An Empirical Test of Purchasing Power Parity Theory for Euro and US Dollar vs the Algerian Exchange Rate

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Abstract: The goal of this study is to examine the existence of Purchasing Power Parity (PPP) between the Euro and US dollar against the official as well as the black market exchange rate of the Algerian dinar, through an empirical study covering various stages such as unit-root test, The Johansen cointegration test, CUSUM and CUSUMSQ tests, the impulse responses and variance decomposition, applied to monthly data for the period 2003 M1 – 2015M5. Results suggest that the administrated official exchange rate is not suitable to support the purchasing power parity (PPP) hypothesis. However, there is strong evidence that Black market exchange rate presents long-run purchasing power parity, suggesting that there is long run relationship between black market exchange rate and relative prices in domestic and foreign markets. The use of black market exchange rate, which represents real equilibrium for market forces rather than the official exchange rate, might reflect the puzzling role of the exchange rate policy to maintain stable purchasing power parity (PPP) in Algeria.

Keywords: Cointegration, Purchasing Power Parity (PPP), Official and Black Market, Exchange Rates.

Jel Classification Codes : C22, F31.

I- Introduction:

The Euro and the US dollar are the major currencies used in the actual International monetary systems. As the Algerian economy is highly vulnerable to Euro and US dollar fluctuations, we shall investigate, in this paper, the PPP concept of these major currencies against the Algerian dinar .

As far as the Algerian exchange rate is concerned, the central bank adopted, since 1996, a managed floating exchange rate after a long experience with the former regime (1974-1995)* that was built upon a strong concentration of the US dollar that played an important role due to its 98% in hydrocarbon export receipts(kamel et al 2015). Purchasing power parity (PPP) is a ratio used to allow for equality between relative prices for two countries with their own moneys. However, as the PPP uses the official exchange rate and relative prices in developed countries, it has been rejected in most emerging and less developed countries, on the basis of the existence of a strong black market exchange rate. Moreover, the use of black market exchange rate data in testing Algeria's PPP is slightly explored in the existing literature review.

The rest of the paper is organized as follows. After a presentation of a literature review in section 2, we shall highlight in section 3 an overview of the Algerian case. Section 4 and 5 presents empirical results of PPP using respectively the official and black market exchange rates. Finally, section 6 contains the main conclusion of the use of wholesale prices.

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I-1- Literature Review:

The early empirical studies have examined for many decades the concept of purchasing power parity (PPP) for major currencies using least square method and testing some elasticity coefficients on domestic and foreign prices: Gilbert and Kravis (1954)[1], Frankel (1981)[2], Kravis and Lipsey (1978)[3], Adler and Lehmann (1983)[4], Cumby and Obstfeld (1984)[5].

Most classical econometric estimations as least square method (GLS) based on non-stationary time series produce spurious regression and statistics may simply indicate only correlated trends rather than a true relationship. Augmented Dickey-Fuller (1981)[6] and Philips and Perron, (1988)[7] tests can help avoid false results through stationary test of times series .

On this basis, several empirical studies introduce dynamics in the PPP estimated equation. Meese and Rogoff (1988)[8], Abuaf and Jorian (1990)[9], draw unit-root test upon non stationary time series. Their results do not support PPP of the major currencies in the long-run .

Taylor (1988)[10] used a Johansen cointegration (1988) to arrive at the conclusion that there is no relationship between prices and exchange rate. On the contrary, Baillie and Selover (1987)[11], Patel (1990)[12] used Engel-Granger cointegration technique to confirm the evidence of purchasing power parity. They pointed out in their results an unfavourable evidence to PPP theory during the after 1971 period considered as a floating period after the Nixon shock.

Cheung and lai (1993)[13] examined long-run purchasing power parity using a fractional cointegration analysis for the period 1914-1989. Their results supported PPP as a long-run phenomenon. Johnson (1993)[14] detected a strong and long-run U.S.-Canada PPP concept.

Philip A. Shively (2001) confirmed the evidence of purchasing power parity in small-sample from annual data spanning 1973 through 1997 over Nominal exchange rates for Canada, France, Italy, Japan, Switzerland and the United Kingdom relatively to U.S. dollar .

On the other hand, Rogoff (1996)[15] highlighted a Purchasing Power Parity Puzzle through his examination of the PPP theory that does not hold between developed and developing countries. Using monthly data from the post-Bretton Woods era for G-10 countries, Haug and Besher (2007)[16] found mixed results for non–linear as well as linear cointegration in the PPP model .

Hussein Al-Zyoud (2015)[17] examined but did not validate the long run movement between Canadian dollar and US dollar exchange rates upon monthly data for the period 1995 M01 to 2008 M08 using the Engle-Granger cointegration test. Other studies used a panel model such as Pedroni (2001)[18] that indicated mixed evidence of PPP based on panel unit root tests. He illustrated the existence of weak PPP but rejected the strong PPP concept .

More recently, Robertson et al (2014) used panel cointegration technique of monthly data from 1982:1 to 2010:2 to investigate the Purchasing Power Parity (PPP) between the US and Mexico. Their results argue in favor of the existence of weak-form as well as strong- PPP form between Mexico and the US.

Numbers of early studies have proved the nonlinearity of exchange rate and PPP concept (see Diebold 1991, Schinasi and Swamy 1989, Engle and Hamilton 1990, Diebold and Nason 1990, Taylor and Peel (2000)).

Recently, Enders and Pascalau (2015)[19] used STAR model for monthly data over the period January 1975 to December 2013 for real exchange rates forecasting of various OECD countries. They found a nonlinear nature of exchange rates, considering that a nonlinear model clearly outperforms a linear one in terms of multi-step-ahead forecasting accuracy .

Paya and Peel (2009)[20] highlighted the nonlinear modeling and forecasting of the dollar-sterling real exchange rate using a long span of data.

Upon monthly data of ASEAN-5 countries plus Japan from the period between January 1977 and the end of March 2006, Khim-Sen Liew et al (2008) pointed out in their study using STAR model, a nonlinear relationship of nominal exchange rate with the monetary fundamentals represented by Consumer Price Index (CPI), M2 and Gross Domestic Product (GDP).

Mikek and Kavkler (2008) [21] Applied for Slovenia and Slovakia a nonlinear framework with a multivariate Smooth Transition Vector Error Correction Model (STVAR methodology) using monthly data for the period 1999-2000 and succeeded to compute the nonlinear dynamics of the real exchange rate. In the same way, Liew et al. (2003) suggested through their empirical study, the importance of nonlinearity for nominal exchange rate in the ASEAN-5 countries using smooth transition autoregressive (STAR) model.

Sarno and Taylor (2002) documented the nonlinear relationship between purchasing rates of 10 major industrial countries using smooth transition autoregressive (STAR). Their results allowed to rejected exchange rate linearity for eight exchange rates.

Lothian and Taylor (1996)[22] used STAR model of monthly data over the period January 1975 to December 2013 in order to prove the nonlinearity of real exchange rate .

Finally, in emerging and less developed countries, the official exchange rate failed to support the PPP concept. Bahmani-Oskooee (1993a) conducts a test of PPP for Iran (1973-86) by using both the official and the black market exchange rate. He found empirical support for PPP only via the black market exchange rate.

Furthermore, many empirical studies investigated the relative version of PPP, Sakka and McNabb (1994) for Egypt (1958-87), Sanchez-Fung (1999) for the Dominican Republic. They found support, using cointegration technique, for the relative version of PPP using the black market exchange rate.

Agenor & Taylor (1993)[23] investigated the causal relationship between official and parallel exchange rates using cointegration and Granger-causality tests over monthly data covering a 13-year period for 19 developing countries. They suggested that a cointegration relationship is not clearly detected. Baghestani H. (1997) study examined the PPP concept between India and some developing countries using official and parallel exchange rates The results show that the official and black market exchange rate respond to correct departures from their own equilibrium relationship.

Bahmani-o and Goswami (2005)[24] investigated the purchasing power parity (PPP) evidence through an empirical analysis using a Johansen-Juselius cointegration technique over monthly data from eight developing Asian countries over a thirty-one-year period. Their Results show that a cointegration relationship is not detected.

Aslan and Kula (2010) supported the existence of long-run purchasing power parity (PPP) hypothesis in Turkey by using the black market and official exchange rate .
Cerrato & Sarantis (2007) examined the purchasing power parity (PPP) hypothesis via the black arket rate for 34 emerging market economies using a panel cointegration of monthly data. They provide strong evidence of PPP for both individual countries and the full panel.

Bahmani-Oskooee et al (2013) [25] used The Sequential Panel Selection Method (SPSM) by examining the purchasing power parity (PPP) hypothesis to arrive at the conclusion that there a strong evidence for the long-run validity of PPP for a group of BRICS (Brazil, Russia, India, China, and South Africa) and MIST (Mexico, Indonesia, South Korea and Turkey) countries, using monthly real effective exchange rate (REER) data from January 1994 to June 2012.

I-2- Overview of the Algerian case:

As far as the Algerian exchange rate is concerned, the central bank adopted, since 1996, a managed floating exchange rate after a long experience with the former regime (1974-1995)** that was built upon a strong concentration of the US dollar that played an important role due to its 98% in hydrocarbon export receipts(kamel et al 2015)[26].

Between 2004 and 2014, this sector accounted for 35% to 45% of GDP and 46% to 70% of government revenue, while trade openness exhibited a high figure of 60% during the same period, (see Table 1). US dollar is not the only dominate currency used in the Algerian trade; the euro is Algeria's largest trading currency as far as imports are concerned. The Algerian imports mostly from The European Union are made in Euros, which account for more than 50 percent of total imports, while Total trade between the EU and Algeria amounted to €52.76 billion in 2014, see Table 02.

Despite the launch during the 1990s of pertinent economic reforms and the implementation of structural Adjustment Program, which was adopted by the Algerian government in cooperation with the International Monetary Fund (FMI) and the World Bank, the Bank of Algeria could not avoid a nominal devaluation of the Dinar for about 78 per cent in1994. The US Dollar increased from nine Algerian Dinars in 1990 to 35 in 1994 and 47 dollar a year later.

In addition, the nominal exchange rate index increased to 2 and 8 percent for nominal and real exchange rate respectively during 1997-1999.

Between January 2003 and January 2013, the Algerian exchange rate varied continuously; from January 2003 to September 2008, the U.S dollar depreciated monthly against the Algerian Dinar by about 19%, followed by a depreciation of 6% during the financial crisis. Between January 2010 and January 2013, the Algerian dinar depreciated against the U.S. dollar by 4.2%. see Kamel et al (2015)[27]

In this context, Price stability which remains a great challenge for the bank of Algeria has shown a satisfying trend for the Algerian economy and the consumer purchasing power. In fact, the first half of the 1970's is characterized by the continuing stability of the Algerian inflation rate oscillating between 3 to 6%. However from 1975 to 1988, inflation registered high trend with an average annual rate of 9.96%. This peak can be explained by two main reasons: firstly, the implementation of a new Algerian exchange rate regime based upon a basket of 14 currencies instead of the strict begs, secondly, the dominance of food products that contributed up to 50% to the total increase in imports due to the expansion of trade openness.

The average increase of the CPI turned around 18.55% in the 90's, whilst in the 20's it witnessed its lowest average at 3.2%. From the beginning of the second decade of the new millennium, inflation rates increased to ranges between 6 to 8.5% to such an extent that it has become necessary for policy makers to grasp inflation trends with their uncertainties. See figure N.01.

II. Methodology and Results of the PPP hypothesis using the administrated official exchange rate:

II-1- Data source:

In our analysis, we make use of four macroeconomic variables representing the relationship between the exchange rate and consumer price indices for the U.S. and European countries. These two categories of nations are the major trading partners of Algeria whose currencies represent about 85 of Algerian official transactions managed through the Algerian official exchange rate.

To test purchasing power parity in Algeria, let P, P* and P** represent the domestic price and the foreign prices in USA and euro area respectively. We use nominal exchange rates series for U.S. Dollar /Algerian dinar and Euro/Algerian dinar. The sample of each equation comprises 149 monthly observations for the period 2003 M1 – 2015M5 collected from different issues of the IMF's International Financial Statistics and World Development Indicators.

II-2- Model Definition:

$$LnE = a + b\ Ln\ P, + c\ Ln/P^* \ldots\ldots(1)$$

$$LnE^* = a + b\ Ln\ P, + c\ Ln/P^{**} \ldots(2)$$

Where:

P is CPI in Algeria (Domestic price index)
P* is CPI in USA (Foreign price index)
P** is CPI in Euro area (Foreign price index)
E is U.S. Dollar /Algerian dinar
E* is Euro /Algerian dinar
C. Stationarity tests

Augmented Dickey-Fuller (1979, 1981) and Philips and Perron, (1988) tests can help avoid false results through stationary test of times series. Results drawn from stationary tests represented in table 3 allow a rejection of the null hypothesis in first difference that signify no stationary in all series, but enable an acceptation at a level, that signify integration of the variables at order 1.

II-3- Analysis of co-integration tests:

In order to explain that nominal exchange rates and consumer price indices are integrated in first difference, Johansen cointegration approach (Johansen, 1988; Johansen and Juselius, 1990) develops two statistical tests : Trace statistics ((λ trace) and maximum Eigen value statistic (λ max). The results of trace and Max-Eigen value tests indicate that there is no long or short run relationships between the exchange rates and relative prices in Algeria, United States and European countries (no cointegration at the 0.05 level, (see

Tables 4); this implies that purchasing power parity in Algeria does not hold and is not a suitable variable to support the purchasing power parity (PPP) concept in the Algerian case.

III. Results of the PPP hypothesis using the black market exchange rate:

As previously mentioned in the literature review (see section II), the black market exchange rate is a better indicator for market forces and has been verified in several emerging economies and less developed countries (See more Baghestani (1997), Bahmani-Oskooee (1993), Aslan and kula (2007), Hassanain, (2005)). The rise of black market exchange rate in Algeria goes back to the beginning of seventies (see figure N.02; official and black market exchange rates, figure.03; Premium exchange rate). During the last three decades, it can be seen clearly that around 40% of business transactions have been carried out through the black market in informal sector where the gap between the official exchange rate of the Algerian Dinar against the Euro and the rate observed in the black market has exceeded 40% Bouteldja A et al (2013)[28]. This discrepancy may be attributed to three main reasons: First, the foreign currency liquidity flows in cash out of the banking circulation system increased from 24, 32, 40 billion euro during 2010, 2012, 2014 respectively. Second, the central bank is no yet since 1996 opened an authorized currency bureau for keeping the official intervention in the foreign exchange market works legally, thus, lets the people prefer the informal market channel and increased the demand for black-market money. Finally, electronic banking payment and information systems security is not yet a useful tool for removing constraints instead provides a ways to identify client requirement with more generalization an unbilled transactions in the black market.

Consequently, we re-examined the long-run PPP hypothesis in Algeria using black market exchange rate upon 113 quarterly data for the period 1975– 2003 .

As previously mentioned, establishing cointegration is not enough to support

PPP. We need to establish that the relation between price levels and the exchange rate follows the formulation by PPP, which are an exchange rate equation and not a price equation.

III-1- Stationary tests:

Results drawn from stationary tests represented in table (5) with Augmented Dickey-Fuller (1979, 1981) [33] and Philips and Perron, (1988) [34] tests allow a rejection of the null hypothesis of a unit root at the 5% level of all variables in first difference, that signify no stationary in all series, but enable an acceptation at a level, that signify integration of the variables at order 1.

III-2- Analysis of co-integration tests:

In this section, we adopted the same analysis based upon Johansen cointegration approach (Johansen, 1988; Johansen and Juselius, 1990[29]) with two statistical tests: Trace statistics ((λ trace) and maximum Eigen value statistic (λ max). The results for Trace and Max-Eigen value tests allow establishing two long run cointegration relationships for black market exchange rates see, Table N.6.

III-3- CUSUM and CUSUMSQ Test:

The validity of PPP hypothesis using cointegration techniques requires consistently checking for the stability of the relationship on the basis of the error correction model.

Following (Bahmani Oskooee and Shin (2002), Bahmani-Oskooee and Oswami (2005)), we put:

$$\Delta \ln Bext = a + \sum B_j \Delta \ln Bex_{t-1} + \sum C_j \Delta \ln P_{t-1} + \sum D_j \Delta \ln P^*_{t-1} + \lambda EC_{t-1} + \varepsilon i \quad .....(3)$$

Results show a significant and negative ECM t-1 coefficient in equation 3. The CUSUM (cumulative sum) and CUSUMSQ (CUSUM squared) tests are then introduced to check for the stability of the relationship in the short run dynamics within a long run equilibrium.

The coefficients plots stay within the critical bounds at 5 percent significance level, implying that the relationship is stable in short-and long-run when the black market exchange rate is used see figures N.04, N.05.

III-4- Short and long- run Error coefficients of the Correction Model:

The empirical results presented in table N.7 show through some elasticity that 1% change in domestic price index leads to a weekly rise of 5% in black market exchange rate in the long-run; and 1% increase in foreign price index leads to 11% increase of the black market exchange rate in the long-run. The short- run estimated elasticity of the same variables has a mixed impact on the black market exchange rate in Algeria. In addition to that, 1% increase in consumer price indices for Algeria and USA respectively leads to 0.67 with -2.3 % in the first lag, and 0.33 with -2.41 % in the second lag of the black market exchange rate.

III-5- Efficiency of the model:

In table N.8, an econometric diagnostic tests is computed in order to exhibit the presence or absence of any serial correlation. Thus, Breusch-Godfrey Serial Correlation LM Test exhibits some coefficients for the existence of serial correlation. In addition, the same results can be highlighted through the arch absence, see table N.9. Finally, the Jarque-Bera test for normality is significant, meaning that the residual is not normally distributed, see figure N.07.

IV- Conclusion:

In this paper, we investigated the Purchasing Power Parity (PPP) in Algeria using the US dollar and Euro against the administrated official and black market exchange rates of the Algerian dinar exchange rate through an empirical analysis applied at various stages: unit-root test, The Johansen cointegration, CUSUM and CUSUMSQ tests, the impulse responses and decomposing variance. However, the estimation of a cointegration test establishes a long run relationship between black market exchange rate and relative price, but it did not exhibit a significant relationship when using official exchange rate. Moreover, our examination of the exchange rate pass-through on Algerian producer and consumer price indices showed a negligible reaction on producer price index (PPI).

- Appendices :

Table (1): GDP & government revenues dependency on oil

	2004	2005	2006	2007	2008	2009	2011	2012	2013**	2014**
GDP (billions of dollars)	85	103	117	135	171	137	199	204	210	227
Share of oil in GDP (%)	35,5	45	45,4	43,3	45,4	31,6	39	31,7	34	36
Government expenditure (billions of dollars)	44,4	46,1	50,8	57,6	73,9	67,4	81	91,4	100	111
Trade Openness (%)	58,1	64,8	64,9	64,6	69,4	60,2	71	53,9	64	64,8

Source:* IMF Country Report of Algeria from 2004-2012.

**Statistics Algeria, The ministry of Finance: http://www.mf.gov.dz/rubriques/15/Activités.html

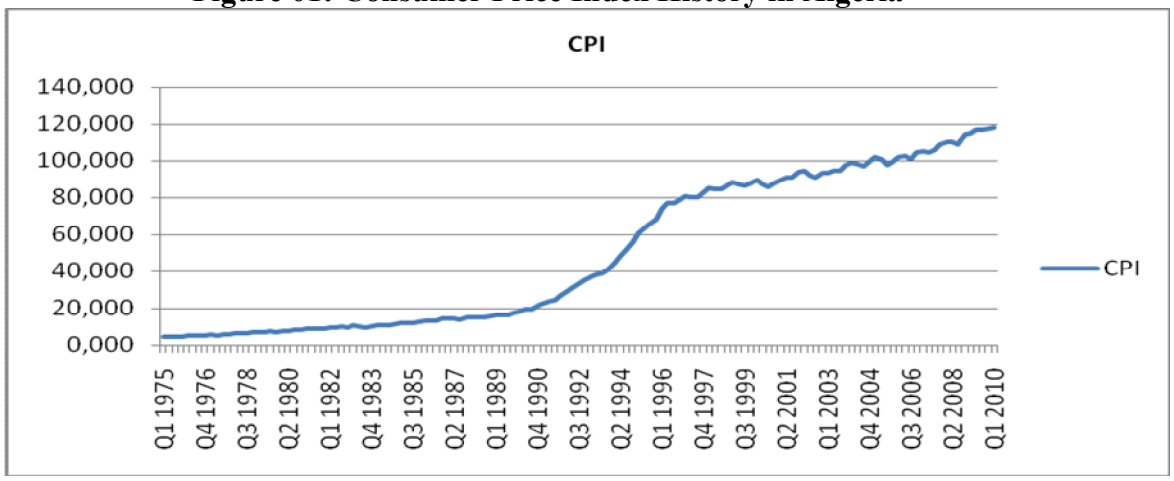
Table 02: Trade in goods 2012-2014, € billions

Year	EU* imports	EU* exports	Balance
2012	33	21	-11
2013	32	22	-10
2014	30	24	-6

Source: Indicator Source IMF (World Economic Outlook)

EU concerns the European Union of 28 members for all indicated years

Figure 01: Consumer Price Index History in Algeria



Source: IMF

Table 3: ADF and PP Unit Root Tests

Variables	Augmented Dickey Fuller (ADF)			
	Level		First difference	
	intercept	Trend and intercept	intercept	Trend and intercept
Ln Euro/ DZ	-1.80	-1.95	-9.96***	-9.98***
Ln US dollar/ DZ	-0.09	-1.30	-9.2***	-9.59***
Ln CPI in Algeria	0.9	-1.54	-9.47***	-9.55***
Ln CPI in Euro area	-1.68	-1.44	2.95*	3.75***
Ln CPI in USA	-1.37	-2.058	7.835***	7.90***
	Philips Perron PP			
Ln Euro/ DZ	-2.09	-2.75	-9.8***	-9.78***
Ln US dollar/ DZ	-0.41	-1.43	-	-10.56***
Ln CPI in Algeria	0.6	-1.78	10.26***	11.98***
Ln CPI in Euro area	-1.48	-1.05	11.18***	8.98***
Ln CPI in USA	-1.63	-2.15	8.95***	5.55***
			5.88***	

- *show values are significant at 5 % level with MacKinnon (1996).
- **show values are significant at 1% level with MacKinnon (1996).
- ***show values are significant at 5 % and 1 level with MacKinnon (1996).

Table 4: The Johansen Cointegration test results

Hypotheses of cointegration equation	PPP between Algeria and USA		PPP between Algeria and Euro Area	
	Trace Test	Max-Eigen Test.	Trace Test	Max-Eigen Test.
None	28.44788 (0.0709)	15.49976 (0.2554)	0.097444 (0.3319)	0.097444 (0.3058)
At most 1	12.94812 (0.1167)	11.11017 (0.1488)	0.044084 (0.6177)	0.044084 (0.5509)
At most 2	1.837950 (0.1752)	1.837950 (0.1752)	0.001152 (0.6837)	0.001152 (0.6837)

** denotes rejection of the hypothesis at the 0.05 leve*

Figure 02: official and black market exchange rates

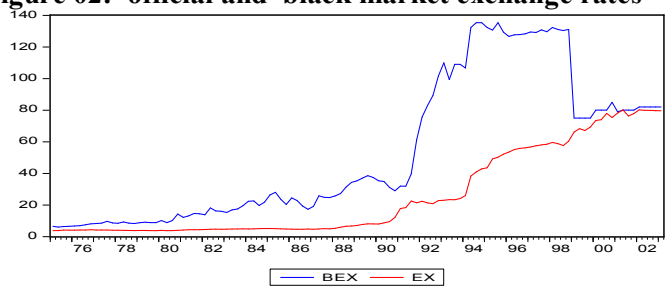


Figure 03: Premium exchange rate

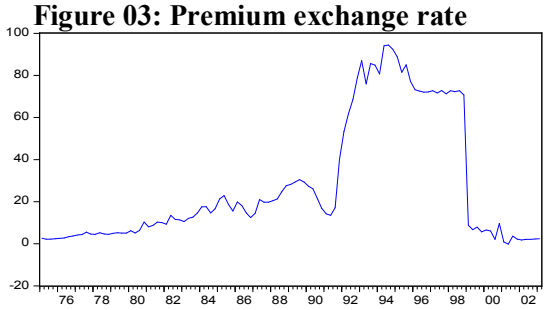


Table 05: ADF and PP Unit Root Tests

Variables	Augmented Dickey Fuller (ADF)			
	Level		First difference	
	intercept	Trend and intercept	intercept	Trend and intercept
Ln Bex	-1.39	-0.99	-9.62***	-9.71***
Ln CPI in Algeria	-1.01	-2.99	-9.21***	-9.25***
Ln CPI in USA	-2.29	-2.39	-3.45*	-3.47*
				Philips Perron PP
Ln Bex	-1.38	-1.19	-9.62***	-9.69***
Ln CPI in Algeria	-0.65	-1.27	-11.06***	-11.05***
Ln CPI in USA	-1.19	-1.61	3.75***	5.22***

show values are significant at 5 % level with MacKinnon (1996).
**show values are significant at 1% level with MacKinnon (1996).
***show values are significant at 5 % and 1 level with MacKinnon (1996).

Table 06: The Johansen Cointegration test results

Hypotheses of cointegration equation	PPP between Algerian and USA Using black market exchange rate	
	Trace Test	Max-Eigen Test.
None	40.40171 (0.0021)	0.228982 (0.0037)
At most 1	11.79691 (0.1669)	0.065886 (0.4321)
At most 2	4.299699 (0.0381)	0.038334 (0.0381)

* denotes rejection of the hypothesis at the 0.05 level

Figure 04: CUSUMSQ Test (black market exchange rate)

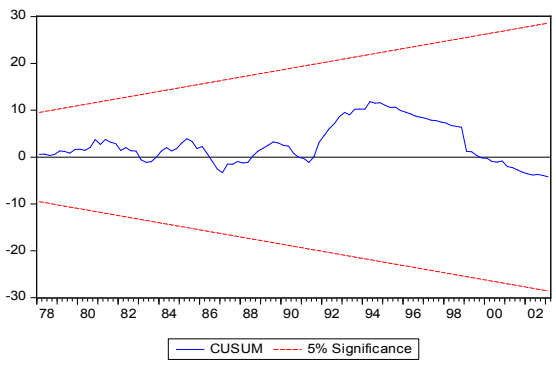


Figure 05: CUSUM Test (black market exchange rate)

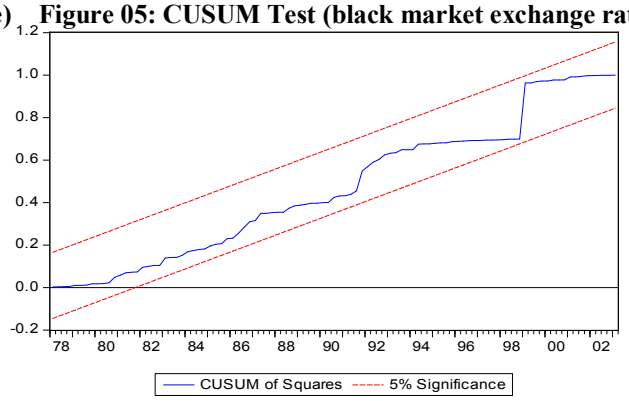


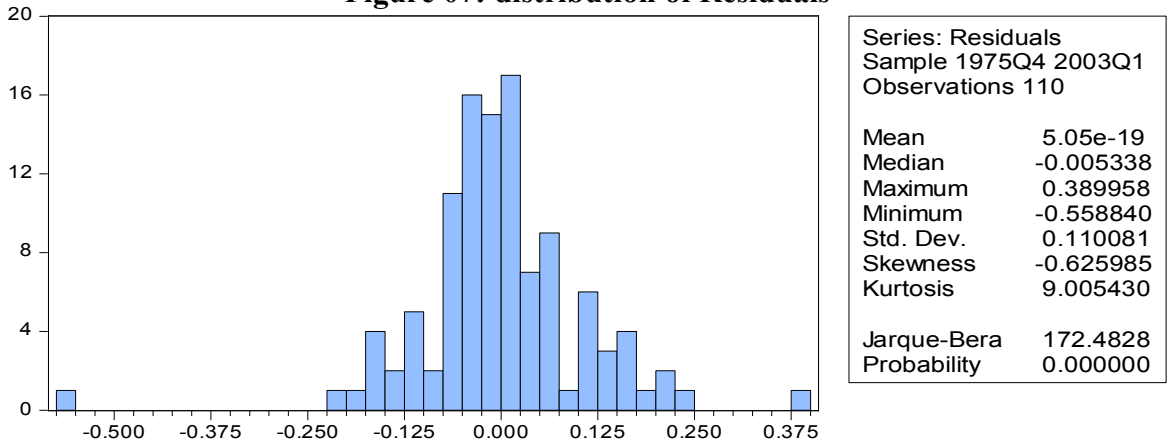
Table 07: Short and Long- run coefficients

Long- run coefficients	
	Ln BEX
EC (-1)	-0.073285
Ln CPI in Algeria	0.055963
Ln CPI in USA	0.111259
Short- run coefficients	
Δ Ln CPI in Algeria i(-1)	0.672915
Δ Ln CPI in Algeria i(-2)	0.337319
Δ l Ln CPI in USA (-1)	-2.291252
Δ Ln CPI in USA (-2)	-2.412304
C	-0.007555

Table 08: Breusch-Godfrey Serial Correlation LM Test			
F-statistic	1.156343	**Prob. F(2,99)**	0.3188
Obs*R-squared	2.510992	**Prob. Chi-Square(2)**	0.2849

Table 09: Heteroskedasticity Test ARCH			
F-statistic	0.088960	**Prob. F(2,105)**	0.9150
Obs*R-squared	0.182694	**Prob. Chi-Square(2)**	0.9127

Figure 07: distribution of Residuals



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*. Algerian exchange rate was based upon a basket of 14 currencies.

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