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## Purchasing power parity in the Colombian exchange rate

Paridad del poder adquisitivo en el tipo de cambio colombiano

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### ABSTRACT:

**Objective:** to determine the fulfillment of the purchasing power parity (PPP) theory in Colombia, the exchange rate with the US dollar using as a standard. **Methodology:** to check if the PPP in Colombia is achieved, monthly and quarterly data was used, which ran from January 1959 to December 2015. To do this, the long-term behavior from the real exchange rate was modeled, contrasting the unit roots presence and structural changes. In addition, a bivariate cointegration model was used. **Results:** it was found that, in the case of Colombia, the PPP theory was not fulfilled, since the peso and the dollar are not cointegrated. Therefore, according to the unitary root methodology, the PPP hypothesis in Colombia for the period 1959-2015 is not validated. Everything seems to indicate that the Colombian peso has little relation with the US dollar. **Conclusions:** the use of general price indices, which include tradable goods between countries, multiple barriers to international trade, imperfect competition and social, economic, political and cultural differences between both countries are important aspects when explaining the unfulfillment of the PPP.

**KEYWORDS:** Purchasing power parity, Real exchange rate, Unitary root, Cointegration.

### RESUMEN:

**Objetivo:** determinar el cumplimiento de la teoría de la Paridad del Poder Adquisitivo (PPA) en Colombia usando como patrón el tipo de cambio con el dólar estadounidense. **Metodología:** para comprobar si se cumple la PPA en Colombia, se utilizaron datos mensuales y trimestrales que van desde enero de 1959 a diciembre de 2015. Para ello, se modelizó el comportamiento a largo plazo del tipo de cambio real, contrastando la presencia de raíces unitarias y cambios estructurales; además, se usó un modelo bivariado de cointegración. **Resultados:** se encontró que, para el caso de Colombia, no se cumplió la teoría de PPA, pues el peso y el dólar no están cointegrados. Por lo tanto, según la metodología de raíz unitaria no se valida la hipótesis de PPA en Colombia para el periodo 1959-2015. Todo parece indicar que el peso colombiano presenta poca relación con el dólar estadounidense. **Conclusiones:** el uso de índices de precios generales que incluyen bienes comercializables entre los países, las múltiples barreras al comercio internacional, la competencia imperfecta y las diferencias sociales, económicas, políticas y culturales entre los dos países, son aspectos importantes a la hora de explicar el incumplimiento de la PPA.

**PALABRAS CLAVE:** Paridad del poder adquisitivo, Tipo de cambio real, Raíz unitaria, Cointegración.

### RESUMO:

**Objetivo:** determinar o cumprimento da teoria de Paridade do Poder Aquisitivo (PPA) na Colômbia, utilizando como padrão a taxa de câmbio com o dólar norte-americano. **Metodologia:** para verificar se o PPA na Colômbia é cumprido, foram utilizados dados mensais e trimestrais, que vão de janeiro de 1959 a dezembro de 2015. Para fazer isso, o comportamento de longo prazo da taxa de câmbio real foi modelado, contrastando a presença de raízes unitárias e mudanças estruturais; Além disso, foi utilizado um modelo de cointegração bivariado. **Resultados:** constatou-se que, para o caso da Colômbia, a teoria do PPA não foi cumprida, uma

vez que o peso e o dólar não estão cointegrados. Portanto, de acordo com a metodologia de raiz unitária, a hipótese do PPA na Colômbia para o período 1959-2015 não é validada. Tudo parece indicar que o peso colombiano tem pouca relação com o dólar americano. Conclusões: o uso de índices de preços gerais que incluem bens comercializáveis entre países, as múltiplas barreiras ao comércio internacional, a concorrência imperfeita e as diferenças sociais, econômicas, políticas e culturais entre os dois países são aspectos importantes no momento de explicar o descumprimento da PPA.

**PALAVRAS-CHAVE:** Paridade do poder aquisitivo, Paridade do poder aquisitivo, Taxa de câmbio real, Raiz unitária, Cointegração.

## INTRODUCTION

The first formulations on the Purchasing Power Parity (PPP) theory date back to the sixteenth century, and then formally raised by Gustav Cassel in 1918. In addition, authors such as Dornbusch (1987), Froot and Rogoff (1995) or Rogoff (1996) performed other analyzes of the PPP theory. Cassel (1918) relies on the Law of One Price for a product that is marketed in an integrated and competitive international market (Rogoff, 1996). The Law of One Price states that in competitive markets (without transport costs or barriers to trade), identical products sold in countries must have the same price if measured in the same currency.

Purchasing power parity is one of the most appropriate measures for comparing living standards, with advantages over gross domestic product per capita, since it takes into account price variations. This indicator eliminates the monetary illusion linked to the variation of exchange rates, in such a way that an appreciation or depreciation of a currency will not change the purchasing power parity of a country, since its inhabitants receive salaries and make purchases in the same currency (Taylor, 2004).

Colombia has used different exchange rate systems to regulate the foreign currency market, from the multiple exchange rate regime for the 1932-1967 period, to the current flotation system which has been in force since 1997.

The multiple exchange rate was applied in Colombia with the fundamental objective to protect the gold holdings in the Banco de la República before the international monetary crisis, based on a temporary intervention in the foreign exchange market. From 1967, with the Decree-Law 444, a currency regime known as "crawling peg" or mini devaluations was established, in response to the dramatic devaluations and exchange imbalances that were presented with the previous system.

The Crawling Peg sought to restore the level of competitiveness in the Colombian economy. It worked the same as the fixed exchange rate system, but the difference is that under this system the exchange rate is fixed at much shorter periods. A system of mini-devaluations or "drop by drop" was adopted, where small adjustments were made every month on the fixed exchange rate, according to the monetary policy proposed by the Banco de la República.

According to Wiesner (1978), the mini-devaluations regime allowed the nominal exchange rate to be managed in such a way that it was intended to maintain an effective purchasing parity taking into account internal and external inflation, as well as subsidies and special taxes.

The 1980s was a period in which the exchange rate in Colombia was continuously devalued, due to phenomena such as the increase in international reserves held by the Banco de la República due to the high international coffee prices between 1976 and 1978, the increase in grain exports in 1978 and external public debt.

The Colombia's Constitution of 1991 granted the Banco de la República full autonomy "to maintain the currency purchasing power, (in light of this) the Issuer changed its economic policy towards a fundamental objective: the reduction of inflation" (Huertas et al., 2005). Given these new conditions and the constant shocks in the balance of payments, the reserves management to reduce inflation and preserve the fixed exchange rate become unmanageable. At this point, we opt for a more flexible system which allows us to acquire greater monetary autonomy. This is how the exchange bands system in Colombia was born, which lasted from January 1994 to September 1999.

Unlike the fixed exchange rate or crowding peg regimes, the currency band system involves setting a ceiling and a floor for the currency price, which were changed daily. Thus, the band's ceiling and the floor were moved in parallel; so that, at the end of the year, the established devaluation goal would be reached, which would correspond to the expected inflation goal.

The exchange bands system was heavily criticized by exporters because at the beginning the peso was revalued, which was a detrimental aspect for exporters. Thus, in September 1998, the band was modified in response to speculative devaluation pressures of economic agents, but, after a long period, the dollar was stuck to the ceiling. In June, 1999, the band was modified again driven by the economic crisis at the time. These repetitive exchange band variations reduced the regime's credibility.

The exchange rate system's low credibility, the government's growing fiscal deficit and the capital flow's dramatic fall all added to a massive withdrawal of capital resulting from the Asian and Russian crises, and thus led the Banco de la República to sell reserves and increase the interest rates to defend the regime. This situation became unsustainable in the face of an impending economic recession, so the Bank opted to eliminate this regime, but not before having negotiated a macroeconomic adjustment package with the IMF that would prevent a speculative attack against the Colombian peso.

In September 1999, a flexible exchange regime was adopted in which the exchange rate floats freely and is determined by market forces. This regime remains to present day. Essentially, a "dirty" exchange rate regime was adopted, which is characterized by the fact that supply and demand can interact freely while the Banco de la República can intervene in the market when it seems necessary under clear rules, pre-established by the Bank. A new structure for buying and selling currencies was established.

This paper aims to study the parity power theory in Colombia with respect to the United States between 1959 and 2015, using monthly and quarterly data periodically. The contrast of the PPP hypothesis is carried out through two methods: i) contrast the unit root hypothesis and ii) cointegration analysis proposed by Engle and Granger (1987) and Johansen (1991). Therefore, this work seeks to answer the following question:

Is the theory of the purchasing power parity in Colombia with respect to the United States during the 1959-2015 period fulfilled?

To study the PPP fulfillment is important because it allows the describing of the inconsistencies among the economic measures in different countries. The PPP is a way to analyze the differences in price levels among countries, in this case Colombia and the United States. In general terms, the PPP allows us to deduce that Colombians could buy goods in Colombia at the same price that they would buy them in the United States.

## METHODOLOGY

The fundamental idea of the purchasing power parity theory is that the value of each currency is determined by its purchasing power as the inverse of the price level and the relative value of two currencies or exchange values as the ratio of its purchasing power; that is, the PPP states that the exchange rate between two currencies will be determined by the relationship among these two economies' price levels.

Two aspects must be distinguished within the PPP concept, absolute PPP and relative PPP. The first refers to the absolute price level of a country which is expressed in monetary units from outside the country by the monetary unit from inside said country. The relative PPP refers to variations in price levels, not to their absolute level. The way to measure the variations is through the index numbers from a base period which is selected.

By defining the value of one currency in terms of another and the national ( $P$ ) and international ( $P^*$ ) price indexes, we can formulate the PPP hypothesis as:

$$E_t = P_t / P_t^*$$

1

Where  $E$  is the nominal exchange rate and  $P$  and  $P^*$  are the price levels of the countries under this study, respectively. It is clear from the previous equation that for the PPP to be fulfilled, it is required that the exchange rate be determined by the ratio between the relative prices.

If the PPP is fulfilled, it would be logical to expect that the purchasing power between the two economies will remain constant over time. Thus,  $P_t/P_t^* = k$  for everything  $i$ , then;  $E = P_t/P_t^* = k$ . Now, if it is proposed that , the real exchange rate, reflects the relative prices between the two economies measured in the same currency, it turns out that;

$$S_t = E_t * \left[ P_t / P_t^* \right]$$

2

If the value obtained by  $S$  is equal to the unit, it is said that the PPP in its absolute version is achieved.

By rearranging equation (2) and transforming its variables into logarithms, the condition of fulfillment with the PPP can be expressed as:

$$e_t = \alpha + \lambda(p_t - p_t^*) + s_t$$

3

Where  $\alpha$  is the constant that would reflect the impact of transport costs and the rigidities associated with international trade,  $e_t$ ,  $p_t$  y  $p_t^*$  are the natural logarithms of the nominal exchange rate, the national price index and the foreign country price index, respectively. By last,  $s_t$  is the real exchange rate expressed in natural logarithms.

After having the PPP concept clear, the first step to do is the PPP hypothesis validation by contrasting the stationarity of the real change type series from the ADF tests (Augmented Dickey-Fuller), Phillips-Perron and ERS (Elliot, Rothenberg, and Stock Point Optimal) [1]. In addition, the Zivot and Andrews test (1992) was applied, implemented by Trujillo (2004) in Eviews to corroborate the existence of structural break in the series studied.

Prior to the existence of a cointegration vector verification through the two-step methodology proposed by Engle and Granger (1987), the degree of the two variables integration was verified, and then the cointegration was checked. Likewise, the condition of counteraction was also verified with the methodology developed by Johansen (1991) from a model of VAR vector autoregression.

For this study, monthly and quarterly data was used, ranging from 1959:1 to 2015:12. In all cases, data came from the National Administrative Department of Statistics (DANE), the US Bureau of Labor Statistics and el Banco de la República. The variables are the nominal exchange rate (NER) expressed by the amount of Colombian currency needed to acquire a unit of US currency, the real exchange rate (RER) expressed as the nominal exchange rate adjusted because of the differences in the prices level or costs between the two countries; Colombian ( $IPC^{Col}$ ) and the United States ( $CPI^{USA}$ ) consumer price indexes. All these variables are expressed in their average values for each period and in some cases transformed to logarithms.

## RESULTS

This section contrasts the PPP fulfillment for Colombia through unit root tests and structural changes. Once the theory fulfillment is verified, a bivariate model of cointegration is used to determine if the variables used in the PPP present a relationship at some level.

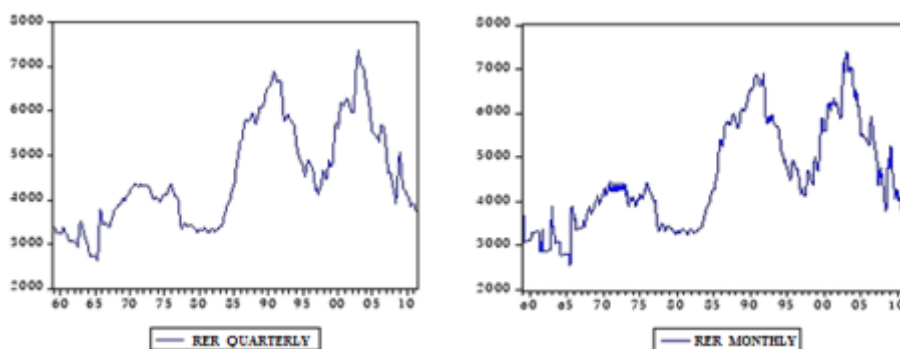
### Unit Root Analysis

The first methodology developed to test the PPP hypothesis is the unit root on the real exchange rate. Therefore, the real exchange rate was calculated based on the following formulation:

$$TCR = TCN * \left[ \frac{IPC^{EEUU}}{IPC^{Col}} \right]^{\frac{1}{4}}$$

Figure 1 shows the real exchange rate in Colombia on a quarterly and monthly basis.

Graphic 1



Colombian Real Exchange Rate 1959-2015

Source: Own elaboration

The period of this study is characterized by constant fluctuations, basically explained by the changes in the exchange rate regimes analyzed by the economic conditions in that time, especially by the economic opening in 1990.

The graph also allows one to determine if the series has intercept, trend or any time series characteristics. So, when the unit root test is performed, this is useful to establish the type of model. Clearly, the series presents intercept, but there is not enough evidence to affirm that the RER has a deterministic tendency, since the series does not seem to rotate around its average (\$ 4,535); thus concluding the pertinence of including intercept in the model.

To perform the unit root tests, the following information criteria were used: with the ADF test, the Schwarz information criterion was used. For the Phillips-Perron test the Barlett-Kernel criterion was used and Newey-West as a bandwidth selection method and finally in the ESR test, AR spectral OLS and the Schwarz information criterion were used. The results are shown in the following table.

Table 1

Period	Ho = Unit Root	t-Statistic	P-Value	Lags Number
RE R Month	Do not reject	-1.805133	0.3781	1
RE R Quarter	Do not reject	-1,81752	0.3713	3

ADF test for the Colombian RER 1959-2015



Source: Own elaboration

The augmented Dickey-Fuller (ADF) test poses as a null hypothesis that there is a unit root for a certain level of confidence (1%, 5%, or 10%). According to the above, the larger the t-statistic in the absolute value, the P-value will be smaller and will be more likely to fall below the significance level[2] which allow to reject the null hypothesis of unit root. In this case, given that the P-value is greater than 0.05, it is concluded that with the ADF unit root test, there is not enough evidence to reject the unit root null hypothesis.

Table 2

Period	Ho = Unitary Root	Adj. t-Stat	P-Value	Bandwidth
RER Month	Do not reject	-1.653432	0.4546	4
RER Quarter	Do not reject	-1.682069	0.4389	7

Phillips-Perron test for the Colombian RER 1959-2015

Source: Own elaboration

The unit root test developed by Phillips-Perron (1988) is one of the first tests to incorporate structural changes in the series over time. In the null hypothesis it is stated that it does not consider structural changes in the series of time under study. The smaller the Adj. t-Stat in absolute value, the P-value will be smaller and will have a higher probability of rejecting the null hypothesis. In this case, the P- Value for both the monthly and quarterly series is again greater than 0.05, so there is no empirical evidence to reject the null hypothesis.

Table 3

Period	Ho = Unit Root	t-Statistic	Critical Values	Lags Number
RER Month	Do not reject	5.767246	1.9900	1
			3.2600	
			4.4800	
RER Quarter	Do not reject	7.122928	1.9144	3
			3.17495	
			4.33825	

ESRS test for the Colombian RER 1959-2015

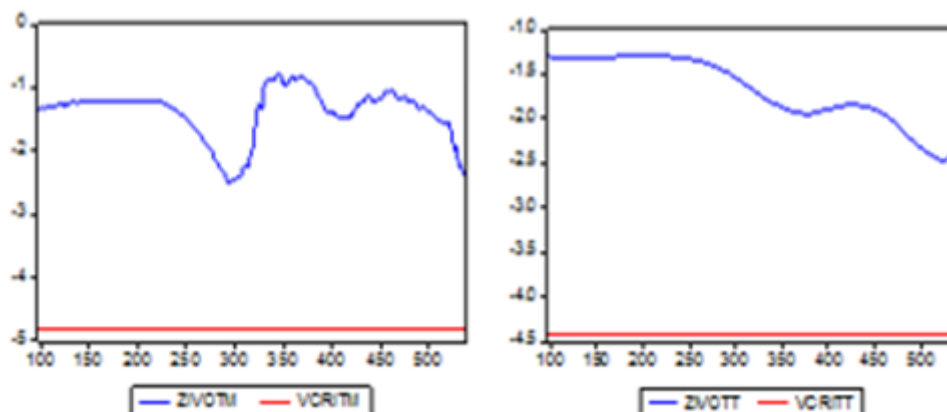
Source: Own elaboration

As seen in the three previous tables, there is no empirical evidence to reject the unit root null hypothesis (in all cases, it is clearly rejected that they are and they are proven to be , or its first difference is stationary). Therefore, using the unit root methodology, the PPP hypothesis in Colombia for the 1959-2015 period is not validated. Everything seems to indicate that the Colombian peso has little relation with the US dollar.

The results show that there is not enough evidence to diagnose deterministic trend in the RER series. In addition, there is no temporary trend[3], so it could be thought that the erratic behavior of the series may be due to a structural break at the level of the variable. This shock can be attributed to the economic opening process in the 1990s and the adoption of a foreign exchange regime. To determine if there is a structural break, the procedure described by Zivot and Andrews (1992) was implemented.

Figure 2 and 3 show the possible breaks in the trend and RER average with monthly and quarterly periodicity, respectively. It is concluded that the RER series with said periodicity does not present evidence that the structural changes considered have significant effects in the series, since the line associated with the test result applied sequentially for both the break in average (zivotm) and for the tendency break (zivott) does not cross the critical value (VCRITM, VCRITT).

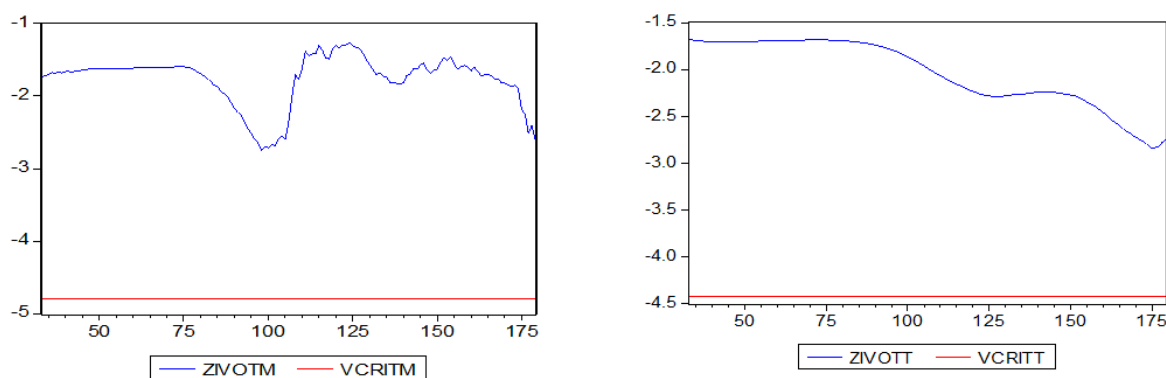
Graphic 2



TCR Structural Break Analysis of Colombia (per month)

Source: Own elaboration

Graphic 3



TCR Structural Break Analysis of Colombia (per quarter)

Source: Own elaboration

Therefore, the erratic behavior of the series is not due to structural breaks but to the characteristics of the series. It is argued that there is no empirical evidence to reject the null hypothesis of unitary root, so the previous conclusion of non-stationarity in the TCR series for Colombia is kept.

From the theoretical approach, when a series is non-stationary, it has unitary roots, thus conducting econometric analysis with non-stationary series can lead to estimating spurious regressions, since it would be concluded that the series presents a high level of correlation when the opposite could happen. To avoid this problem, the cointegration analysis is used when the series is non-stationary.

## Cointegration analysis

Prior to the verification of the cointegration condition of the variables, it is necessary to identify the order of integration of the series to be studied, the nominal exchange rate (TCN) and the difference between Colombia CPI and the US CPI (IPC\_COL\_USA). If the series is stationary OLS can be applied without prejudice to the estimated coefficients, otherwise it should be checked that the series has the same order of integration and then verify if there is at least a long-term cointegration relationship between the variables.



The results of the unit root tests ADF, Phillips-Perron and ERS for the series of equation (3) are shown in table 4. If the series presents the same order of integration, it can be expected that the combination of these will be stationary, if this happens, there would be a cointegration vector between the series.

Table 4

Series	ADF		Phillips-Perron		ERS	
	Levels	Prim. Dif.	Levels	Prim. Dif.	Levels	Prim. Dif.
TCN Month	-0.1768	-15.4127 ***	-0.2144	-15.8773 ***	67.2996	0.1199 ***
TCN Quarter	-0.2801	-9.8025 ***	-0.3311	-9.0532 ***	63.7894	0.1767 ***
IPC_COL_USA Month	-1.5745	-14.1038 ***	-1.4191	-14.3992 ***	613.1231	0.1404 ***
IPC_COL_USA Quarter	-1.1348	-2.9150 **	-1.2489	-9.5019 ***	103.2	2.5274 **

Test of Unitary Root of TCN and IPC\_COL\_USA of Colombia

Source: Own elaboration \* Significant at 10%, \*\* Significant at 5%, \*\*\* Significant at 1%.

According to these results, it can be accepted that all series are integrated in order 1, since the cointegration condition between the series requires that the series be integrated in the same order and the difference resulting from the linear combination between them produces a stationary series, thus, the procedure can be advanced to determine if there is a cointegration relationship in the presented model of equation (3).

For this, the two-stage technique developed by Engle and Granger (1987) was used on the formulation (3), whose econometric estimation is expressed as follows:

Where is the nominal exchange rate expressed in Napierian logarithm, is the difference between the logarithms of consumer price indices between Colombia and the United States[4], and are the residuals of the regression expected to be a white noise series, expressing in this case the logarithm of the real exchange rate.

The results of the estimation are presented below.

Periodicity	N. Obs.	Coefficient		Standard Error		Prob.	
		C	$\Lambda$	C	$\Lambda$	C	$\Lambda$
Monthly	672	8.689215	1.090532	0.014569	0.00377	0	0.000
Quarterly	224	8.689177	1.08987	0.025006	0.006462	0	0.000

Table 5

Engle and Granger Model Estimation

Source: Own elaboration

In order to verify the cointegration condition of the variables, a unit root test must be performed on the estimated residuals of the regression. If the residuals are, it is verified that according to the methodology of Engle and Granger, there is a relationship of cointegration between the Nominal Exchange Rate and the differences in the price indices of Colombia and the United States. The Augmented Dickey-Fuller test was used for this purpose (since in unit root tests on the residuals of a regression it is not appropriate to include trend or intercept). The results are presented below.

Table 6

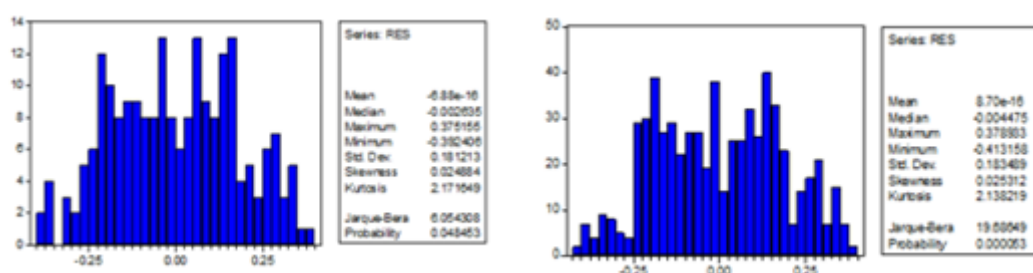
Periodicity	t-Statistic ADF	Critical value at 5% <sup>5</sup>	Bandwidth	Jarque- Bera	Mean
Per month	-2.404838	-3,350	3	6.054308	-7.33e-16
Per quarter	-1,877273	-3,368	1	19.68649	7.78e-16

ADF Test of the residuals of Engle and Granger Model

Source: Own elaboration \* Significant at 10%, \*\* Significant at 5%, \*\*\* Significant at 1%.

The empirical values obtained (-2,404 monthly, and -1,877 quarterly) of the ADF test on the residuals of the regression, contrasted with the value of -3.35 and -3.36 for monthly and quarterly cases respectively, do not allow the rejection of the null hypothesis of unit root in the residuals, that is, they confirm the non-stationarity character of the cointegration relationship. Therefore, residuals are not , so there is no cointegration relationship between the nominal exchange rate and differences in price indices of Colombia and the United States.

Graphic 4

Monthly and quarterly normality of residuals  
Source: Own elaboration

The Jarque-Bera test analyzes the relationship between the coefficients of asymmetry and kurtosis of the residuals of the equation and those corresponding to those of a normal distribution, such that if these relationships are amply different, the null hypothesis of normality would be rejected. Based on the Jarque-Bera values, the normality of residuals is not verified, therefore, it is concluded that they do not behave in a normal way. "The exact normality of OLS estimators hinges crucially on the normality of the distribution of the error, , in the population.

If errors came from random samples of a different distribution to a normal one, they would not be distributed as normal; this means that statisticians would not have distributions, and this is a serious problem. These results allow us to conclude that the estimators are not efficient and it can not be said that their sample distribution is normal; therefore, the estimation of the variation of the model is affected. In any case, the null hypothesis of residuals as zero, an important requirement to verify PPA condition, could not be accepted.

In order to verify the cointegration of the series, the methodology implemented by Johansen (1991) was used to verify the number and probable existence of any cointegration parameter. The first step was to estimate the VAR model taking as endogenous variables the integrated series of order (1) (Nominal exchange rate and the difference between the CPI of Colombia and the United States) and endogenous variables being the constant, to calculate the ordered from the origin.

The literature suggests that when working with quarterly data, it should take 4 to 6 delays; therefore, the number of Lag Intervals for Endogeneous used is 1 to 6, meaning 6 delays, ranging from 1 to 6. For

monthly data, 16 delays were taken. Estimations from VAR determined the Lag Order Selection Criteria under the Schwarz and Hannan-Quinn criteria for the quarterly data (5 lags) and sequential modified LR, final prediction error and Akaike for the monthly data (19 lags).

The next step was to perform Johansen cointegration test for all types of models and with the number of lags established to determine the number of cointegration relationships between the series.

Table 7

MONTHLY DATA					
Data					
Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	0	0	0	0	0
Max-Eig	0	0	0	0	0
* Critical values based on MacKinnon-Haug-Michelis (1999)					
QUARTERLY DATA					
Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	0	0	0	0	0
Max-Eig	0	0	0	0	0
* Critical values based on MacKinnon-Haug-Michelis (1999)					

Johansen's Cointegration Test  
Source: Own elaboration

The results show that there is no long-term cointegration relationship between Colombia's nominal exchange rate variables and the difference in consumer price index between Colombia and the United States, both series expressed in logarithms. This implies that the hypothesis of PPA for Colombia in the period 1959-2015 is not valid. These results confirm what was found with the unit root method and the methodology of Engle and Granger (1987). In the following section, some reasons support why the theory of purchasing power between Colombia and the United States during the referenced period was not met.

## Non-compliance of PPA

Non-compliance of PPA in Colombia for the estimated period does not mean that the work is lost. Literature supports many reasons why the PPP hypothesis is not validated.

Balassa (1964) and Samuelson (1964) independently explained the lower relative price of non-tradable goods in poor countries, which is known as the "Balassa-Samuelson model". Basically, this model highlights the difference in productivity between the sectors of tradable and non-tradable goods in different countries and their effect on real exchange rates.

These authors stated that labor productivity is higher in rich countries than in poor ones, marking a difference in productivity especially in marketable goods, while wages are presumed equal in sector of tradable goods and non-tradable goods, which is positively correlated to productivity. Although wages are the same in the two industries in each of the two economies, the productivity is higher in the tradable goods sector of rich economy other than in the poor country, it raises wages in sector of non-tradable goods, although it is not more efficient than the poor country in this sector; therefore, when exchange rate is used to measure prices of non-tradable goods, these are higher in developed countries than in developing countries (Waiter, 1994).

The choice of the appropriate index to prove compliance with the PPA has generated abundant literature on the topic. Hakkio (1984) argues that PPP can fail in the presence of real disturbances if aggregate indices are used instead of an index of marketable products, since domestic and foreign goods can be imperfect substitutes, so a real disturbance can change the relative demand of these products, demanding a change in the real exchange rate. Some authors consider that the use of the CPI to measure PPA may introduce a bias and its use is not recommended (Thygesen, 1978).

According to Cassel (1918), one of the necessary conditions for compliance with the absolute PPA was the absence of barriers to free trade and transportation costs; however, it is evident that both exist and that trade restrictions have been changing over the years, it has been difficult to measure due to lower transparency, but significantly affecting international exchanges (Camarero, 1994). Thus, explaining why among neighboring countries with high trade, traditionally, have obtained better results. The United States is Colombia's main trading partner, despite Colombia not being the main trading partner of The United States. Furthermore, the geographical distance is also a factor against PPA: transportation costs, consumer culture and other social, economic and political aspects, favor the compliance with the PPA.

Frenkel (1981) received interesting results when comparing the most important European countries with the United States; for example, that PPP is more frequently between geographically close countries with a high level of exchanges. Miller (1984) also attributes the best results among European countries to the lower transport costs between them and, especially, to the institutional element constituted by the European Economic Community, with the consequent greater commercial, financial and monetary integration.

Another reason for non-compliance with PPA is based on the use of the dollar as reference currency. It is demonstrated in numerous studies on the subject. Trozano (1992) compares PPA with several econometric methods finding no differences between them: the tests where dollar participates get worse results than those of other currencies, such as the European currencies or the Yen.

The PPA is based on the comparison of the same baskets of products in two countries; hence, an important problem, from the statistical point of view, is that each country assigns different weights to different categories of goods and services when preparing the price indices (Waiter, 1994).

According to Dornbusch (1976) in a world in which capital markets are highly integrated and goods markets show slow adjustments in prices, there are substantial deviations from the exchange rates with respect to the PPA. The basic idea of the overshooting model is that, in the short term, the prices of goods, both in the domestic economy and abroad, can be considered fixed, while the exchange rate quickly adjusts to the new information available and changes in economic policy. In that case, the variations in the exchange rate can be substantial and move away from the PPP for extended periods of time. According to Frenkel (1981), exchange rates and price levels are not comparable. The exchange rate can be considered the price of an asset, on which expectations about the future decisively influence, which reflects high volatility of the exchange rates in times of uncertainty.

## CONCLUSIONS

In this paper, the hypothesis of the Purchasing Power Parity between the Colombian and American economies was tested, with monthly and quarterly series for the period between January 1959 and December

2015. Based on the most relevant literature on the subject, PPA was tested using two methodologies, contrasting the presence of unit roots and structural changes, and a bivariate cointegration econometric model.

It was found that, through the unit root test, the real exchange rate is not stationary; therefore, compliance with the PPA is not validated under this methodology.

The use of a bivariate model of Cointegration, it was possible to verify that the series are by means of ADF test (Augmented Dickey-Fuller), Phillips-Perron and ERS (Elliot, Rothenberg, and Stock Point Optimal). Next, the possibility of cointegration was analyzed using the two-step methodology of Engle and Granger (1987), with which it was verified that the residual is not stationary, and also lack of normality, so it was possible to verify the non-compliance of PPA. In addition, the methodology developed by Johansen was implemented using a VAR model, with which it was found that there is no cointegration relationship between the variables analyzed.

Therefore, and according to the results of the two methodologies implemented, it is concluded that compliance with the hypothesis of PPA for the Colombian economy in relation to the US economy for the period studied is not accepted.

There are many reasons for non-compliance with PPA, but the literature especially highlights the use of general price indices that include marketable and non-commercial goods, the multiple barriers to international trade and imperfect competition contradict the assumptions necessary for compliance with PPA, as well as social, economic, political and cultural differences between the two countries.

Finally, from the statistical point of view, it is concluded that each country assigns different weights to different categories of goods and services when preparing price indexes, depending on consumer preferences, that greatly vary between Colombia and the United States solely because the latter is a developed country.

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## NOTES

- [1] The ERS test is based on the Dickey-Fuller version estimated from generalized least squares.
- [2] The significance levels range from 1% to 10%. Most theorists agree that a 5% level of significance is adequate.
- [3] Because the figures do not show any trending behavior over time.
- [4] The variables are expressed in logarithms since this transformation aligns relationships that simplify calculations and conclusions.
- [5] The critical values for comparison are those obtained from Enders (2010, p. 490 table c) with a significance level of 5% for a sample of 500 and 200 data respectively.