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ESTIMATING CENTRAL BANK BEHAVIOR IN ADJUSTING INTEREST RATES: EVIDENCE FROM ALGERIAN ECONOMY

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ABSTRACT: We develop in this paper an empirical framework to estimate the reaction function of Algeria's Central Bank using an augmented Taylor rule. Our purpose is to test the relationship between interest rates and the stated monetary policy goals of controlling inflation and stimulating output growth. We propose the use of Kalman filter technique to estimate both the unobserved variables and the parameters of the model. Our empirical findings based on quarterly data covering the period Q1:2000 to Q1:2019 on Algerian economy, which is considered as oil dependent and a dollarized small open economy, show that the Central Bank instrument does not have an effect on inflation and output gap.

Keywords : Monetary Policy, Taylor Rule, Unobserved Variables, Kalman Filter.

JEL Classification : E52, E58, C32, C54.

1. INTRODUCTION

To achieve the objective of price stability, Central Banks rely on intermediate objectives, such as monetary aggregate (a target for monetary base growth). However, the economic experience has shown that this target does not systematically contribute to lower inflation in a reasonable time. Indeed, in the short term the growth of monetary aggregate and inflation does not go on the same trend.

Taylor rule, which is a simple instrument linking nominal interest rate to inflation and output, remains the recognized instrument currently used in the conventional monetary policy. More generally, welfare maximization involves finding an appropriate policy rule that links interest rate to the target variables. This implies that control of the interest rate is sufficient to drive an optimal policy. Furthermore, this rule characterise the theoretical

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foundation of the Inflation Targeting approach, and provide an explicit justification of the links between the policy rate and the ultimate goals of policy.

In the emerging markets, other alternative goals can be assigned for a Central Bank. The announcement of targets for variables other than inflation, notably the exchange rate (as in fixed exchange rate regimes) or a monetary aggregate (a target for monetary base growth), are justified by the relative shallow depth of financial markets and the high degree of dollarization.

Furthermore, financial markets are more susceptible to sudden capital account reversals, and more likely to promptly respond to sudden movements in exchange rates when compared with developed countries. In emerging markets, the exchange rate volatility may affect inflation expectations, since this volatility generally affects the price of imported goods and it is reflected in the consumer price index. It may also affect the output gap by affecting supply and then employment decisions when changing the marginal rate of substitution between labour and capital. As used by Clarida & al. (2000), inflation and output gap are taken in the monetary policy rule, but emerging market Central Bank can choose to correct their rule for the exchange rate movements.

Svensson (1997) shows that more complex rules can be more effective to achieve the policy objectives, but Taylor-type rules remain quite optimal. However, the determination of the rule is impeded by a lack of temporary information for the variable inflation and output. Thus, several researchers and economists have criticized the rules determined by current data of inflation and output gap. In this context, most researchers and economists, including McCallum (1993) notes that this type of function is no longer operational given that needs information that policy makers do not have at the time of the decision. To make them feasible and effective, they suggest to replace these variables by forecasts of inflation and real output by taking into account the objectives of the central bank. This enables the connection of the available information, from which emerges the notion of Forward -looking of the rule.

We study in this paper the transmission mechanisms of the monetary policy in Algeria. Since 2000's; the macroeconomic context is characterized by a high liquidity due to hydrocarbon resource inflows. A rapid increase in the net foreign assets and in the public spending led to an important rise in liquidity. In this context, the interbank market becomes progressively sluggish and the Central Bank of Algeria shifted its operating lever from interest rates to liquidity management to contain the growth in liquidity. Monetary policy is established to compress inflation, by the increasing volumes of liquidity absorption with price controls combined to a relatively stable exchange rate.

The purpose of this paper is to estimate the behavior of the Central Bank with respect to key economic variables, such as inflation and output. We also try to estimate the reaction function of the Bank of Algeria in terms of adjusting its interest rates by inspiring, like many Central Banks around the world, from monetary policy rule of Taylor-type. Therefore, the following question is asked: what is the most likely specification of the monetary policy rule that reflects the behavior of the Bank of Algeria to the main macroeconomic variables such as inflation and output gap?

We will estimate an empirical model, subsequently by imposing different implicit assumptions:

- First, the response of the Central Bank is not immediate, i.e. we assume that the Bank of Algeria considers smoothing interest rates and therefore the lagged interest rate is included in the rule.

- Second, the Central Bank is concerned with only the economic environment, which means that we do not accept the systematic changes in the behavior of the Central Bank even if it is influenced by an internal mechanism or political influence.
- Third, we still assume that, in equilibrium, money demand equals to the money supply.

2. THE EMPIRICAL MODEL

Interest rate rules, as proposed by Taylor (1993) summarize the optimal monetary policy rule by a simple reaction function of the form:

$$i_t = \alpha_t + \theta_x x_t + \theta_\pi \pi_t + \varepsilon_{1t} \quad (1)$$

This rule states that the monetary policy rate should respond to a natural rate of interest α_t. Thus, the Central Bank perfectly stabilizes inflation and output gap taking into account the shocks of natural interest rate according to Woodford (2003).

Moreover, given the criticism advanced by McCallum (1993) notes that the formulation of Taylor is not operational given it needs information that policy makers do not have. Hence, according to some authors, data on current inflation and current output need to be replaced by their forecasts.

Our empirical model is formulated by assuming that the Central Bank follows an augmented Taylor rule in a forward-looking perspective in the framework of adjusting its interest rates to control inflation and stabilize production. In other words, the reaction function of the Bank of Algeria responds to changes in inflation expectations, to the output gap and to a natural interest rate that remains to be defined.

The basic model is written as follows:

$$i_t = \alpha_t + \theta_x x_t + \theta_\pi \pi^e_{t\backslash t+1} + \varepsilon_{1t} \quad (2)$$

Where:

i_t: is the interest rate;

x_t: is the output gap;

$\pi^e_{t(t+1)}$: is the expected inflation of $(t+1)$ expected at time *t;*

α_t : the natural rate which we will replace by the money gap demand $\mathrm{m}^{\mathrm{g}}_{\mathrm{t}}$.

By putting the assumption that the Central Bank smooths its interest rate, the model is written:

$$i_t = \theta_m m^g_t + \theta_i i_{t-1} + \theta_x x_t + \theta_\pi \pi^e_{t\backslash t+1} + \varepsilon_{1t} \quad (3)$$

Moreover, the deviations of exchange rate affect inflation expectations. In this context, inflation is not directly observable by the Central Bank, but it can be inferred in a way that it is compatible with the state of the economy as described by the model. This leads to the following specifications:

$$m_t = \varphi m_{t-1} + (1-\varphi) m^p_t - m^g_t + \varepsilon_{2t} \quad (4)$$

$$m^g_t = \lambda m^g_{t-1} + \varepsilon_{3t} \quad (5)$$

$$m^p_t = m^p_{t-1} + \psi_{t-1} + \varepsilon_{4t} \quad (6)$$

$$\psi_t = (1-\eta)\psi_0 + \eta\psi_{t-1} + \varepsilon_{5t} \quad (7)$$

For the output gap, it is identified as follows:

$$x_t = \tau_1 x_{t-1} + \tau_2 r_t + \tau_3 q_t + \tau_4 \pi_t + \varepsilon_{6t} \quad (8)$$

Expected Inflation is : $\pi^e_{t\backslash t+1} = E_t(\pi_{t-1})$

Where:

$$\pi^e_{t\backslash t+1} = \alpha_1 \pi_t + \alpha_2 \Delta S_t + \alpha_3 \Delta S_{t-1} + \varepsilon_{7t} \quad (9)$$

Such as:
r_t: is the real rate of interest expressed by the Treasury bounds rate at 3 months (BTC);
q_t: is the real effective exchange rate;
π_t: is the current inflation rate (observed);
ΔS_{t-1}: is the deviation of the nominal exchange rate in period t relative to period t-1;
ΔS_{t-2}: is the deviation of the nominal exchange rate in period t relative to period t-2;
ψ_t: is the rate of growth of potential money supply;
η_t : is the persistence of deviations from the potential supply.

Finally, θ_m, θ_i, θ_x, θ_π,φ,η ,ψ_0,λ,$\tau_{1,t}$,$\tau_{2,t}$,$\tau_{3,t}\tau_{4,t}$, α_1,α_2, and α_3,are coefficients to be estimated and ε_{1t},ε_{2t},ε_{3t},ε_{4t},ε_{5t},ε_{6t} and ε_{7t} represent standard errors of the system are assumed i.i.d. with mean zero and constant variances $\Sigma_1, \Sigma_2, \Sigma_3, \Sigma_4, \Sigma_5, \Sigma_6$ and Σ_7 respectively, to be estimated.

Equation (2) is an augmented Taylor rule that we adopt in our estimations, and it represents our basic model. The Central Bank responds to changes in expected inflation, described by the term $\pi^e_{t,t+1}$and the difference of the current output to its potential level (output gap), described by the term x_t. The variable α_t represents the natural interest rate to which the Central Bank is facing as specified by Woodford (2003).

Simple interest rate rules as in equation (1) are interesting themselves, but they are considered very effective for the conduct of an optimal monetary policy, which is generally more complicated in a wide range of models.

The main drawback of the interest rate rule (1) is that the natural interest rate and the output gap are difficult to measure. Consequently, the practical applications of this rule often replace the natural interest rate, which changes over time by a constant specific term. However, the Central Bank does not respect the natural interest rate, and instead of replacing it by a constant term, the Central Bank can meet the standard money demand m_t^g (Berger & Weber, 2012).

The introduction of a lagged dependent variable of i_{t-1} reflects the inertia of monetary policy or the adjustment of the Central Bank interest rate. The formulation used here assumes that the dynamics of the interest rate is autoregressive of order 1 (AR (1)), in accordance with the choice made more generally. From a theoretical point of view, Woodford (1999) has indeed demonstrated in the framework of a simple model taking into account an optimizing behavior of private agents that a certain degree of inertia of the interest rate of the Central Bank could be optimal. From a more practical point of view, the smoothing of the rates by the Central Bank can be explained by its concern to preserve its credibility by avoiding excessive volatility of the director rate or to limit the impact on long rates (geometric average of expected future short rates). This is what brings us to estimate equation (3).

In order to transmit the model to the state-space setup, we add the following different specifications of the natural interest rate, the output gap and the expected inflation.

2.1. The natural interest rate and the demand for money

The demand for money can play an important role in identifying the natural interest rate, which is difficult to measure, because both variables depend on the marginal utility of consumption. The link between the demand for money and the natural interest rate has been examined by Woodford (2003), Gali (2008) and Walsh (2010) in the context of a New Keynesian model. According to these authors, a practical method to extract information on the natural interest rate from the demand for money is to calculate the money demand gap $\mathrm{m}_\mathrm{t}^\mathrm{g}$.

The money demand gap, as in the work of Berger and Weber (2012), is the difference between potential demand for money and the real or current demand for money. By integrating the dynamic demand function for money that emphasizes the partial adjustment as specified in equation (4) : the real demand for money partially adjusts to the previous demand for money m_{t-1}, at rate φ and at the potential demand for money m_t^p. The remaining part of real demand money is money gap demand m_t^g.

The equation (5) represents the evolution of money demand gap which is autoregressive of order 1.

Equation (6) describes the evolution of the demand for money. We specify a random walk with a drift (trend), where the growth rate of the potential demand for money, ψ_t, is time dependent. The last is expressed by Equation (7), persistence of the growth rate is expressed by an AR (1) process with η_t represents deviation persistence of long-term growth rate ψ_0.

2.2. Expected Inflation

Equation (9) expresses the dynamics of inflation expectations, $\pi^e_{t,t+1}$, with the current rate of inflation π_t and changes in nominal exchange rates lagged by one period and two periods, respectively $\Delta S_t$and ΔS_{t-1}. The last reflects the effect of past exchange rate (pass-through). The pass-through effect measures the effect of a change in the exchange rate on prices through changes in the prices of imported products.

Moreover, given the openness of the economy, external shocks are transmitted through exchange rate fluctuations. These movements can influence inflation expectations as they affect generally the prices of imported goods, and hence the consumer price index.

Ample evidence from the literature indicates the importance of exchange rate fluctuations in determining the future price level. Kara & Ögunç(2005) provide evidence for the Turkish case, that the pass through effect is relatively high which might justify looking at effect of exchange rates fluctuations on expected inflation separately, rather than including exchange rates explicitly in a Taylor rule that already includes expected inflation.

2.3. Output Gap

Equation (8) defines the dynamics of the output gap. Instead of modeling the output gap by a purely stochastic process, we introduce variables that can provide additional information on the evolution of the output gap (Sarikaya & al., 2005). The variables used in this equation were chosen to determine the major macroeconomic variables that can affect real output but not potential output. The main variables considered are the output gap lagged one period x_{t-1}, current inflation π_t and the real effective exchange rate q_t. Although these factors are essential to explain the performance of the output in the short term, they are perceived as being more effective on the demand side and therefore neutral for the behavior of potential output in the short term. Consequently, these variables appear in the equation of the output gap to account for the difference between effective GDP and its potential level.

In this regard, the real interest rate fulfils its traditional role which is affecting consumption and investment behavior in the economy. The inclusion of π_t is supposed to capture the business anticipations on demand conditions, which might be a determinant factor of the output gap and the real interest rate.

Although the role of inflation and real interest rates in the entire system are clear, the role of the dynamics of the exchange rate on the output gap is less certain and should be discussed. From a theoretical point of view, the relationship between inflation and the output gap is positive; it may be due, in part, to another factor that could affect these variables simultaneously. Therefore, the real exchange rate can play this role.

In addition, the real exchange rate affects the output gap through two distinct and opposing channels. First, an appreciation led to a decline in the relative price of imported goods and led to a temporary increase in effective demand, which increases the gap between real output and potential output. Second, in a country where equipment goods are imported for most time, an appreciation of the exchange rate induces firms to substitute capital for labor, leading to an increase in labor productivity, and increasing thereby potential output. Furthermore, such appreciation will lead to lower costs of imported intermediate goods, which would increase supply to the economy. The question of which of these factors dominates may depend on the specific state of the economy.

Therefore, the net effect of exchange rate variations on the output gap is not clear. Various factors such as the elasticity of the exchange rate of net exports, the magnitude of pass-through exchange rate, and the importance of imported capital goods into the global production must be taken into account to achieve a robust conclusion (Sarikaya *& al.*, 2005).

Finally, several other measures of the exchange rate could be used both in the specification of the inflation and the output gap equation. We consider a common variable, which could be effective in both the inflation rate and the dynamic of the output gap might be more appropriate to identify links between the dynamics of output, inflation and exchange rate. Therefore, the real effective exchange rate will be used for specifying the output gap (8) and changes in nominal exchange rate will be used in the equation of expected inflation (9).

Equation (9) describes the effect of past exchange rates (pass-trough), so nominal rates are used while equation (8) is a specification of the Philips curve of an open economy. That means that all the variables are real and therefore the real effective exchange rate is used for this equation.

The above model can be expressed in state-space form defined by the following system $[(10),(11)]$:

$$Z_t = AZ_{t-1} + BX_{t-1} + u_{t-1} \tag{10}$$

$$Y_t = CZ_t + DW_t + v_t \tag{11}$$

Where Y_t is an $k\times 1$ vector of observed variables, X_t and W_t are $i\times 1$ and $j\times 1$vectors of predetermined or exogenous variables. Z_t is a $n\times 1$ vector of unobserved state variables. A, B, C and D are coefficient matrices.

The state equation (10) is obtained by combining the equations (5), (6), (7), (8) and (9):

$$\begin{pmatrix} m_t^g \\ x_t \\ \pi_{t,t+1}^e \\ m_t^p \\ \psi_t \end{pmatrix} = \begin{pmatrix} \lambda & 0 & 0 & 0 & 0 \\ 0 & \tau_1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & \eta \end{pmatrix} \begin{pmatrix} m_{t-1}^g \\ x_{t-1} \\ \pi_{t-1,t}^e \\ m_{t-1}^p \\ \psi_{t-1} \end{pmatrix}$$

$$+ \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ \tau_3 & \tau_2 & 0 & 0 & 0 & \tau_4 \\ 0 & 0 & \alpha_2 & \alpha_3 & 0 & \alpha_1 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & (1-\eta)\psi_0 & 0 \end{pmatrix} \begin{pmatrix} q_t \\ r_t \\ \Delta S_t \\ \Delta S_{t-1} \\ 1 \\ \pi_t \end{pmatrix} + \begin{pmatrix} \varepsilon_{3,t} \\ \varepsilon_{6,t} \\ \varepsilon_{7,t} \\ \varepsilon_{4,t} \\ \varepsilon_{5,t} \end{pmatrix}$$

The measurement equation (11) is obtained by combining equations (3) and (4):

$$\begin{pmatrix} i_t \\ m_t \end{pmatrix} = \begin{pmatrix} \theta_m & \theta_x & \theta_\pi & 0 & 0 \\ -1 & 0 & 0 & (1-\varphi) & 0 \end{pmatrix} \begin{pmatrix} m_t^g \\ x_t \\ \pi_{t,t+1}^e \\ m_t^p \\ \psi_t \end{pmatrix} + \begin{pmatrix} \theta_i & 0 \\ 0 & \varphi \end{pmatrix} \begin{pmatrix} i_{t-1} \\ m_{t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{pmatrix}$$

We then estimate the unobservable components as well as the parameters of the state-space model using the Kalman filter algorithme.

3. DATA AND METHODOLOGY

We used in this paper quarterly data covering the period (Q1:2000 to Q1:2019. The choice of a quarterly rather than monthly frequency, sometimes used in other studies, returns to the lack of data for some variables on the one hand and the difficulty of estimating a monthly GDP on the other hand. This choice does not diminish the interest of the study because the economic and monetary policy is oriented towards a goal of maintaining price stability in the medium term.

3.1. Data: sources and processing

The data used are taken from the following sources: the National Statistics Office (ONS) for Consumer Price Index (CPI), the Ministry of Finance for quarterly Gross Domestic Product (GDP) and the International Monetary Fund (IMF) database for monetary data such as : money supply (M2), interest rates and nominal exchange rate, treasury bonds (BTC of 3 months) and then real effective exchange.

Prior to the estimation of the empirical model, preliminary tests must be run. In order to avoid spurious results, it was imperative to ensure the stationarity of the variables using unit root tests (Augmented Dickey and Fuller (ADF)).
Series of variables (Stationary Series) used in the estimation are summarized in the following table:

Table N°1: Summary of data

Model Variables	**Stationary Series**	**Description**
$\boldsymbol{m_t}$	dm2	Money supply aggregate M2
$\boldsymbol{\pi_t}$	inflation	The current inflation rate measured as follows: $inflation_t = 100 * [(PCI_t - PCI_{t-4})/PCI_{t-4}]$ Where: t is the time index, it represents the quarters.
$\boldsymbol{r_t}$	BTC	Real rate expressed by the rate of Treasury bonds at three months
$\boldsymbol{i_t}$	interbank	Interest rate (interbank market rate)
$\boldsymbol{q_t}$	TCER	The real effective exchange rate
$\boldsymbol{\Delta S_t}$	TCN1	The change in nominal exchange rate (DA/USD) from the previous period at time t

Source: Elaborated by authors

3.2. Methodology of estimation

Our methodology finds its origins in the literature dealing with the estimation of real time forward-looking Taylor rule specification. This approach allows us to track the Central Bank behavior in his process of stabilizing inflation (Hatipoglu & ALPER, 2008). Our full empirical model is estimated using the Kalman filter algorithm, which allows us to estimate, at the same time, the unobserved variables and the parameters of the model.

3.3. Computational algorithm of Kalman filter

The state filter uses an a priori state estimate (vector of initial values) and an a priori parameter estimate to produce a current state estimate. The current state estimate is then updated using the measurements taken on observed variables to produce an a posteriori state estimate. The parameter filter, on the other hand, uses the a priori state estimate to produce a current parameter estimate, and then it updates it using the current state estimate and the measurements taken on the observed variables.

In our case, unobservable state variables will be initialized as follows:

- money demand gap is initialized by the standard deviation of the demand for equilibrium money : $m_0^g = \sqrt{\sum_{t=1}^{T} \frac{(m_t - \overline{m_t})^2}{(T-1)}}$;
- expected inflation is initialized by the mean of current inflation : $\pi_{0,1}^e = \frac{\sum_{t=1}^{T} \pi_t}{T}$;
- potential money demand is initialized by the mean of demand for equilibrium money: $m_0^p = \frac{\sum_{t=1}^{T} m_t}{T}$;
- the output gap is initialized by the mean of the output gap estimated by HP filter.

Regarding, the initial parameters, and to deal with the convergence problem of the algorithm used for the log-likelihood maximization, we use the Globalsearch function of the MATLAB software. The Globalsearch function makes it possible to identify, in the case where the objective function (- log likelihood) admits several local minimums, the potential global minimum. For this, the Globalsearch function starts from several starting points in order to find this minimum (see appendix).

4. ESTIMATION RESULTS AND DISCUSSION

We present the findings after estimating our empirical model using the interbank market rate as instrument of monetary policy, the obtained results are presented as follows:

Figure N°1: Estimation results

Value of likelihood	77.8393			
Number of parameters	22.0000			
parameter	beta	stderr	t-student	p-value
1	22.4235	76.1410	0.2945	0.7695
2	0.1562	0.1126	1.3874	0.1710
3	-0.0204	0.0117	-1.7509	0.0856
4	-0.1234	0.2771	-0.4454	0.6578
5	0.6843	0.1232	5.5546	0.0000
6	0.0008	4.3886	0.0002	0.9999
7	-2.2368	0.4813	-4.6478	0.0000
8	1.0000	4.7021	0.2127	0.8324
9	0.2180	0.7382	0.2953	0.7689
10	0.7429	0.4610	1.6113	0.1130
11	-32.6914	60.0652	-0.5443	0.5885
12	-1.5778	0.7424	-2.1254	0.0381
13	-1.4447	2.8758	-0.5023	0.6175
14	5.8589	39.4566	0.1485	0.8825
15	1.0000	0.1092	9.1550	0.0000
16	0.6597	0.3133	2.1057	0.0399
17	0.0005	0.0062	0.0795	0.9369
18	0.0000	0.0001	0.0000	1.0000
19	5.6290	2.7847	2.0214	0.0482
20	7.6800	21.0053	0.3656	0.7161
21	0.0001	0.0061	0.0082	0.9935
22	1.0000	0.2241	4.4618	0.0000

Source: From MATLAB software

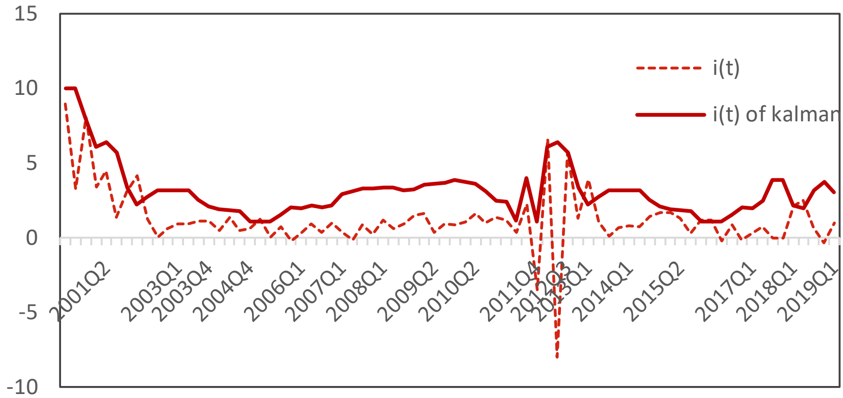
Estimation results display (07) significant parameters at 5% threshold: $\theta_i, \tau_1, \alpha_2, \psi_0$ and the other parameters are the variances of the equation of state. These results can be interpreted as follows:

- The Bank of Algeria's reaction function adjusts only to changes in the interest rate of the previous period, with a high positive coefficient (θ_i =0.68);
- The natural interest rate does not seem to be explained by the demand for money and therefore does not explain the behavior of the interest rate;
- Expected inflation responds only to changes in nominal exchange rates lagged by one period (α_2=-1.57);
- According to the same results, no economic variable, such as expected inflation and output gap, enters into the determination of interest rate level. Thus, the adjustment of this instrument does not seem to be induced by the effect of the other economic variables of the model.

In general, the policy rate instrument can not represent the behavior of the Central Bank. Therefore, it can not be used as an effective control instrument for adjusting inflation and stimulating output.

To compare the actual series and the Kalman smoothing, we present the following graph of the measurement variable i_t and the corresponding smoothed series:

Figure N°2: Filtering the interest rate Series i_t



Source: Elaborated from the results of programming with MATLAB software

To assess the quality of the smoothing, we calculate the Euclidean distance between the vector i_t and the conditional vector (i_t of kalman), given by the following formula:

$$d_{i,i\ cond} = \sqrt{\sum_1^T (i_t - i_t\ cond)^2} = 23.99$$

The graph of figure N°2 shows that the smoothing of the measurement variable is not good and therefore does not effectively represent its real variable. This finding is confirmed by the high value of the Euclidean distance. Having said that, the interbank market rate, as instrument of monetary policy in Algeria, does not react to fluctuations in the explanatory variables of the presented model.

However, we notice in figure N°2 that the kalman smoothing of the series i_t has globally the same tendency as the real series. This may be due to the adjustment of the interest rate to its past value, which confirms the estimation results presented in the table of figure N°1.

5. CONCLUSION

This paper focused on estimating the behavior of the Central Bank and the interest rate adjustment mechanism in Algeria. In order to study this issue, we used a Taylor-type monetary policy rule to estimate the model using Kalman filter algorithm. The study was conducted over the period from (Q1: 2000 to Q1: 2019).

A typical Taylor rule involves a response of monetary policy rate (interest rate) to inflation and output gap, which has not been captured by our empirical model.

The estimation findings reveal that the interbank market rate, as instrument of monetary policy, does not seem the best to represent the behavior of the Central Bank in Algeria. However, the conduct of this instrument over the period of study shows that the Bank of Algeria applies an interest rate adjustment policy, which is not close to the theoretical foundation of the Taylor rule. Relevant economic interpretation of the results seems more difficult because of the lack of consistent macroeconomic policies.

The model presented in this paper can be useful in studying Bank of Algeria's behavior by relaxing the second hypothesis of systematic changes. This leads to allow for time-variable coefficients and thus to estimate a time-varying Taylor rules.

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APPENDIX

MATLAB code for optimization

```
function  optim
load y
load VV
load U

a0 =zeros(5,1);
P0 = zeros (5,5);
a0(1)= std(y(:,2));
a0(2)=-2.20;
a0(3)= mean(U(:,6));
a0(4)= mean(y(:,2));
x0 = 0.01*ones(22,1);

%Dimensions
Z = zeros(2,5);
D = zeros(2,2);
T = zeros(5,5);
B = zeros(5,6);
H = zeros(2,2);
Q = zeros(5,5);

%Optimisation
opts=optimset('UseParallel','always','algorithm','sqp','displ
ay','final','MaxFunEvals',5000,'MaxIter',10000,'TolCon',1e-
6,'Tolx',1e-6);
kalfi = @(x)Kalman_fil(x,y,Z,D,T,B,H,Q,VV,U,a0,P0);
problem =
createOptimProblem('fmincon','x0',x0,'objective',kalfi,'Aineq
',A,'bineq',bb,'options',opts);

gs = GlobalSearch
[x,fval,exitflag,output,solutions] = run(gs,problem);
xmin=x;
save('xmin.mat', 'xmin')
save('solutions','solutions')
save('fval.mat', 'fval')

%P values
[beta,stderr1,vc,logl]=Max_lik(@ml,xmin,fval,'Sandwich',...
    y,Z,D,T,B,H,Q,VV,U,a0,P0);
```

```
%Results besides parameters
par=beta;
[Z,D,T,B,maxlogl,y_cond,P,P_cond,v,a,a_cond,F,K_gain,H,Q] =
Kalman_filterbis(xmin,y,Z,D,T,B,H,Q,VV,U,a0,P0);

% Saving results
save('Z.mat', 'Z')
save('D.mat', 'D')
save('T.mat', 'T')
save('B.mat', 'B')
%save('maxlogl.mat', 'maxlogl')
save('y_cond.mat', 'y_cond')
save('P.mat', 'P')
save('P_cond.mat', 'P_cond')
save('v.mat', 'v')
save('a.mat', 'a')
save('a_cond', 'a_cond')
save('F', 'F')
save('K_gain.mat', 'K_gain')
save('H', 'H')
save('Q', 'Q')
```