, fractional integration, as well as error correction models. The results of these studies favoured the PPP predictions: these also supported the real exchange rate mean-reverting behavior (Rogoff, 1996). Mollick (1999), using data for Brazil, analysed long-time period data over 1885 to 1990. The results, however, were mixed; the unit root hypothesis was not rejected by the formal unit root tests, while the trends of time series favoured a stationarity of the variables. Autoregressive processes used in the model yielded robust and satisfactory estimation of the real exchange rate compared with regression methods.

Consistently, Lothian & Taylor (1996) applied the annual real exchange rate data of Franc-Sterling and Dollar-Sterling for a total of two centuries. The results over such a long time period were satisfactory, rejecting the null hypothesis of unit root test for PPP using both ADF and Phillips-Perron (PP) test (Phillips & Perron, 1988). Also, in a separate study, Lothian & Taylor (2000) supported their belief about the PPP reliability over long run and used a method of faster estimation of mean reversion speed for the real exchange rate. Meanwhile, Andersson & Lyhagen (1999) developed a panel unit root test, through which the null hypothesis of no co-integrating relationship between the domestic and foreign price levels was rejected for some of the sampled countries. Using a relatively similar small sample as the one applied by Andersson & Lyhagen (1999), with long-time horizon for real exchange rate data of 21 countries, Shively (2001) found evidence of consistent PPP relationship to add up another satisfactory result for longer time periods.

Concerning the results obtained supporting the PPP, after three decades of floating exchange rates, there is still evidence from various studies that the strong prediction of PPP is not borne out in tests for either short or long run. Failure to support PPP's predictive power has been termed the "PPP Puzzle" in a recent paper (Bahmani-Oskooee *et al*., 2009).

International Fisher Effect

The relationship between real interest and real exchange rates (that is after inflationary effect is removed) is highlighted in several studies using post-Bretton Woods data. One primary and yet well-known model of exchange rate is the sticky price model of Dornbusch (1976), which suggests that under a flexible exchange rate framework,

prices of goods in a country are subject to slower (stickier) adjustments than those of capital assets, thus initiating arbitrage opportunities in the short-run, as suggested by IFE (see Manzur & Ariff, 1995, identifying the time periods for stickiness).

Apart from these models, there is evidence of several important studies on the correlations of real interest and exchange rates with several different assumptions. Mishkin (1984) considers the equality of real interest rates across a sample of major economies unlike the finance theory which indicates that risk premium for comparable securities in different currencies of denomination may differ from each other. Likewise, Mark (1985) tests for the conditions of high capital mobility and equality of short term *ex ante* real interest rates and net of tax real rates among flexible and specific market-linked exchange rates. The results are consistent with those of Mishkin in that the IFE hypothesis of parity conditions was rejected considering its joint relationship with the *ex-ante* PPP.

Large number of critics made obvious conclusions that there is lack of support for some of the theories concerning their validity with a view that the cointegration of real returns are not tested in Mark & Mishkin's study. Other studies tried to control for the drawback by introducing tests of cointegration. Notably, the two-step method of Engle-Granger test of co-integration was applied in several preliminary studies in the late 1980s and in the early 1990s in order to examine how the real exchange rates are cointegrated with real interest rates. Examples include Edison & Pauls (1993), and Throop (1993), all of which failed to support a significant (possibly long-run) co-integrating relationship between the respective variables. After applying the maximum likelihood estimation method for the Johansen co-integration test, the results became somewhat more favourable supporting the theory (Johansen & Juselius, 1992; Edison & Melick, 1999).

Similar to PPP, there is evidence in several empirical studies that long-run relationship between exchange rate and interest rate difference appears to hold well (Hill, 2004). On the other hand, in the short-run, the IFE has not been proven to hold (Cumby & Obstfeld, 1981). Such mixed evidence motivated us to re-test the IFE hypothesis.

Non-parity Factors

While these theories are generally treated as general equilibrium conditions - known as parity theorems in monetary economics framework - researchers have recently identified, as mentioned earlier, a number of other-than parity factors as influencing exchange rates. Given the lack of strong evidence for a complete explanatory power of parity factors as determinants of exchange rate behavior, these so-called 'non-parity' factors are gaining significant popularity in recent years in exchange rate studies.

The level of international reserves of a country is one of the significant

determinants of exchange rates (Frankel & Rose, 1996); this comes from the Philip's Curve effect long observed in international economics studies. A country's currency is subject to movements as a result of unexpected changes in foreign reserves held by the central authority to service the trade bills arising from international trade and also from the use of reserves to defend currency during crisis periods. Hence, there is a direct relationship between the currency value and any sort of unexpected changes in the country's reserve or even the level of foreign currency debt. The relationship between level of international reserve and currency value has been tested by a number of scholars (Martínez, 1999; Marini & Piersanti, 2003). They showed a significant association between the respective variables.

The level of capital flows also plays a crucial role in determining the behavior of exchange rates. The accessibility to cash from capital markets has become easier because of new rules and regulations and general reduction of capital controls leading to improved globalisation of cash flows. This is partly relevant to exchange rates, given the freedom in global flows of capital. There are several studies that have identified significant relationship between the level of capital flows and exchange rate changes. Examples are the studies of Kim (2000), Calvo, Izquierdo, & Talvi (2003), and Rivera-Batiz & Rivera-Batiz (2001).

RESEARCH DESIGN, VARIABLES, HYPOTHESES AND MODELLING

This research was designed to investigate whether a relationship between exchange rates and parity variables exists, with and without controls for non-parity variables specified in the test models. The data series on variables (exchange rate, inflation, interest rate differences, non-parity factors) are from the US and UK data sources. In this study, a long period starting from the pre-floating era of 1960 to 2014 was used, with a 55-year data set. "What are the factors that had significant influences on the US$ rate" is the research question.

The test model was developed by specifying inflation and interest rate differences as parity factors on the right-hand side, and then in repeated tests introducing control variables, which are non-parity factors. In such a full model that was developed, a single regression could do for tests, while also re-estimating the effects of parity and non-parity factors.

We believe that this approach has yielded new insights into how: (i) exchange rates behave differently and (ii) the validity of non-parity factors for the US$ exchange rate. During the test periods, both US$ and the British pound (GBP) played significant roles as international currencies.

Data, Variable Transformation and Testing

The data employed in this study are Nominal Exchange Rate (NER), Consumer Price Index (CPI), short-term risk-free

(Treasury) interest rates, Total Reserve, Population, Total value of imports, Current Account Balance, GDP, and Total value of exports. The GDP data were used to standardise other variables. The series are quarterly dated from 1960 to 2014. Table 1 provides a summary of the variables, with their expected signs in the tests.

TABLE 1
Variable specification, definitions and expected signs

No.	Variables	Definition	Expected Sign
1.	LNER	Log of Nominal Exchange Rate over time periods	Dep Variablea
2.	LCPI	Log of Prices over time periods	+
3.	IFE	(1+ Short-term Domestic Interest Rate) / (1+Short-term Foreign Interest rate)	–
4.	CA/GDP	Current Account Balance / GDP	+
5.	TTrade/GDP	Total Exports and Imports / GDP	+
6.	Productivity	GDP / Population	+

Note: [a]Dep. Variable stands for Dependent Variable

The major sources of data included *the International Financial Statistics* (IFS) CD-ROM, *Thomson Reuters DataStream*, and the *Capital IQ* database. The Consumer Price Index (CPI) was used as a proxy for measuring the purchasing power parity. The CPI measured the prices of a basket of goods available in each country: the US and the UK. The theory of international Fisher Effect was measured according to short-term risk free interest rates (Treasury bills) for the US dividing by the corresponding interest rate for the UK as a measure for the foreign interest rate.

Hypotheses

The maintained hypothesis is that the two parity variables in the monetary economics theory should hold provided that: (a) the data series are long enough with appropriate specifications, (b) the parameter estimation is done with robust test methods, and (c) non-parity factors are embedded in the tests. Prior research has failed to satisfy these special conditions needed to measure and test the parity theorems.

H1: The null hypothesis is that the price differences across traded countries are not likely to affect the nominal exchange rate of a country. We expect to reject this null hypothesis to support the PPP theory;

H2: The null hypothesis is that the real interest rate differences across two countries are not likely to affect the exchange rate of a country. Rejection of this will support the IFE prediction; and

H3: The null hypothesis is that the non-parity factors recently found to affect nominal exchange rates are not significantly correlated with the nominal exchange rates of the US. Rejecting this null would suggest that the controls introduced in our tests are significant factors for exchange rate determination.

These three testable hypotheses will be verified by the usual t-tests on the parameters on those factors in the test models. There are other tests which will report on preparation of data series, and in assuring the assumptions of the tests are not violated.

Modelling

The first model for the exchange rate is based on a single equation which includes a number of parity and non-parity factors. The following equation was used to test the basic relationship among the variables, and to obtain base estimates, which will be later compared with more advanced tests.

$$ln\left(\frac{NER_t^d}{NER_t^f}\right)_t = \gamma_1\left(\frac{1+i_t^d}{1+i_t^f}\right)_t + \gamma_2 ln\left(\frac{CIP_t^d}{CIP_t^f}\right)_t + \gamma_3\left(\frac{TTrade}{GDP}\right)_t + \gamma_4\left(\frac{CA}{GDP}\right)_t + \gamma_4\ Prodty_t + \varepsilon_t \quad (3)$$

where NER represents the Nominal Exchange Rate, denotes the Domestic Interest Rate, is the Foreign interest rate, as in the Eq.(2), stands for the Consumer Price Index, as in the Eq. (1), $\frac{TTrade}{GDP}$ represents the total trade as a proxy of total trade (export and import) over Gross Domestic Product (GDP), is ratio of current account balance over GDP, and *Prodty* is Productivity measured as GDP over total population, over time.

As a general rule, the validity of co-integrating series is determined by investigating the order of the variable integration, which by definition, should be similar. One may note that an equilibrium long-run relationship exists between variables (say exchange rate and parity conditions) if the variables are integrated of the same order. Thus, two series are said to be co-integrated if they move in one direction over the long-run. One popular approach for this purpose is the Auto Regressive Distributed Lag (ARDL) with a bound test to examine the long-run and the short-run relationships among variables (Pesaran & Shin, 1997; Pesaran, Shin, & Smith, 2001). Under this approach, a number of variables with different orders of integration can also be applied.

In order to ascertain the existence of co-integration, a bound test was conducted. Using this approach, the simultaneous modelling of long-run and short-run dynamics in a conditional ARDL-ECM framework can be done. In order to verify the existence of long-run relationship, the critical values proposed by Pesaran *et al*. (2001) were used by comparing the calculated F-statistics from the pre-determined lower and upper bound measures. Finding the two series to be cointegrated in the long-run would indicate that there is error-correction (ECM) and convergence of the series in the long-run. The ECM estimate would therefore indicate the long-run dependence of the two series.

FINDINGS

In this section, the results are presented and the reasons why these results are significantly different from the published studies are discussed. The central research question is: Do relative prices *and* relative interest rates have significant impacts on nominal US$ exchange rate when controls for non-parity factors are embedded in the models applied?

Descriptive and Diagnostic Statistics

Table 2 is a summary of descriptive statistics on the variables used in this study. To confirm the order of the integration of time series, two unit root tests were conducted using the augmented Dickey-Fuller (ADF: Dickey & Fuller, 1979, 1981) and the Phillips & Perron (1988) (Henceforth PP) tests. The ADF model can be very useful in identifying higher order serial correlation in conjunction with higher order lags. The Phillips & Perron (1988) test allows for relatively weak assumptions regarding the distribution of the residuals in the equation.

TABLE 2
Descriptive statistics of the variables in the tests

Basic descriptive statistics of the variables are provided in this table. [a]'Mean' represents the average or the mean value; [b]SD represents standard deviation; [c]Skew represents skewness; [d]Kurt denotes kurtosis; [e]JB stands for Jarque-Bera test.

Quarterly Data Series	Mean[a]	SD[b]	Skew[c]	Kurt[d]	JB[e]
NER (Dependent)	0.6478	0.2312	0.3822	1.9122	15.6884
CPI	0.1812	0.2822	0.8585	1.9942	35.1404
RIFE	-0.0011	0.0112	1.7257	11.7569	786.2976
TTRADE	0.0351	0.0126	-0.0495	2.1574	6.3870
CAGDP	-0.0145	0.0180	-0.3762	1.8236	17.3051
Productivity	21,922.4	15,803.3	0.4275	1.8331	18.5710

These statistics suggest that the means of the variable are very close to zero in most cases because of data transformation, except for the variable, Productivity, which is a large value. The first two variables (Exchange rates: LNER) and the inflation (LCPI) are *ln* of the variables. The relative real interest rate is the ratio of two-country interest rates expressed as explained earlier. The non-parity variables are after standardization by GDP.

These statistics suggest that the variables are likely to be stationary. The JB tests show that one variable has issue (RIFE). Since the tests are going to be done with ARDL, this is not a problem for the reliability of the test results. The results reported in Table 3 suggest that

most of the series are integrated of order one and the degree of integration of all of the series are not identical. Examining the results in Panel B, it is observed that all the tests show stationarity of the series. The levels data are not stationary, except in the cases of interest rates (RIFE) and total trade (TTRADE). Hence, these series to be used for ARDL satisfies the necessary condition for reliable test results.

TABLE 3
Results on data transformation (unit root tests)

Table below reports the statistics on stationarity of data series. The statistics suggests that most of the data are stationary at first difference, which is judged by the respective ADF and PP tests of unit root.

	Augmented Dickey Fuller (ADF)		Phillips Perron (PP)	
Panel A	**Level**			
Variable	**Constant Without Trend**	**Constant With Trend**	**Constant Without Trend**	**Constant With Trend**
NER	-1.87	-2.26	-1.892	-2.45
	(14)	(14)	[3]	[4]
RIFE	-3.34**	-3.56**	-13.29***	-13.43***
	(14)	(14)	[10]	[10]
PPP	-1.96	-0.88	-2.20	-0.60
	(14)	(14)	[10]	[10]
TTRADE	-0.65	-4.09***	-0.58	-3.25*
	(14)	(14)	[8]	[6]
CAGDP	-1.36	-2.24	-1.40	-2.44
	(14)	(14)	[2]	[3]
Prodty	2.11	2.35	3.23	-2.47
	(14)	(14)	[9]	[8]
Panel B	**First Difference**			
NER	-11.39***	-11.38***	-12.68***	-12.65***
	(14)	(14)	[1]	[0]
RIFE	-10.84***	-10.82***	-43.85***	-43.72***
	(14)	(14)	[7]	[7]
PPP	-4.06***	-4.44***	-13.21***	-13.33***
	(14)	(14)	[11]	[10]
TTRADE	-9.26	-9.24	-10.05***	-10.23***
	(14)	(14)	[14]	[14]
CAGDP	-13.39***	-13.36***	-13.39***	-13.36***
	(1)	(1)	[1]	[1]
Prodty	-5.13***	-5.85***	-7.87***	-98.79***
	(14)	(14)	[7]	[6]

Note: *** and ** denote significant at 1% and 5% significant levels, respectively. The figure in parenthesis (…) represents optimum lag length selected based on Akaike Info Critirion. The figure in bracket […] represents the Bandwidth used in the KPSS test selected based on Newey-West Bandwidth criterion.

OLS Test Results

The first model tested is a multiple regression on the series using the dependent variable, the exchange rate, to examine its correlation with independent variables on the right-hand side. Table 4 provides a summary of the results for the set of data over the entire period of study. The OLS model is not fully appropriate because it does not take into account the distributed lag effects and the long-run effect can only be captured by alternative models such as ARDL. It is important to note that, unlike the other studies, the entry of one lag of the dependent variable is statistically significant.

TABLE 4
Ordinary least square result

Ordinary Least Square Dependent Variables = NER	Overall Sample 1960-2014	
Intercept	0.009	(0.31)
NER(-1)	0.877	(24.52)***
PPP	0.127	(3.27)***
RIFE	-0.607	(-1.89)*
TTRADE	1.864	(1.77)*
CAGDP	-0.327	(-0.84)
PRODTY	-0.0000001	(-1.55)
Observations	212	
Adjusted R-Squared	0.96	

Note: Figures in parentheses represent the t-statistics. *** Represents null hypothesis rejection at 1%; ** Represents null hypothesis rejection at 5%, and* Represents null hypothesis rejection at 10% degree of significance.

Since PPP is known to affect the dependent variable (given its stickiness), specifying the lag somewhat controls for this effect. Now, the long-run relationship of the exchange rate and the five independent (2 parity, and 3 non-parity factors) are tested. The computed F-value, the likelihood ratio and Lagrange multiplier are used for testing the long-run relationship. Pesaran, Shin and Smith (2001) provide critical values for the bound tests.

If the calculated F-statistics (F(6,186) = 3.94) reported in Table 5 is greater than the upper bound at 5 percent and 10 percent degree of significance, then we have support for the theory. These procedures satisfy (long-run) co-integrating relationship between the variables under consideration. The other parameters also affirm the model as relevant for a long-run relationship between the five independent variables on the exchange rate.

TABLE 5
Results of Bound tests

In this table, k is the number of variables; the maximum lag identified is 2; the tests identified the upper and lower bounds at three levels of significance as shown in the table.

NER = f (PPP, IFE, TTRADE, CAGDP, PRODTY)		**F-Statistic (6,186)** = 3.9359** k=5, n=55 Lag = 2	
Pesaran *et. al* (2001) Critical Value		Lower Bound I(0)	Upper Bound I(1)
	99% Level	3.41	4.68
	95% Level	2.62	3.79
	90% Level	2.26	3.35
Lagrange Multiplier Statistic		23.6585***	
Likelihood Ratio Statistic		25.1006***	

Table 6 provides a summary of the results from the ARDL tests. The model shows that the R-squared value is very high (96.38 per cent), indicating the extent to which the factors explain the variation in the exchange rate in the US; both parity factors are significant and one of the three non-parity factor is significant, while the other two are not significant.

Two parity variables (inflation from PPP and relative interest rate from IFE) were found to be significant. Note the PPP coefficient is close to -1 (-0.89) and the effect of real interest rate in the IFE is measured as 4.59. These are excellent estimates, consistent with the higher impact of IFE and lower impact of PPP on nominal exchange rate. Also note that, unlike in the prior tests, the real interest rate was used by subtracting inflation from interest rate in these tests; this helps to remove the inflation element embedded in the IFE variable. In the long run, the control variables appear to be insignificant.

Thus, with the necessary data transformation and appropriate modeling, *a full support was obtained for parity theorems (PPP and IFE) for the first time*. These results make sense as some scholars have discovered evidence of long-run relationship mostly for IFE, while only a scant number of studies (such as those on

TABLE 6
Long run Relationship and Diagnostics Tests

NER	**PPP**	**RIFE**	**TTRADE**	**CAGDP**	**PRODTY**	**Intercept**
-1.00	-0.893	4.586	-7.792	-0.160	0.000003	-0.270
	(-5.23)***	(1.95)*	(-1.09)	(-0.05)	(0.69)	(1.38)

Test	LM Version	P-Value	F-Version	P-Value
Serial Correlation	CHSQ(4) = 10.501	0.033**	(4, 197) = 2.5925	0.038**
Functionality	CHSQ(1) = 0.0009	0.976	(1, 200) = 0.0008	0.977
Normality	CHSQ(2) = 9.0478	0.011**		
Heteroskedasticity	CHSQ(1) = 3.4088	0.065**	(1, 208) = 3.4320	0.065**
	R-Squared = 0.9638		**DW-Statistic = 2.02**	

half-life; Divisia methods; long-interval data series) showed PPP to hold in the long run. The diagnostics tests provided in the Table 6 are seriously needed in order to obtain these results.

The ARDL framework has shown to be robust against any symptom of serial correlation among the residuals. Thus, it can be noted that the presence of serial correlation does *not* impact the estimators as long as our concern is about ARDL (Laurenceson & Chai, 2003). The functionality test or the stability test is supported by its critical value. The heteroskedasticity and non-normality are natural under the ARDL approach, given the fact that a combination of different orders of integration of variables is used.

The results were further tested using the error correction version of the model to provide a robustness test. Error correction estimation is presented in Table 7. This test is meant to identify the speed of adjustment for the variables on the exchange rate. Hence, this test will identify the time to revert to the equilibrium positively; the coefficient should be negative and significant.

TABLE 7
The error correction representation for the chosen ARDL model

NER	**dNER1**	**dPPP**	**dIFE**	**dTTrade**	**dCAGDP**	**dPRODTY**	**Intercept**	**ecm(-1)**
	0.171	0.124	-0.639	8.801	0.022	-0.53E-6	0.037	-0.139
	(2.49)**	(3.13)***	(-2.05)**	(3.87)***	(0.05)	(-0.69)	(1.31)	(-3.83)***
	R-Squared = 0.168							
	DW-Statistics = 2.02							

The empirical results can be based on the re-parameterization of the estimated ARDL (2, 0, 0, 1, 0, 0) model. According to this table, the lagged error-correction term (ecm) has the expected negative sign and is statistically significant at 1 percent level. Kremers, Ericsson, & Dolado (1992) found that a significant error-correction term is rather efficient in establishing cointegration between variables. The lagged differences in the model are used to capture short-term dynamics among the variables.

The long-run relationship between the exchange rate and its determinants was further verified using the CUSUM and CUSUM-squared tests (Brown, Durbin, & Evans, 1975). The aim of the tests was to check for the consistency of long-run parameters. This test was applied on the residuals of the model. The outcome of each test is in terms of plots showing the cumulative sum of recursive residuals and recursive squared residuals for a set of n observations. As a condition for the stability of the estimates, the CUSUM and CUSUM-squared should range within the 5 per cent level of significance.

Fig.1 is the plots of the respective tests. The data shown in the two figures fall within the specified range of acceptance (critical bounds), which is a requirement for this relationship to exist. Therefore,

the plots reveal evidence to support the significant relationship between exchange rates and parity as well as non-parity variables. This then confirms the existence of strong evidence to support the monetarist theorems on prices and interest rates, in our view, for the first time in one test.

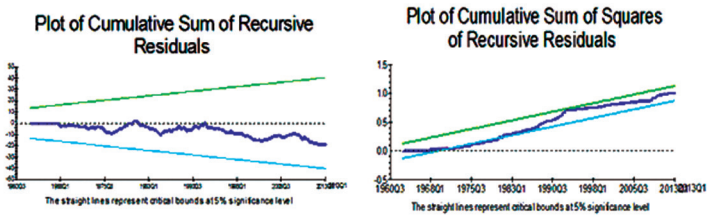

Fig.1. Plots of CUSUM and CUSUM-SQUARES values

This figure shows two plots of cumulative sum and cumulative sum of squared values of recursive residuals of the long-run relationship. The plots are within the bounds, showing there is significant relationship in the tests.

CONCLUSION

This paper conceived a novel way to re-state the often-tested parity theorems widely tested in monetary economics. There are some creative innovations in this paper. The reasons for this are: there is only a weak support to-date for these theorems, especially the price parity, despite lots of studies; and the literature suggests that a more appropriate econometric approach is needed to reveal the underlying behavior. The maintained hypotheses are that the relative prices (inflation) and relative interest rates of two trading economies are significant factors, *only* if controls for non-parity factors are embedded in a properly-specified full model with long-length time series.

The US and UK data were used since long-length data are readily available for these economies. The methods used range from OLS multiple regressions to ARDL bound testing, which in our view satisfies the long-length equilibrium for PPP already supported in some earlier studies. To understand the behavior of any local currency (for example, RM), it is pertinent to find evidence on price and interest rate differences affecting the US exchange rate.

The results reveal that both the PPP and IFE theorems are strongly supported, which is, in our view, a new finding reported in this paper to fully appreciate the idea that any price difference and interest rate differences - for example between the US and Malaysia - are likely to fully affect the US exchange rate over a long period of time. Non-parity factors as hypothesised are also significantly affecting the US exchange rate, which were used as the control factors. The econometric tests conducted in this study, in our view, have made these results reliable and robust compared to the earlier studies. Perhaps,

the research process followed in this study provides a new approach, which may be useful to study other economies to reveal if the parity theorems hold in more economies than in the United States of America.

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