NOMINAL EXCHANGE RATE AND MONETARY FUNDAMENTALS: EMPIRICAL EVIDENCE FROM ALGERIA OVER THE SPAN OF 40 YEARS

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ABSTRACT

This paper examines the long run relationship between exchange rate and its fundamentals on the basis of the flexible price monetary model to exchange rate determination, the Johansen multivariate technique is applied to an unrestricted version of the flexible price monetary model using annual data covering the period 1980-2017 between the Algerian dinar and US dollar ,a strong evidence is found in favor of the existence of cointegration between nominal exchange rate, relative money supply and relative income. However, the restrictions imposed on the coefficients of the model are rejected which indicates that the process of exchange rate determination is too complex to be described as single equation of the monetary model.

KEYWORDS

Exchange rate, monetary fundamentals, Johansen cointegration

JEL CLASSIFICATION : C32, F41, E58.

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سعر الصرف الاسمي والاساسيات النقدية، ادلة تجريبية من حالة الجزائر على مدى 40 سنة

ملخص

تعالج هذه الورقة البحثية العلاقة طويلة الاجل بين سعر الصرف و الاساسيات النقدية باستعمال النموذج النقدي للأسعار المرنة لتحديد سعر الصرف، تم تطبيق تقنية يوهانسون المتعددة لصيغة مقيدة من النموذج النقدي للأسعار المرنة باستعمال بيانات سنوية تغطي الفترة من 1980 الى 2017 بين سعر صرف الدينار الجزائري والدولار الامريكي، تم ايجاد دليل قوى على وجود علاقة تكاملية طويلة الاجل بين سعر الصرف الاسمي، العرض النقدي النسبي، والدخل الاسمي، لكن القيود المفروضة على معاملات النموذج تم رفضها مما قد يبين ان سيرورة تحديد سعر الصرف سيرورة معقدة ولا تكفي لوصفها بمعادلة واحدة للنموذج النقدي.

كلمات مفتاحية: سعر الصرف ، الاساسيات النقدية، تكامل يوهانسون

تصنيف جال: C32، F41، E58

TAUX DE CHANGE NOMINAL ET FONDAMENTAUX MONÉTAIRES : PREUVES EMPIRIQUES DE L'ALGÉRIE SUR UNE PÉRIODE DE 40 ANS

RÉSUMÉ

Ce papier scientifique traite la relation à long terme entre le taux de change et les fondamentaux monétaires en utilisant le modèle monétaire des prix flexibles pour déterminer le taux de change. Nous avons appliqué la technique multivariée de JOHANSEN à une formule restreinte du modèle monétaire des prix flexiblesen utilisant des données annuelles couvrant la période 1980-2017 entre le Dinar Algérien et le Dollar Américain. Les résultats ont démontré qu'il existe une relation de cointégration à long terme entre le taux de change nominal, la masse monétaire relative et le revenu nominal; toutefois, les restrictions imposées aux coefficients du modèle ont été rejetées, ce qui peut indiquer que le processus de détermination du taux de change est un processus complexe et pas suffisant pour le décrire avec une seule équation pour le modèle monétaire.

MOTS CLÉS :

Taux de change, fondamentaux monétaires, cointégration de JOHANSEN

JEL CLASSIFICATION : C32, F41, E58.

INTRODUCTION

The exchange rate is perceived in the monetary model approach as the relative price of currencies, this relative price is determined by the demand and supply of money, there are two variants of the monetary model, the flexible price monetary model and sticky price monetary model, in the first one the purchasing power parity(PPP) is assumed to hold continuously, while in the second it holds only in the long run (Menzie D. chinn, 2012, p.46), the monetary model is one of the most important models for the exchange rate determination, this model was developed by Frenkel (1976), Mussa (1976) and Bilson (1978), it relies on the assumption that the PPP must hold continuously, if we assume that the conventional money demand is given as follows (keith Pilbeam, 2006, p.152).

$$m - p = ay - br \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where

m is the log of domestic money stock

p is the log of domestic price level

y is the log of domestic real income

r is the nominal domestic interest rate,

According to the theory, the demand for money has a positive relationship with real domestic income due to increasing transaction demand for money (the coefficient a is positive), but it vary negatively with domestic interest rate (the coefficient b has to be positive), the real money demand for foreign country can be represented as:

$$m^* - p^* = ay^* - br^* \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where all the variables are as defined previously in equation (1), the starred variables stand for foreign country variables, if PPP holds as assumed in the domestic country, the exchange rate can be written as (keith Pilbeam, 2005, p.314).

$$s = p - p^* \ldots\ldots\ldots\ldots\ldots (3)$$

Where s indicates the spot exchange rate, the parameters for money demand functions are assumed to be the same across the two countries.

If the assumption of free capital mobility and perfect substitution between assets across countries is true, the equality of returns on assets can be represented as (Robert C. Feenstra, Alan M. Taylor, 2014, p.465).

$$r - r^* = \Delta s \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where Δs denotes the expected rate of depreciation of domestic currency, holding domestic asset generates a return which is the domestic interest rate, while holding the foreign asset generates a return for the investors in two different ways; they receive foreign interest rate, but they also receive a gain or loss from the change of exchange rate.

If we subtract the foreign price equation from the domestic price one, we will get:

$$s = p - p^{*} = (m - m^{*}) - a(y - y^{*}) + b(r - r^{*}) \ldots\ldots\ldots (5)$$

The equation (5) shows that the coefficient of relative money supply is equal to 1, it also indicates that there is proportionality between relative money supply and nominal exchange rate which can be tested empirically, the basic monetary model can be instead expressed in an unrestricted form as following (Georgoutsos, D.A., Kouretas, G.P, 2017, p.991).

$$s = \lambda_1 m - \lambda_2 m^{*} + a_1 y - a_2 y^{*} + b_1 r - b_2 r^{*} + \varepsilon \ldots\ldots (6)$$

Where$(\lambda_1 = \lambda_2 = 1)$, $(a_1, a_2) < 0$, $(b_1, b_2) < 0$

In an alternative version of the monetary model that goes back to Dornbusch prices are assumed to be sticky adjusting slowly towards equilibrium such that the PPP only holds in the long run, in this case, the monetary model is a representation of the long run equilibrium, but in the short run exchange rate may overshoot its long run equilibrium due to the price inertia, the sticky price version of monetary model with expected domestic and foreign inflation rates can be represented empirically in an unrestricted form as the following (IMAD A. Moosa, 1994, p.280).

$$s = \lambda_1 m + \lambda_2 m^{*} + a_1 y + a_2 y^{*} + b_1 r + b_2 r^{*} + \gamma_1 p^{e} + \gamma_2 p^{*e} + \varepsilon \ldots\ldots (7)$$

Where p^{e}, p^{*e}, denotes expected domestic and foreign inflation rates respectively such that γ_1>0, γ_2<0, Subsequent developments of the monetary model included the role of wealth and current account as additional explanatory variables which gives rise to the portfolio balance approach, empirically, the cointegration relationship between nominal exchange rate and monetary fundamentals forms the basis for the monetary model testing.

The other component of flexible price monetary model, that is, the uncovered interest rate parity depends on exchange rate expectation and requires more than just frictionless financial market, Interest rate theory is typically only holds when it is applied in high-income countries over the span of many years, and among currencies traded in developed and internationally integrated financial markets, but if the monetary fundamentals follow a random walk, the monetary model is reduced to a standard monetary approach (Riane de Bruyn et al, 2012, p.21).

1- OVERVIEW OF THE LITERATURE

The era of floating experience has seen an enormous growth in the literature about the exchange rate economics, some versions of the monetary model to exchange rate determination have been put forward, but, the experimental results have found a little support for the monetary model to exchange rate, this failure of monetary model to exchange rate would be the result of using a shorter span of data , or it could also be the result of using an inadequate method in testing the long run relationship between exchange rate and its fundamentals such as ordinary least square and Engle-granger two step procedure, despite that, there are some studies that have found support for the monetary model to exchange rate determination, MacDonald and Taylor (1994) in their article "***the monetary model for exchange rate, long run relationship, short run dynamic and how to beat a random walk***" have reexamined the flexible price monetary model by using Johansen multivariate technique for the long relationship and have demonstrated that the monetary model does not behave as badly as it is widely thought if it is given a better treatment, indeed, the predictive ability of monetary model has outperformed the naïve random walk model.

Long Dara and Samreth, Sovannroeun (2008) conducted a study to investigate the validity of monetary model of both short and long run monetary models of exchange rate of Philippine by using the autoregressive distributed lag (ARDL) approach, it is found that the monetary model of exchange rate determination is a valid framework for the long run exchange rate between the Philippine peso and US dollar both statistically as well as economically.

Support for the long run monetary model in more recent studies has emphasized the use of longer spans of data in a variety of testing procedure, Repach and Wohar (2002)in their article ***testing the monetary model of exchange rate determination, new evidence from a century of data***" tested the long run monetary model, with the application of panel data cointergration technique by using annual data for 14 industrialized countries in post Bretton Woods era, they found strong support for long run relationship between exchange rate and monetary fundamentals, moreover; this result indicates that the monetary model out of sample forecasting has been superior to those provided by a naïve random walk model.

Riane de Bruyn et al (2012) tested the relationship between the south African Rand relative to US dollar over the span of 101 years of data using a vector error correction model (VECM), the results obtained from the study provide support for the monetary model to exchange rate determination, Lee chin et al (2007) investigated the validity of monetary model to exchange rate determination via the cointegration and error correction model, they found that the monetary model to exchange rate determination was a valid framework for long run relationship between the Philippines peso and the US dollar; These positive findings have motivated us to apply the monetary model to exchange rate in the case of Algeria.

Huseyin Ince & al., (2019) in their article entitled *"an artificial neural network-based approach to monetary model of exchange rate"* investigated the predictive accuracy of the flexible price monetary model of exchange rate using approach based on combining a vector autoregressive model with feed forward neural network, this suggested approach is compared with four models for forecasting using six different exchange rates and three forecasting periods, the result showed that this suggested approach was better than other estimated models when using root mean square error, mean return and sharp ratio as criteria for comparison.

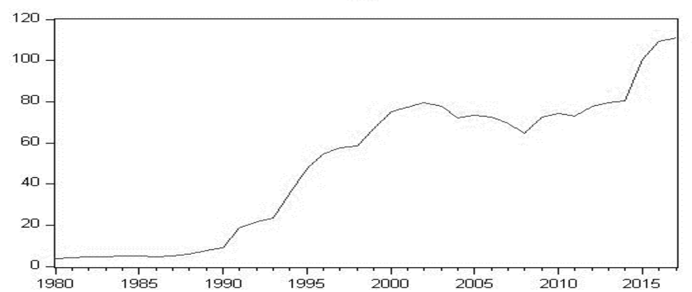
2- THE DATA

In this study, we have used the approach adopted by MacDonald and Taylor (1994) for the flexible price monetary model, we will apply a modern econometrics technique to test the long run properties of exchange rate between the Algerian dinar and American dollar, according to MacDonald and Taylor (1994) the monetary model did not behave poorly as commonly thought if it is given better treatment by allowing long run equilibrium and short run dynamic, they have shown that the monetary error correction model outperformed random walk forecasting.(MacDonald Taylor, 1994, p. 277).

The American dollar is chosen as a base currency, since the United States is an important partner for Algeria for many commodities , in fact, the major part of Algeria revenues is dominated in US dollar, empirically, the model is tested in a less restricted form to check the different restrictions implied by the theory of exchange rate determination.

The data used in this study are obtained from the International Monetary Fund's international financial statistics and the World Bank, the sample period runs from 1980 to 2017, the frequency of data is annual, the official exchange rate used in this study refers to the exchange rate determined by national authorities and it is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar), the evolution of bilateral exchange rate of Algerian dinar vs the US dollar during the period (1980-2017) is represented in the figure 1 below.

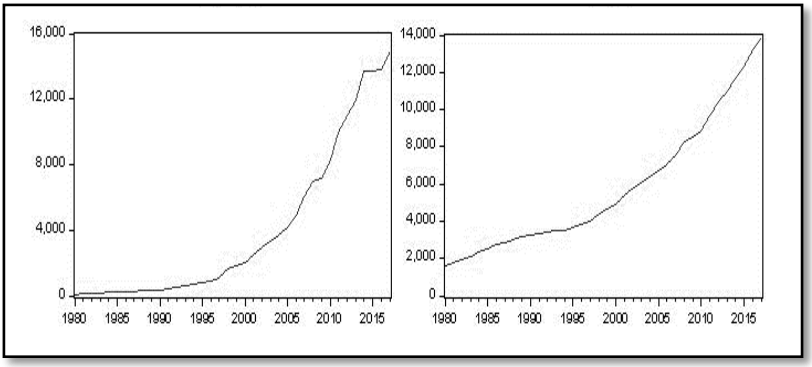
Figure n°1. Evolution of Algerian dinar against the US dollar during the period (1980-2017)



Source; World Bank data

The chosen monetary aggregates are broad money stock M2 (in billions) for both home (Algeria) and foreign (United States) countries, the data are taken from International Monetary Fund 'international financial statistics, the frequency is annual covering the period 1980 to 2017, the evolution of theses aggregates is shown in the figure2 below.

Figure n°2. The evolution of monetary aggregate M2 in Algeria and the United States of America during the period (1980-2017)

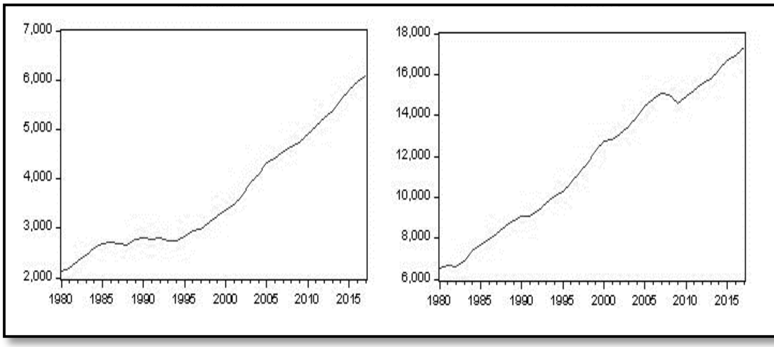


Source: world Bank and international monetary fund

The evolution of M2 money stock for Algeria in billions of Algerian dinars is shown on the left of the figure 2, while the evolution of M2 money stock for United States (in billions of American dollars) is shown on the right.

Gross domestic product (GDP) in constant prices for Algeria and the United States is used as proxy for real income, data are taken from International Monetary Fund' international financial statistics, the sample period runs from 1980 to 2017 in both countries, the evolution of GDP in billions of local currency unit in each country is shown in figure 3 below, GDP in Algeria is shown on the left of the figure3, while GDP for the United States is shown on the right.

Figure n°3. The real GDP in Algeria and the United States inbillionsof local currency units from 1980 to 2017.



Source: international monetary fund

3- METHODOLOGY

In this paper, we follow the method that has been adopted by MacDonald and Taylor (1994) for the flexible price monetary model, we will investigate the relationship between exchange rate and its fundamentals by using Johannsen cointegration technique to test the long run properties of an unrestricted version of the monetary model, The unrestricted version of the monetary model has the following representation (Aristidis Bitzenis, John Marangos, P.68).

$$s = \lambda_1 m + \lambda_2 m^* + a_1 y + a_2 y^* + b_1 r + b_2 r^* + \varepsilon \dots (8)$$

Where

m; Broad money supply in Algeria (billions of local currency units)

m^*; Broad money supply in the United States (billions of US dollars)

y; Real GDP in Algeria ((billions of local currency units)

y^*; Real GDP in the USA (billions of US dollars)

The interest rate variable is not included in the model as Algeria has been practicing capital control for many years; in fact, the financial market in Algeria is not widely integrated in the international financial market. Moreover, interest rate variable was most of the time not available and did not reflect the reality of the monetary market; as a result, the model will be instead estimated in the following way:

$$s = \lambda_1 m + \lambda_2 m^* + a_1 y + a_2 y^* + \varepsilon \dots\dots..(9)$$

The uncovered interest rate parity implies that $(\mathrm{r} - \mathrm{r}^*) = \mathrm{E}(\Delta \mathrm{s}_{\mathrm{t}+1}/\mathrm{I})$, where E represents the expectation operator conditional on information available at time t (Ibhagui, O.W, 2019, p.257), if the difference in exchange is stationary, the relative interest rate must also be stationary, , therefore, the statistical long run relationship can be estimated in following way (Keith Cuthbertson, Dirk Nitzsche, 2004, p.619).

$$s = (m - m^*) - \theta(y - y^*) \dots\dots\dots..(10)$$

Using non-stationary time series data in estimation produces many serious problems such as; spurious regression and invalid critical values, therefore; it is important to determine whether the data are stationary or not before doing any meaningful estimation or hypothesis testing about the regression parameters (Chris Brooks, P. 353-354).

It turns out that the variable broad money supply variable for the United states is I(2), therefore; we have to impose some restrictions according to the monetary model to be able to statistically estimate the model with the Johansen procedure, one of these restrictions takes the form $\lambda_1 = 1$, $\lambda_2 = -1$, the equation (9) then will be;

$$s = (m - m^*) + a_1 y + a_2 y^* + \varepsilon = \mathrm{md} + a_1 y + a_2 y^* + \varepsilon \dots\dots(11)$$

Wheremd = $m - m^*$

Another approach that has been extensively used in recent studies is autoregressive distributed lag (ARDL), it has many advantages in small samples as opposed to other testing procedure, because it used even if the variables have a different order of integration such as I(0), I(1) (Syed Ali Raza, Sahar Afshan**,** P.828)

There are three main trend assumptions encountered in practice when we test for the unit root in the data (Damodar Gujarati, p: 213).

- Random walk
- Random walk with drift
- Random walk with drift around a deterministic trend

All the variables in this study are expressed in logarithm, the logarithmic transformation has at least three main beneficial applications in practice, first, taking logarithm can often help in rescaling the data so that the variance becomes more stable, which in turn may solve another common statistical problem, second, taking logarithm can restore symmetry for positively skewed distribution to be closer to normal distribution. Third, using logarithm transformation can effectively convert the nonlinear multiplicative relationship into a linear additive one (Chris brooks P. 608). For the empirical model we will use the following notations:

$$ler_t = a_1 md_t + a_2 y(dz)_t + a_3 y(us) + \varepsilon_i \dots\dots (12)$$

Where;

ler_t: Logarithm of exchange rate

md_t:Difference of M2 stock in logarithm form

$y(dz)_t$: Real GDP in Algeria ((billions of local currency units)

$y(us)$: Real GDP in the USA (billions of US dollars)

a_i: Constants, ε_i: residuals

4- EMPIRICAL FINDINGS AND DISCUSSION

Before doing any meaningful estimation, the variables must be tested for stationarity, in this study we have used augmented Dickey-Fuller test, the result obtained from this test differ according to trend specification included in the model. We see from figure 1,2 and 3 that the time series fluctuates around some linear trend, therefore we include a drift and linear time trend when performing unit root test, the results are given in the table 1 where all the variables are expressed in logarithm.

Table. 1. Augmented Dickey Fuller test

	At level			
	ln er	md	lny(dz)	lny(us)
With constant	0.4450	0.5177	0.9866	0.4539
With constant and trend	0.9749	0.9968	0.7875	0.8435
	At first difference			
With constant	0.0046	0.0024	0.0098	0.0046
With constant and trend	0.0145	0.0432	0.0426	0.0102

Source; Eviews.10 output

As it can be seen from table 1, all the P values (numbers inside the table.1 represent the probability values) are less than 0.05 the significance level chosen at the first difference, therefore the variables have one unit root, that is, all the variable are I(1), then; the appropriate method for testing the long run relationship is Johansen technique.

Before testing the long run relationship we have to specify what kind of trend should be included, in this study we assume that the cointegration equations are trend stationary, and the first difference has a constant, because the constant in an equation for the first difference of a variable represent a linear trend in level of the variable, similarly; quadratic time trend in level of equation for a variable represent a linear time trend in the first difference equation (Sean Becketti. 2013, p: 391).

Table. 2. Johansen tests for cointegration

Trace eigenvalue statistics			
Null hypothesis	alternative	Trace statistics	1% critical value
r≤0*	r≥1	103.78	70.05
r≤1*	r≥2	57.15	48.45
r≤2	r≥3	30.31	30.45
r≤3	r≥4	9.61	16.26
Maximum eigenvalue statistics			
r≤0*	r=1	46.62	36.65
r≤1	r=2	26.45	30.34
r≤2	r=3	17.08	23.65
r≤3	r=4	9.61	16.26

Source; Stata.12 output

From table 2 the trace statistics at r≤2 is 30.31 less than its critical value 30.45 we do not reject the null hypothesis that there are two cointegration vectors or fewer, in contrast; the maximum eigenvalue statistics using the same logic, indicates only one cointegration vector, in this case of conflicting result, we will use the trace statistics and estimate the vector error correction model assuming two cointegration vectors.

Because all the variables appear to be fluctuating around some linear time trend, we estimate a VECM model by including linear but not quadratic trend in levels of the variables, and we assume that the cointegration equations are trend stationary; we will estimate a VECM with two lags at which the residuals obtained are well behaved and normally distributed with no autocorrelation as can be seen from table 6. The VECM will have the following representation.

$$\begin{pmatrix} \Delta er_t \\ \Delta y(dz)_t \\ \Delta y(us)_t \\ \Delta md_t \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \\ a_{31} & a_{32} \\ a_{41} & a_{42} \end{pmatrix} \begin{pmatrix} z_{1t-1} \\ z_{2t-1} \end{pmatrix} + \sum_{i=1}^{2} \Gamma_i \begin{pmatrix} \Delta er_{t-i} \\ \Delta y(dz)_{t-i} \\ \Delta y(us)_{t-i} \\ \Delta md_{t-i} \end{pmatrix} + \gamma + \xi_t$$

$$\alpha = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \\ a_{31} & a_{32} \\ a_{41} & a_{42} \end{pmatrix} = \begin{pmatrix} -0.58 & -4.70 \\ -0.02 & -0.17 \\ 0.04 & 0.11 \\ -0.03 & -0.3 \end{pmatrix}$$

The matrix α is,known as the speed of adjustment towards equilibrium, it measures the proportion of the disequilibrium corrected for in the last period.

The first vector $z_{1t-1} = er_{t-1} - 7.09y(us)_{t-1} - 2.95md_{t-1} + 0.33t + 54.72$ indicates the first long run cointegration vector obtained by normalizing on the coefficient of log exchange rate variable.

The second vector $z_{2t-1} = y(dz)_{t-1} + 0.59y(us)_{t-1} - 0.42md_{t-1} - 0.07t - 12.07$ indicates the second long run cointegration vector obtained by normalizing on the coefficient of real output variable for Algeria.

Γ_i ; Are 4*4 matrices that indicate the short run impact matrices, and γ , ξ_t represent vector of constants and residuals respectively.

4.1- Testing for weak exogeneity in the VECM

The coefficients in the speed of adjustment matrix give information about which corresponding eigenvector enters the VECM equation as well as the speed of correction towards equilibrium, for instance, the presence of r cointegration vectors would suggest that the remaining (n-r) columns in the leading matrix are zero, similarly, the presence of all zeros in a given row of the leading matrix may suggest that the corresponding eigenvector does not enter in the VECM equation for that variable, this variable is called weakly exogenous variable, the long run relationship can be conducted conditional on the weakly exogenous variable (Richard Harris. P.98) The test for weak exogeneity of the variables is shown in table .3 below.

Table.3. Speed of adjustment back to equilibrium

Equation	Parameters	Chi2	P value
Δer_t	2	23.06	0.00
$\Delta y(dz)_t$	2	0.91	0.63
$\Delta y(us)_t$	2	30.91	0.00
Δmd_t	2	0.28	0.86

Source; Stata.12 output

We can see from table 3 that all the coefficients are highly significant at 5 % level except those for real output in Algeria and relative money supply, therefore; real output in Algeria and relative money supply are both weakly exogenous variables and do not respond significantly to disequilibrium in long run equation, therefore; we can estimate a partial VECM without including the weakly exogenous variables as long run corrector variables. The speed of adjustment for exchange rate is significant in both cointegration vectors, whereas, it is significant only in the first cointegration vector for real output in the USA. It appears from the speed of adjustment matrix that exchange rate coefficient (58.74 %) is significantly negative representing the negative feedback necessary to restore equilibrium for the first cointegrating vector.

4.2- Testing for long run cointegration vectors

The trace and maximum eigenvalue statistics have previously shown that there are two cointegration relationships, the VECM representation of each cointegration equation is presented in the table.4.

Table. 4. The parameters of long run cointegrating vectors (all the variables are in log)

The first cointegration vector					
ER	$Y_{(DZ)}$	$Y_{(US)}$	MD	Trend	Constant
1	0	7.098	2.95	0.33	54
P value	-	0.000*	0.001*	0.000*	-
The second cointegration vector					
$Y_{(DZD)}$	INF	$Y_{(US)}$	MD	Trend	Constant
1	0	-0.597	-0.41	0.077	12
P value	-	0.007*	0.000*	0.000*	-

Source: STATA.12 output

Table 4 contains the estimates of the long run parameters along with the P values, if there are two cointegrating vectors, then we need at least four restrictions to identify the long run relationship, we have used the Johansen identification scheme as default for identification, all the variable are very highly significant in the two cointegration equations, they also have the expected sign in the first cointegration equation, we interpret the coefficient in the first cointegration equation as follows:

- 1% increase in real output in the United States leads to 7% increase in exchange rate.
- 1% increase in relative money supply leads approximately to 3% increase in exchange rate instead of 1% as predicted by flexible price monetary model.

The second cointegration does not contain the variable of interest (exchange rate) but it predicts a significant and causal long run relationship between relative real output and relative money supply, because it can be written as (1+0.596)Δy_t=-0.41md+0.07trend+12.

4.3- Testing hypothesis on cointegration vectors

The Johansen reduced rank regression technique identifies only how many cointegration vectors span the cointegration space, furthermore; any linear combination of the cointegrating vectors is also in the cointegration space, that is, the estimates produced for any particular column in matrix containing the cointegrating vectors are not necessarily unique, therefore, obtaining unique values of the coefficients, requires imposing some restrictions driven by economic conditions (Richard Harris, Robert Sollis, 2003, p. 143).

There are some commonly imposed restrictions in the literature (MacDonald and Taylor 1994, p.280); the restrictions to be imposed in this study are listed in table.5:

Table. 5. Some commonly imposed monetary restrictions

Hypothesis	Ki squared	Probability
$\boldsymbol{H_1 : B_{14} = 1}$	5.1001	0.0239*
$\boldsymbol{H_2 : B_{14} = B_{24} = 1}$	9.0449	0.0108*
$\boldsymbol{H_3 : B_{12} + B_{13} = 0}$	1.8414	0.1747
$\boldsymbol{H_4 : H_1 \cap H_2}$	4.5033	0.0338*

Source: STATA.12 Output

As shown in table.5, the first hypothesis H_1 concerning the proportionality between relative monies and exchange rate is strongly rejected in the first cointegration vector, similarly, the hypothesis H_4 that tests for a unique cointegration vector as specified by the flexible price monetary model is also rejected, but the hypothesis of equal and opposite coefficients on relative income cannot be rejected in the first cointegration vector, from these results we can generally conclude that the monetary model is not a valid framework for exchange rate determination and the relationship between monetary fundamentals may not be as simple as the basic flexible price monetary model suggests.

4.4- VECM diagnostic tests

The analysis of residual normality and autocorrelation as well as the VECM stability can show the potential defects of the model and provide a useful insight about the robustness of the model, table 6 shows the Jarque-Bera test along with Breush-Godfrey test for serial correlation which is also known as LM test.

Table.6. Jerque-Bera test for residuals normality

		Normality test		
Jerque-Bera test		Chi2	df	Prob
All equations		12.519	16	0.61814
		Autocorrelation test		
LM test	lag	Chi2	df	Prob
	1	7.8940	16	0.95196
	2	9.7554	16	0.87909
	3	18.1707	16	0.31400
	4	13.7392	16	0.61814
	5	11.1623	16	0.79936
	6	15.7968	16	0.46723
	7	12.7847	16	0.68843
	8	14.8342	16	0.53682
	9	19.7356	16	0.23273
	10	13.2660	16	0.65322

Source: STATA.12 Output

The assumption that the errors are normally distributed with zero mean and finite variance allows the derivation of the likelihood function, if the errors do not come from a normal distribution the parameter estimates are still consistent but they are not efficient, we see from table.6 that the P value is more than 5%, so we do not reject the null hypothesis of residual normality.

The null hypothesis of no autocorrelation in the residuals up to tenth lag is also not rejected at 5% level, thus this test finds no evidence of model misspecification.

The stability of the estimated VECM should also be evaluated to check whether the number of cointegrating equations are correctly specified, the companion matrix of the VECM with four endogenous variables and two cointegrating equations should have two unit eigenvalues, the process is stable if the remaining eigenvalues are strictly less than one, as it can be seen from table.7 all the remaining eigenvalues are less than one in absolute value, therefore, we can conclude that the VECM is stable.

Table.7. the companion matrix of the estimated VECM

Eigenvalue	Modulus
1	1
1	1
0.9048	0.9048
0.4919+0.5671i	0.7507
0.4919-0.5671i	0.7507
-0.2667+0.6259i	0.6927
-0.2667-0.6259i	0.6927
0.4248+0.3909i	0.5773
0.4248-0.3909i	0.5773
0.2878+0.3951i	0.4888
0.2878-0.3951i	0.4888
-0.3713	0.3713

Source: STATA.12 output

CONCLUSION

In this paper we have investigated the validity of flexible price monetary model in a small economy using annual data running from 1980 to 2017 for the Algerian dinar relative to US dollar, Appling the Johansen cointegration technique we have found two long run relationship between exchange rate and its fundamentals, the evidence in favor of flexible price monetary model is at best mixed. there is a long run relationship between exchange rate and its fundamentals, however; this relationship is not as predicted by monetary model for exchange rate determination for the reason that all the restrictions implied by the theory are rejected except for the restriction related to equal and opposite effect of income differential which may indicate that foreign and domestic growths are important determinants of the monetary model.

This study also highlighted that the process of exchange rate determination is too complex to be described by a single equation for many countries, for Algeria, many of the requirements of flexible price monetary model are not fulfilled in the first place: the consumer price index is largely dominated by controlled prices, moreover, the Algerian economy is characterized by limited international financial market integration and the interest rate is not effective and unresponsive to change in monetary conditions.

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