INFLATION DYNAMICS IN ALGERIA: ESTIMATION OF THE HYBRID NEW KEYNESIAN PHILLIPS CURVE

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Abstract :

The aim of this paper is to estimate the hybrid New Keynesian Phillips curve for Algeria on the period 1994-2011. In the first part, the hybrid New Keynesian Phillips curve is discussed theoretically for the purpose of highlighting the equation to be estimated. The second part is devoted to the presentation of the data. The obtained results confirm those gotten in the literature. Our data analysis suggests that the nature of inflation dynamics in Algeria doesn't match the hybrid New Keynesian Phillips curve.

Keywords : Inflation, Phillips curve, Output gap, Algeria.

JEL CLASSIFICATION : E3, E5, C1.

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Introduction

In macroeconomics, the study of the short-term dynamics of inflation is a crucial issue because of its promiscuity with the conduct of monetary policies. Since the 90s, several OECD countries have adopted monetary policies based on inflation targeting. For example, New Zealand, Canada, Australia, Sweden and the U.K, all have adopted targeting inflation as a monetary policy rule (Svensson, 1999). Thus, knowledge and explanation of temporal variations in inflation are essential elements for the conduct of monetary policy.

Recently, many theoretical studies have tried to model the inflation dynamics. Especially the works of Taylor (1980), Calvo (1983) and Fischer (1977), they focused on the stickiness of the adjustment of wages and prices due to the forward looking of individuals and firms. From the work of Fischer (1977), for example, it appears that the rational expectations of monetary policies affect their effectiveness. If in the long-term labor contracts the nominal wages are indexed to price levels, then monetary policy will be ineffective. Thus, the effectiveness of monetary policy requires that nominal wages would not be indexed to price levels, implying the appearance of a relationship type Phillips curve on the short term. This relationship is known as the new Keynesian Phillips curve (NKPC).

From a practical standpoint, the number of empirical studies on NKPC remains limited. However, obtained results show some discrepancy with the theoretical conclusions. In particular, researchers have come to a relationship, between inflation and real income, in contradiction with the NKPC (Galí & Gertler, 1999). This contradiction was at the origin of an alternative which consists to imbricate the new Phillips curve with the old one, to reach a hybrid version.

Among the most important empirical work on the hybrid NKPC, we can include the papers of Chadha, Masson, and Meredith (1992), Fuhrer (1997) and Roberts (1997). Chadha et al. (1992) and Roberts (1997) obtained reasonable parameter estimates with annual data. On its side, Fuhrer (1997) reached significant parameters with quarterly data. Reference work is the paper of Galí and Gertler (1999). They proposed to replace the output gap by the real marginal cost. Using the GMM method, they obtained good results with both – annual and quarterly data.

A number of empirical works has followed the paper of Galí and Gertler (1999). The findings are mitigated. For Abbas and Sgro (2011), the forward looking baseline NKPC is better than the hybrid NKPC to explain inflation dynamics in Australia. Dufour, Khalaf, and Kichian (2006) assessed the Galí and Gertler (1999) specification for the U.S. and Canadian data. They find that hybrid NKPC explains the inflation dynamics for the U.S., but not for Canada.

This shows that, the projection of the Galí and Gertler (1999) model on Algerian data can help to improve the knowledge on the ability of the hybrid NKPC to explain the inflation dynamics.

Despite the importance of the topic, as far as we know, there are no empirical studies on the hybrid NKPC in Algeria. Moreover, the topic is of major interest for the Central Bank of Algeria. In this country, the main objective of the monetary policy is "to ensure the price stability" (Latreche, 2012). Hence, the study of the short-term dynamics of inflation becomes a crucial issue for the Bank of Algeria.

Starting with these facts, the present study seeks to estimate the determinants of the dynamics of the inflation in Algeria. To achieve this, an econometric approach was adopted by using the generalized method of moments (GMM). The calculations were realized with the free software gretl v.1.9. The sources of data are the databases of the World Bank and the University of Sherbrooke (Sample period 1994 – 2011).

On the other hand, due to the absence of data on nominal wages in Algeria, the estimated hybrid NKPC was the one which depends of real output gap. Estimate was made for annual and quarterly data.

The paper is divided into three parts. The first part deals with the theoretical framework of the hybrid Phillips curve. The second is dedicated to the presentation and preparation of data. The results and analysis come in the third and last part.

1. The theoretical framework of the hybrid phillips curve

According to Galí and Gertler (1999), the starting point to derive the new Phillips curve is to assume that firms are monopolistically competitive. Under the new Keynesian model, the adjustment of nominal wages and prices is not realized automatically in the short term because of menu costs. Thus the firms' price setting is not always optimal, i.e., firms will adjust their prices only if they expect that incomes will be superior to the menu costs.

To simplify the aggregation problem, Calvo (1983) assumes that firms have two behaviors. Either they maintain their prices unchanged or they move them to the optimal level. Using probabilities we can interpret this idea in the following way. In any given period, each firm can change its prices with $(1-\theta)$ probability. Thus, the probability to maintain prices unchanged equal θ. Since this probability is independent of time, the average time during which prices are fixed equal:

$$(1-\theta)\sum_{k=0}^{\infty} k\theta^{k-1} = \frac{1}{(1-\theta)} \qquad (1)$$

where k is the number of periods

For example, if $\theta = 0{,}5$ in annual data model then prices will be fixed for 2 years on average.

If we assume that firms are identical and the price elasticity is constant, we can, according to Galí and Gertler (1999), write the aggregate price level as follows:

$$p_t = \theta p_{t-1} + (1-\theta)p_t^* \qquad (2)$$

where p_t^* is the optimal aggregate price level, which can be written follows:

$$p_t^* = (1-\theta\beta)\sum_{k=0}^{\infty}(\theta\beta)^k\, E_t\{mc_{t+k}^n\} \qquad (3)$$

where β is a coefficient and mc_t^n is a nominal marginal cost at time *t*.

Let us assume that inflation is $\pi_t \equiv p_t - p_{t-1}$ and mc_t is the percent deviation of the firm's real marginal cost from its steady state value. According to Galí and Gertler (1999), from equations (2) and (3) we can rewrite the inflation equation as:

$$\pi_t = \lambda mc_t + \beta\, E_t\{\pi_{t+1}\} \qquad (4)$$

where $\lambda = (1-\theta)/\theta$ is a coefficient.

To reach the Phillip's equation we have to include the output gap in equation (4). Let y_t and y_t^* denote respectively the log of output and natural level of output. The equation of output gap is $x_t = y_t - y_t^*$. According to Rotemberg and Woodford (1999) and Galí and Gertler (1999) we can write the approximate equality:

$$mc_t = kx_t \qquad (5)$$

where *k* is the output elasticity of marginal cost.

From (4) and (5) we obtain:

$$\pi_t = \lambda k x_t + \beta\, E_t\{\pi_{t+1}\} \qquad (6)$$

The equation (6) represents the new Keynesian Phillips curve. What distinguishes it is the dependence of the current inflation to expected inflation. It has a forward-looking dynamics.

However, econometric estimates of equation (6) were not conclusive. Hence the idea to consider a hybrid version: new Phillips curve with a backward-looking part. It can be write as follows:

$$\pi_t = \lambda x_t + \gamma_f\, E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1} + u_t \qquad (7)$$

where γ_b and γ_f are coefficients included between 0 and 1.

2. Presentation and preparation of data

Before starting the estimation of equation (7), it is necessary to calculate the output gap and ensure that time series are stationary.

The output gap represents the difference between the current output and its natural level. Thus, if we consider the presence of potential growth in Algeria then the output gap is equal to the deviation of output from the trend of its natural level (*i.e.* the output gap in time *t* is the deviation from the potential output in time *t*).

The issue is to estimate the trend of natural output. To solve this problem we used the HP filter (Hodrick & Prescott, 1997), which is considered as one of the best statistical methods to extract the trend from time series in macroeconomics. This technique was used in many econometric studies, especially because it has some interesting statistical characteristics. In particular, the gap thus calculated is stationary.

HP filter works to decompose the output into a trend g_t and cyclical component hp_t by minimizing the following:

$$\sum_{t=1}^{T}(y_t - g_t)^2 + \lambda' \sum_{t=2}^{T-1}\left((g_{t+1} - g_t) - (g_t - g_{t-1})\right)^2 \quad (8)$$

The smoothing parameter λ' plays a key role in equation (8). To determine it, we have analyzed the transfer function of the filter.

From the paper of (Mnif-Trabelsi, 2012), it appears that the length of short-term cycle in Algeria is 5.47 years. On this base, the value of the smoothing parameter was calculated supposing that 90% of volatility of the cycles (with length equal to 5.47 years) returns to cyclical component. Approximately $\lambda' = 6{,}5$. The calculated output gap is shown in Appendix A (Graphic 1).

To ensure the validity of results, the output gap correlogram was examined. As it is shown in Appendix A (Graphic 2), the series is stationary.

On the other hand, the correlogram of inflation shows that this series is not stationary. Hence the use of the ADF test. This test illustrates the presence of a unit root by calculating Student statistics of the following equation:

$$(1-L)y_t = b_0 + b_1 t + b_2 t^2 + (a-1)y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + \epsilon_t$$

From the correlogram of inflation and the results of ADF test, we concluded that $p = 3$ and the non-stationarity is double - TS and DS (Appendix B, Table 1). Thus, the series was stationarised.

By the same way, the series of used instruments were tested. The results are illustrated in the table below.[1]

Tableau N°1 : **Stationarity of instruments**

Series	ADF (p-value)	stationarity	Type of non-stationarity
Oil prices (2000 constant US$)	0,2295	No	TS+DS
Real interest rate	0,0841*	Yes	-
Exchange rate	0,9031	No	TS+DS
Algerian foreign currency reserves (2000 constant US$)	0,1583	No	TS+DS

Source: *Realized by researchers using gretl program.*

(*) the correlogram shows the stationarity of this series (ADF is an asymptotic test)

The method of Chow and Lin (1971) was used to calculate the quarterly values of the variables. According to this method, the

[1] Economically, chosen instruments are linked to the inflation rate. The relationships Exchange rate/Real interest rate – inflation are obvious. In Algeria, the relationship between inflation and the Oil prices is due to the dependence of this country of oil revenues. Oil revenues rise with the rise of the oil prices. Mechanically, this led to the rise of Government spending which generate inflationary pressures. Moreover, it was found that the rise of foreign currency reserves generates inflationary pressures (Mohanty & Turner, 2006).

best linear approximation, type $Y = \beta X + u$, for quarterly data is calculated as follows:

$$\hat{\beta} = \left(\dot{X}'\dot{V}^{-1}\dot{X}\right)^{-1}\dot{X}'\dot{V}^{-1}\dot{Y}$$

where $\dot{V} = CVC'$ and V is covariance matrix of the annual series Y. C is the matrix that converts annual data into quarterly data.

The quarterly data plots of all variables are presented in Appendix A (Graphics 3 – 8).

3. Results And Analysis

The hybrid Phillips curve is characterized by the forward-looking component $E_t\{\pi_{t+1}\}$. This component is not directly observable and, therefore, requires a limited information method of estimation. Thereby we have to use instruments. By replacing $E_t\{\pi_{t+1}\}$ with $\pi_{t+1} - \eta_{t+1}$, where η_t is a one-step ahead forecast error of inflation in time *t*, we obtain the following estimable function:

$$\pi_t = \lambda x_t + \gamma_f \pi_{t+1} + \gamma_b \pi_{t-1} + e_t \qquad (9)$$

where $e_t = u_t - \gamma_f \eta_{t+1}$

Since the assumption $E_{t-1}(u_t) = 0$ means that $E_{t-1}(e_t) = 0$, equation (9) can be estimated by GMM method using instruments Z_t (Kleibergen & Mavroeidis, 2009).

The GMM method was suggested by Hansen (1982). If instruments Z_t are exogenous, it means that $E(Z_t u_t) = 0$. Thus, from equation (9) we can write:

$$E\left(f_t(\theta)\right) = 0 \qquad (10)$$

where $f_t(\theta) = Z_t\left(\pi_t - \lambda x_t - \gamma_f \pi_{t+1} - \gamma_b \pi_{t-1}\right)$

and $\theta = \left(\lambda, \gamma_f, \gamma_b\right)$

For each moment, equation (10) can be written in the following approximate form:

$$E\left(\overline{f_t}(\theta)\right) = \frac{1}{n} Z_t\left(\pi_t - \lambda x_t - \gamma_f \pi_{t+1} - \gamma_b \pi_{t-1}\right) = 0$$

Therefore, the idea behind GMM method is to estimate values of θ in such manner that each moment tends to zero. If the model is over identified, i.e., there are more instruments than endogenous variables, then the weighting matrix W is used to calculate the following objective function:

$$J(\theta) = n\overline{f_t}(\theta)'\, W\overline{f_t}(\theta) \qquad (11)$$

The GMM method seeks the values of θ, which minimize the objective function. Hence, we have to solve the first-order condition:

$$\frac{\partial J(\theta)}{\partial \theta} = 0 \qquad (12)$$

According to equation (11) the number of possible solutions depends of weighting matrix. The optimal weighting matrix is the one which allows minimizing the asymptotic variance of the estimator S (Baum, Schaffer, & Stillman, 2002). This is attained through equality $W = S^{-1}$. By replacing the weighting matrix in equation (11) and solving equation (12), we get the efficient GMM estimator as following:

$$\ddot{\theta}_{EGMM} = (X'ZS^{-1}Z'X)^{-1}X'ZS^{-1}Z'_{\pi}$$

where X is the matrix of independent variables.

The issue is that the matrix of covariance is unknown and this is why it must be estimated. Estimated matrix of covariance is calculated by the following equation:

$$\hat{S} = \frac{1}{n}(Z'\hat{\Omega}Z)$$

where $\hat{\Omega}$ is the estimated error covariance matrix

Consequently, the calculation of the efficient estimator $\ddot{\theta}_{EGMM}$ requires proceeding according to the following algorithm (Baum et al., 2002):

1. Estimate equation (9) using instrumental variables method;
2. Use residuals to form the errors covariance matrix;
3. Calculate the matrix of covariance;
4. Form the optimal weighting matrix;
5. Estimate the efficient GMM estimator.

This algorithm is iterated until the estimator converges.

Despite the power of GMM method, its cost is high. Firstly, it requires a large sample size (Hayashi, 2000). Indeed, the weighting matrix is a function of the fourth moment. Secondly, the GMM necessitates a high quality instruments. It means that instruments are strongly correlated with exogenous variables and orthogonal to the error term. Mavroeidis (2005) showed that GMM estimators are unreliable when instruments are weak.

Starting from this base and works of Galí and Gertler (1999), Stock, Wright, and Yogo (2002), Nason and Smith (2008), Kleibergen and Mavroeidis (2009), Zivot and Chaudhuri (2009), a number of instruments have been identified. The hypothetical existence of economic relations between the exogenous variables and instruments as well as the abundance of data, were taken into consideration.

The study of cross-correlograms and calculation of F-statistic, associated with the regression of each endogenous variable on external instruments, bring us to the following conclusion. The variable "Oil prices" is rejected as a valid instrument. Besides the constant and the first four lags of the inflation variable (internal to the model), selected exogenous instruments were:

1. The real interest rate without lags;
2. Exchange rate with first and second lags;
3. Algerian foreign currency reserves without lags.

The orthogonality condition was tested using the J-statistic of Hansen (1982). The J-statistic is asymptotically distributed with a chi-square distribution with (K-L) degrees of freedom. The rejection of the null hypothesis means that either the model specification is incorrect or that the condition of orthogonality is not accepted.

Before presenting the results, we point out that the sample size is relatively small. It extends from 1994 to 2011, which is binding somewhere for the GMM method.

For annual data, the results are presented in the Table 2. (*c.f.* Appendix B, Table 2).

Tableau N°2 : **Estimates of the new hybrid Phillips curve with annual data**

	γ_b	γ_f	Λ
The Value	0,260031	0,217166	8,35773
Critical p-value	1,68e-021	1,93e-143	0,0419
Z	9,523	25,50	2,034
J-statistic	Chi-deux(7) = 4,98526 (0,6618)		

Source*: Realized by researchers using gretl program.*

From Table 2, we can see that obtained values are significant at the 95% level. The J-statistic is low which means that the orthogonality condition is accepted. Those values are compatible with exposed theories, since all parameters are positive and inferior to the unity (for γ_b and γ_f). Thus, the results are broadly consistent with works of Chadha et al. (1992) and Roberts (1997) who obtained acceptable values for annual data.

On the other hand, the sum of γ_b and γ_f is different from unit. The restriction test was rejected (details in Appendix B, Table 2). This means that the economic specification of the model is not correct. This hypothesis looks to be the most plausible because of the significance of parameters.

Regarding quarterly data, the results are presented in the Table 3 (*c.f.* Appendix B, Table 3).

Tableau N°3 : **Estimates of the new hybrid Phillips curve with quarterly data**

	γ_b	γ_f	Λ
The Value	-0,664505	1,10730	160,736
Critical p-value	1,68e-021	0,0010	0,0099
Z	-4,663	3,303	2,580
J-statistic	Chi-deux(7) = 5,76311 (0,5677)		

***Source**: Realized by researchers using gretl program.*

The data in table 3 shows that estimated parameters are significant. The orthogonality condition is also satisfied, seeing the value of the J-statistic. Unfortunately the parameters are incompatible with the economic theory. Indeed, γ_f is superior to the unit and γ_b is negative. Thus, the results are quite similar to those obtained by Galí and Gertler (1999). The difference is that in our case the coefficient of lagged inflation was negative, while for Galí and Gertler (1999) it was the output gap coefficient.

The restriction test was also rejected (details in Appendix B, Table 3). Therefore, economically the model is not accepted for quarterly data.

The robustness test was not realized due to the rejection of the model. In particular, we mean the stability test of sub-samples according to the critique of Lucas (1976).

In view of the preceding, the current data of the Algerian economy, whether annual or quarterly, do not allow us to conclude that the nature of inflation dynamics in this country is type hybrid NKPC.

4. Conclusion

Obtained results are very interesting. First, we concluded that the hybrid NKPC model, used in our study, is not appropriate to be exploited by the Bank of Algeria to characterize the dynamics of inflation in this country. However, the results are not surprising since the Galí and Gertler (1999) model is challenged by some recent studies. Such is the case, for instance, of the works of Dufour et al. (2006) and Abbas and Sgro (2011) that we mentioned in the introduction.

This being said, it is important to note that our study includes certain limits, relating mainly to the sample size and the absence of data on nominal wages in Algeria. The lifting of these limits could lead to other results.

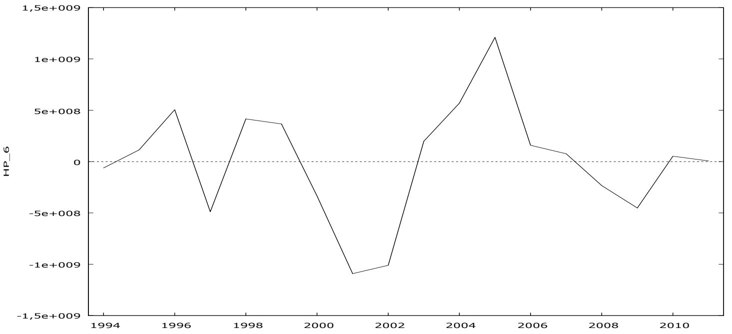
Obtained results raised another issue. The backward-looking coefficient ($\gamma_b = 0.26$) is similar to the forward-looking coefficient ($\gamma_f = 0.22$) of inflation. Hence, we cannot decide which aspect is dominant. For example, if the inflation dynamics were backward looking rather than forward looking, we could suggest investigating the baseline NKPC rather than the hybrid one. Unfortunately, this is not the case.

This is why we propose some directions for further research. In particular, we can point two interesting directions. The first is related to the role of foreign factors. Galí and Monacelli (2005), studying a small open economy, included the terms of trade and real exchange rate in the formula of the pure forward looking NKPC. The same can be done with a hybrid NKPC.

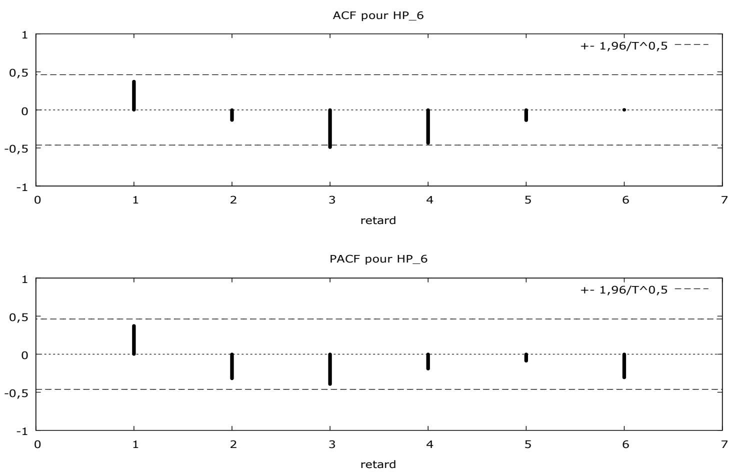
Second direction is related to the works of Zhang, Osborn, and Kim (2009). They suggested the use of more than one period lag inflation as regressors in the hybrid NKPC. Hence, the idea is to verify that the inflation dynamics in Algeria is more backward looking rather than forward looking.

Appendix A:

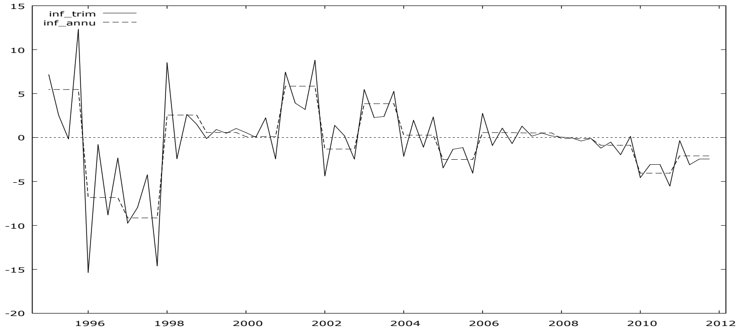
Graphic N°1: **Cyclical component of the output ($\lambda = 6.5$)**



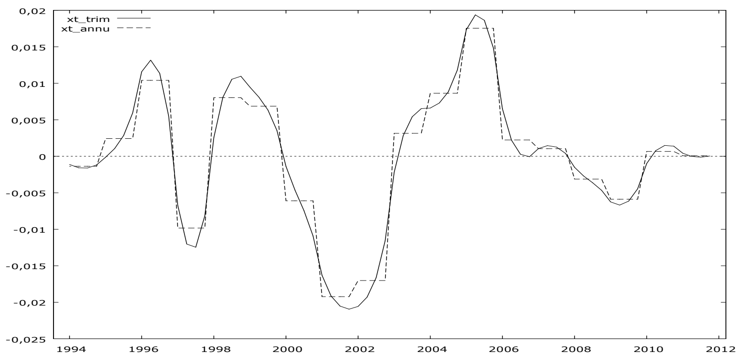
Graphic N°2 : **Correlogram of the output gap series**



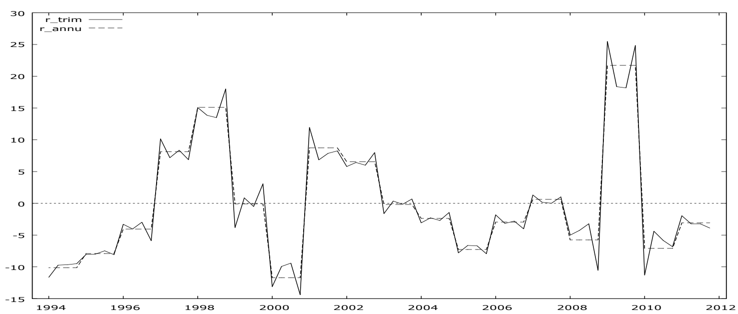
Graphic N°3 : **Inflation series**



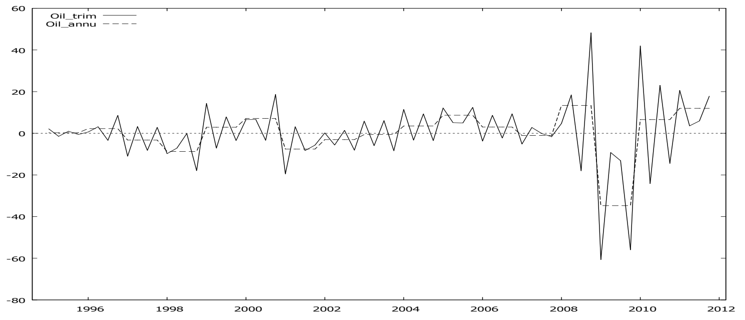
Graphic N°4 : **Output gap series**



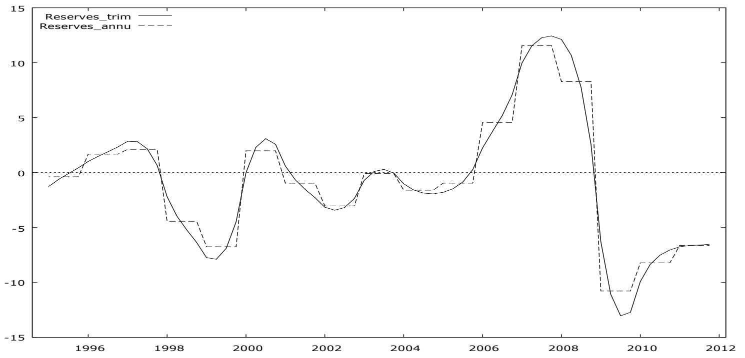
Graphic N°5 : **Real interest rate series**



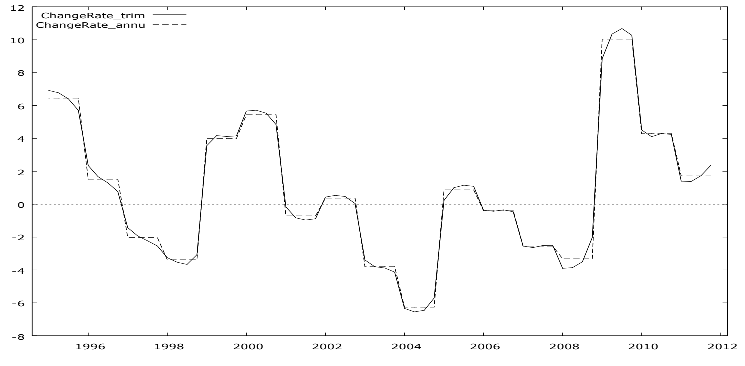
Graphic N°6 : **Oil prices series**



Graphic N°7 : **Algerian foreign currency reserves series**



Graphic N°8 : Exchange rate series



Appendix B

Tableau N°1: **ADF test of the inflation series**

Case I: Constant Only

Model: $(1-L)\pi_t = b_0 + (a-1)\pi_{t-1} + \epsilon_t$

	Coefficient	Std. error	t-ratio	p-value
b_0	0,009134	0,018592	0,4913	0,6291
π_{t-1}	-0,142401	0,121966	-1,168	0,6670

Case II: Constant and time trend

Model: $(1-L)\pi_t = b_0 + b_1 t + (a-1)\pi_{t-1} + \sum_{i=1}^{3} \alpha_i \Delta\pi_{t-i} + \epsilon_t$

	Coefficient	Std. error	t-ratio	p-value
b_0	0,115435	0,088142	1,310	0,2170
π_{t-1}	-0,466657	0,241775	-1,930	0,6385
$\Delta\pi_{t-1}$	0,348951	0,304057	1,148	0,2755
$\Delta\pi_{t-2}$	0,132450	0,251761	0,526	0,6093
$\Delta\pi_{t-3}$	0,417661	0,222751	1,875	0,0876 *
t	-0,005820	0,004906	-1,186	0,2606

Case III: Constant and quadratic trend

Model: $(1-L)\pi_t = b_0 + b_1 t + b_2 t^2 + (a-1)\pi_{t-1} + \sum_{i=1}^{3} \alpha_i \Delta\pi_{t-i} + \epsilon_t$

	Coefficient	Std. error	Z	p-value
b_0	0,758717	0,156827	4,838	0,0007 ***
π_{t-1}	-1,28118	0,238360	-5,375	0,0001 ***
$\Delta\pi_{t-1}$	0,762798	0,209531	3,640	0,0045 ***
$\Delta\pi_{t-2}$	0,298645	0,159373	1,874	0,0904 *
$\Delta\pi_{t-3}$	0,328183	0,138459	2,370	0,0393 **
t	-0,090353	0,019573	-4,616	0,0010 ***
t^2	0,002757	0,000630	4,371	0,0014 ***

Tableau N°2 : **Estimation of the model for annual data**

	Coefficient	Std. error	Z	p-value
x_t	8,35774	4,10893	2,034	0,0419 **
π_{t+1}	0,217166	0,00851	25,50	≈ 0 ***
π_{t-1}	0,260031	0,02730	9,523	≈ 0 ***

GMM criterion: $Q = 0{,}415438\ (TQ = 4{,}98526)$
J-test: $X^2\ (7) = 4{,}98526[0{,}6618]$

Restriction: $\gamma_f + \gamma_b = 1$
Statistic test: $X^2\ (1) = 272{,}37$ with $p - value \approx 0$

Tableau N°3 : **Estimation of the model for quarterly data**

	Coefficient	Std. error	Z	p-value
x_t	160,736	62,3115	2,580	0,0099 ***
π_{t+1}	1,10730	0,335244	3,303	0,0010 ***
π_{t-1}	-0,664505	0,142498	-4,663	≈ 0 ***

GMM criterion: $Q = 0{,}0914779\ (TQ = 5{,}76311)$
J-test: $X^2\ (7) = 5{,}76311[0{,}5677]$

Restriction: $\gamma_f + \gamma_b = 1$
Statistic test: $X^2\ (1) = 6{,}65599$ with $p - value = 0{,}00988232$

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