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Abstract

This paper estimates the Taylor rule under the static version, then the dynamic version of the Central bank of Tunisia (CBT), using monthly data from 2002:Q1 to 2014:Q12. The empirical results indicate that the CBT followed the Taylor rule in its dynamic version.

1.Introduction

Taylor (1993) was the first who proposed a simple rule to model the monetary policy of federal funds. Such a rule provides a focal point for discussing the reaction functions and is increasingly used as a very famous reference in monetary policy discussions. This rule can be used to evaluate the subsequent monetary policy and to ensure the determination of future policy. It shows an increase in interest rates when inflation is above its target level and a decline in a recession. In his study of US data Taylor (1993) assumed that both inflation target rate and equilibrium real interest rate are equal to 2%. Because the Federal Reserve Bank aimed the stability of inflation and economic activity, it granted two coefficients equal to 0.5 for the deviation of inflation and output-gap. However, several theoretical[1] and empirical studies concerned with the exploitation of optimality conditions of this rule for the conduct of monetary policy.

Aims its simplicity, several economists have criticized this rule because it is unlikely that such a rule is optimal for all countries, especially since the economy is more complicated and its structure varies across countries. In this context, McCallum (1993), noted that this type of function that is to say according to current data has not been operational since it needs the information due to the political decision makers don't have actually.

Svensson (2003), showed that although the primary objective of monetary policy is the stability of inflation and output, a simple Taylor-type rule will not be optimal within a reasonable macroeconomic model. In the years ninety, economists have criticized the Taylor

[1] On the theoretical level, given a quadratic loss function of the central bank and linear curves of demand and aggregate supply, in the dynamic structure of the economy, we can get the Taylor rule by minimizing the loss function .

rule on variable timings. To solve this problem, the first reflections expressed the interest rate based on the values delayed in inflation and output. It's called "Backward-looking model." The fundamental principle of this type of model is to implicitly assume that private sector expectations are adaptive. It results in retrospective rules "Backward-looking". Many economists have criticized these types of rules. The most famous criticism is that of Lucas (1970), he studied how agents form their expectations of the future influencing actual behavior. According to Lucas economists do not change their behavior, based on past policies and static to describe the future behavior of agents.

In addition to the Lucas critique, when following a version rule Backward -looking, the instrument of monetary policy reacts only to shocks transmitted by these two variables. However, in the presence of other types of shocks, such a rule does not lead to the price stability objective. furthermore, a central bank adopts a Backward-looking rule can achieve short-term goals rather than long-term goals.[2]

Given the limitations of the rule type Backward-looking, recent research, such as that of Clarida, Gali et Gertler (1999), Svensson (2002) et Woodford (2004), argue that the models based on future expectations of economic indicators are better than those that meet the present or past variables. However, in practice central banks do not tend to take the past or current inflation as a target but expected inflation. Therefore, many researchers as Gali and Gertler (1998), Kozicki (1999), Clarida, Gali, and Gertler (2000) and Mayes et al (2000) have introduced inflation expectations and / or production for building a forward-looking version of the Taylor rule. In the late ninety, economists like Ball (1999), Svensson (2000) et Taylor (1999b) have criticized the Taylor rule on the point of failure of other key variables such as the exchange rate is an important variable in an open economy. The objective of this work is to determine the nature of the rule that better reflect the behavior of the central bank of Tunisia. This paper is organized as follows. Section 2 reviews the previous literature studies. Section 3 describes the data used in this paper. Section 4 introduces the basic methodology used in this paper. Section 5 discusses the empirical results. Section 6 draws conclusions.

2. Literature review

After Taylor (1993), many economists estimated Taylor rule and its extensions. Indeed, McCallum (2000) used historical analysis to estimate a Taylor rule by using the economic

[2] the interest rate response to past changes in inflation will create more of the variability in the level of inflation than desired

data of U.S and U.K for the period from 1962 to 1999, and Japon from 1972 to 1998. He suggested that rules messages are dependent upon which instrument rather more than which target variable is used.

Clarida, Gali and Gertler (1998) studied and tested forward-looking monetary policy to study the behaviour of central banks in the United States, Japon and some European countries. They used the Generalized Method of Moments (GMM). The result showed that the Central banks in these countries followed the Taylor rule in their interest setting behavior[3].

Following Clarida et al (1998.2000), Ghadha, Sarno and Valente (2004) studied empirically whether asset prices and exchange rates may be included in a standard interest rate rule by using the data for the United States, the United kingdom and Japon since 1979. The result showed that asset prices and exchange rates can be utilised as information variables for a standard Taylor rule.

Gorter, Jacobs and De Haan (2008) estimated Taylor rules by using Consensus Economics data for expected inflation and output growth, for the euro area, they found that ECB takes expected inflation and expected output into account in the setting interest rates. They showed that the indications of accommodating behavior by the ECB implied by contemporaneous Taylor rule seem to be mainly driven by the lack of a forward-looking perspective.

Some empirical studies focused on emerging countries, they have estimated monetary policy rules of central banks in these countries.

Yazgan and Yilmazkuday (2007), estimated forward-looking monetary policy rules for Israel and Turkey, the results showed that forward-looking Taylor rules seem to provide a reasonable description of central bank behaviour in both countries. Aklan and Nargelecekenler (2008) estimated the backward-looking and forward-looking monetary policy reaction functions of the central bank of the Republic of Turkey (CBRT). They suggest that CBRT followed the Taylor rule in its interest setting behaviour. The response coefficient of inflation and output gap is more greater in the forward-looking model than in the backward-looking model.

De Carvalho (2012), estimated Taylor rules by using the Consensus Economic Forecasts database for four largest Latin American economies, he used the GMM and real-time data of

[3] see for example Clarida et al (1999, 2000), Gerlach and Schnabel (2000), Orphanides (2001), Gerdesmeier and Roffia (2003), Huston and Spencer(2005), Taylor and Darvradakis (2006).

the output gap in Brazil and Mexico. He found that only for Mexico, interest rate market forecasts can be explained by Taylor rules.

3.Data and stylized facts

In this study, we use monthly data from 2002 M1 to 2014 M12 of the interest rate, that was used as a proxy for the money market short-term interest rate. The seasonally adjusted industrial production index (IPI) was used for the measure of the output gap. The output gap is defined as the change in the log of the observed output from its potential trend. The expression of this variable is given by:

$$output\ gap = 100 * (\frac{\text{IPI}- \text{potential IPI}}{\text{potential IPI}})$$

In economic literature, the methods of determination of potential output are diverse, namely, the method of estimating a production function and its factors. A second, by Hodrick Prescot (HP), and a third method of adjusting a linear trend with any disruptions.

Several studies conducted tests of robustness of their estimates with different measures of the output gap. The majority of these studies showed that the HP filter can give a good estimate of the potential output is unobservable variable, since it reduces the fluctuations around the trend component. Therefore, we use the HP filter to estimate the potential output with a coefficient (λ = 14400) because the data are monthly. The index of consumer prices (CPI), and real effective exchange rate. These data are available in the database of the Central Bank of Tunisia (BCT) and the International Financial Statistic (IFS).

4.Methodology

Taylor (1993) suggests a very specific and simple reaction function of monetary policy that can be described by the contemporary inflation and the output gap given by:

$$i_t^* = \bar{r} + \pi_t^* + \alpha(\pi_t - \pi_t^*) + \beta y_t \quad (1)$$

with:

i_t^* the interest rate targeted by the central bank. In other words, it is the rate only in response to changes in inflation differentials and outptut gap, π_t the inflation rate, π_t^* Variable target for inflation, $\bar{r}$ the real interest rate of long-term equilibrium, α the amount by which the central bank raises the real interest rate in ex-post response to a rise in inflation to its target level, y_t the output gap in period t it comes to the difference between actual output and potential, β amount by which the central bank raises the real interest rate in response to an increase in real output above its potential level. In practice, central banks aim to smooth the interest rate. However, the reaction function is then described in terms of partial adjustment of interest rates[4]. The interest rate smoothing can be introduced into the model by means of the following partial adjustment mechanism[5]:

$$i_t = (1-\rho)i_t^* + \rho i_{t-1} + \nu_t \quad (2)$$

The smoothing parameter ρ ϵ [0.1], with this partial adjustment the central bank at each period adjusts his instrument to remove only a fraction (1-ρ) of the gap between the current target level and some linear combination of its past values.

Following Taylor (1993), Clarida et al (1998, 1999, 2000) and Aklan and Nargelecekenler (2008), we specify the reaction function of the central bank where i_t^* is the nominal interest rate target for the short term of the central bank.

$$i_t^* = \bar{r} + \pi_{t+n}^* + \alpha\left[E\left(\frac{\pi_{t+n}}{\Omega_t}\right) - \pi_{t+n}^*\right] + \beta E\left(\frac{y_t - y_t^*}{\Omega_t}\right) \qquad (3)$$

Where $\bar{r}$ is the real interest rate of long-term equilibrium, π_{t+n} the inflation rate between the period t and t+n, π_{t+n}^* the inflation target for the period formed at the period t, α et β are parameters that describe the response of the policy rate to deviations of inflation and output from their targets respectively. E() expectation operator, Ω_t the information provided for the period t. if Equation 2 and 3 are combined, the result is as follows:

$$i_t = (1-\rho)\{\bar{r} + \pi_{t+n}^* + \alpha\left[E\left(\frac{\pi_{t+n}}{\Omega_t}\right) - \pi_{t+n}^*\right] + \beta E\left(\frac{y_t - y_t^*}{\Omega_t}\right)\} + \rho i_{t-1} + \nu_t \quad (4)$$

if the expression of the mathematical expectation is excluded, the result follows:

$$i_t = (1-\rho)\phi + (1-\rho)\alpha\pi_{t+n} + (1-\rho)\beta x_t + \rho i_{t-1} + \mu_t \ (5)$$

Where $\phi = \bar{r} + \pi_{t+n}^*$, $x_t = y_t - y_t^*$, $\mu_t = -(1-\rho)\left\{\alpha\left(\pi_{t+n} - E\left[\frac{\pi_{t+n}}{\Omega_t}\right]\right) + \beta\left(x_t - E\left[\frac{x_t}{\Omega_t}\right]\right)\right\} + v_t$, μ_t is an error term which is not correlated with information at the instant t.

Specification of Clarida et al (1998, 1999,2000) are implicit rules with fixed targets. In the existing literature, Eq. 5 is usually estimated by the GMM. In order to determine which specification represents better the policy followed by the Central Bank of Tunisia. This study estimates the Taylor rule in the statistical version, the dynamic version and the forward-looking rule.

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[4] Several researchers like McCallum (1999) Levin et al (1999) argue that a Taylor rule type with an interest rate smoothing is relatively robust.

[5] voir Clarida et al (1998, 2000).

5. Results and Interpretation

We begin this empirical work by evaluating the Taylor rule in the traditional version. then we estimate the Taylor-type reaction function.

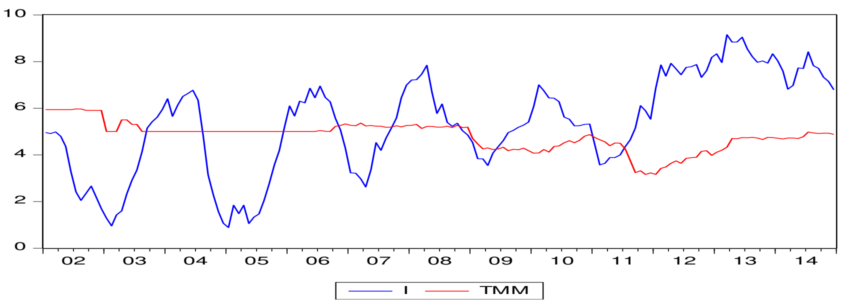
- *Evaluation of the traditional Taylor rule (RTT)*

The aim is to determine whether the traditional Taylor rule translates the behavior of policy makers of the Central Bank of Tunisia . The results of the equation (1) presented in Table 1.
In this framework we adopt the idea of Ftiti (2010), which consists to calculate an interest rate i_t named the Taylor rate from the equation (1) then we will compare this rate with the interest rate of the monthly money market (tmm). When rates are statistically equal, we can conclude that the traditional Taylor rule is optimal. In contrast the rule will not be optimal and therefore we will try to find the optimal rule among the Taylor-type rules.

Table.1 Descriptive Statistics of Taylor rates (i) and the monthly money market interest rates (tmm)

Series	N[6]	Mean	DS[7]	Min	Max
Tmm	156	4.810	0.603	3.160	5.970
I	156	5.315	2.089	0.882	9.152

figure.1 Correlogram of the response of interest rates (in case of expansion) for Tunisia



according to the results of table.1 we found a noticeable difference between the two series. Graphics devolution of TMM and the resulting Taylor rates show a net incompatibility between the two curves for the Central Bank of Tunisia. As a result, the equation (1) does not

[6] Number of observation
[7] Standard deviation

present the central bank behavior, the low explanatory power can be justified by the absence of the prospective nature in the traditional Taylor rule.

- *Reaction functions to Taylor*

Taylor-type reaction functions can be classified into two categories that are static reaction functions they are functions with the same variables as the Taylor rule, but with traditional estimable coefficients (without partial adjustment of the interest rate) . dynamic reaction functions, are rules that take into account the partial adjustment of interest rates based on current inflation data and the output gap.

- *Estimates of the static reaction function*

Under its static version reaction function is given by:

$$TMM_t = \alpha + \alpha_\pi(\pi_t - \pi^*) + \alpha_y(y_t - \ddot{y_t}) + \varepsilon_t \quad (6)$$

equation (6) is a linear rule, econometrically, this kind of rule is estimable by ordinary square method (OLS). However, the estimation results by such method leads in the presence to an autocorrelation error: DW = 0.13. In this case, the estimation may be produced by the GMM or by the method of instrumental variables. In this work we will use the GMM method[8].

The application of MMG method requires the choice of instruments, in most cases, the choice of instrumental variables is determined by the economic literature. It is to select the delays of the explanatory variables to determine the vector of instruments, without using too many instruments or too late to avoid the risk of over-identification.

Gerdesmeir and Roffia (2003) estimate the different specifications to determine the optimal Taylor rule which represents the behavior of the monetary authorities in the euro area. They use MMG method, instruments are delays of one to six explanatory variables. Ftiti (2010) uses a four delays to estimate the optimal rule for New Zealand. In the case of Tunisia, Amiri and Talbi (2013) use the delays from one to four independent variables. Other studies with the same purpose, use delays from one to four of the independent variables. Thus, in connection with the estimation of equation (6) we choose the variables from one to four as instruments. The results are shown in Table.2.

[8] The generalized method of moments is used to take into account the problem of endogenous one hand and then the hétérosédasticité and correlation with unknown on the other hand.

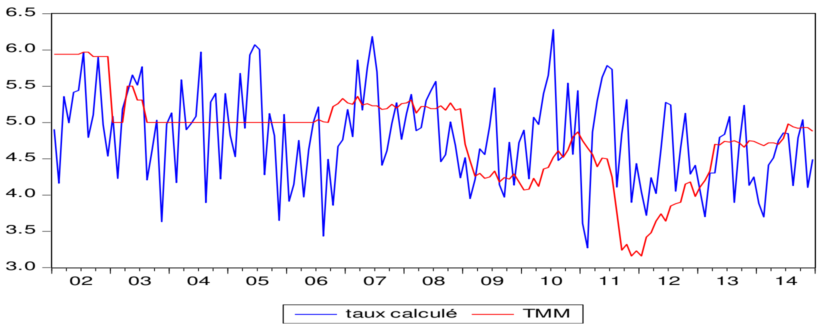
Table.2 Estimation results of the static feedback function for Tunisia

Variable	Coefficient	t-Statistic	probability
C	5.004365***	43.01126	0.0000
α_π	-0.196666***	-3.036665	0.0028
α_y	0.118501*	1.960806	0.0517
R^2	-0.489675	-	-
$\bar{R}^2$	-0.509276	-	-
J	0.0000	-	-

*Indicate the significance level at 10%.

**Indicate the significance level at 5%.

***Indicate the significance level at 1%.



The coefficient of inflation is (-0.196), it is statistically significant, but it is not consistent with the theory (negative coefficient). However, according to the graph of the evolution of TMM and the resulting Taylor rates, we can see a clear incompatibility between the two curves. This shows the low explanatory power of the estimated equation. Therefore, such an equation (6) cannot be regarded as an optimal response function for the BCT. J-Statistics is equal to zero, indicating that these coefficients supplied by MMG are efficient

- *Estimates of the dynamic response function*

Rearrange the terms of the equation (6), adding the smoothing interest rates. The equation to be estimated takes the following form:

$$TMM_t = c + \rho TMM_{t-1} + \phi_\pi(\pi_t - \pi^*) + \phi_y(y_t - \ddot{y_t}) + \varepsilon_t \qquad (7)$$

with

$$\phi_i = (1-\rho)\alpha_i$$

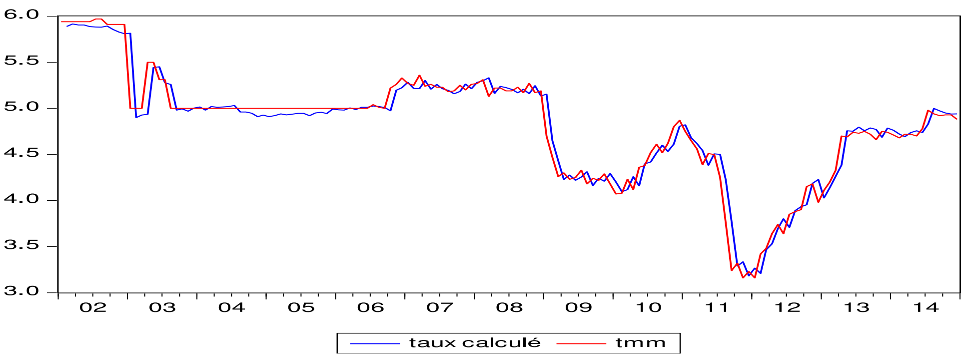
Table.3 Estimation results of the dynamic response function for Tunisia

Variable	Coefficient	t-Statistic	Probabilité
C	0.068937	0.125735	0.548277
ϕ_{tmm}	0.979365***	40.50994	0.0000
ϕ_{π}	0.022354*	1.798697	0.0741
ϕ_{y}	0.002581	0.206943	0.8363
R^2	0.942697	-	-
$\bar{R}^2$	0.941535	-	-
J	0.000000	-	-

*Indicate the significance level at 10%.

**Indicate the significance level at 5%.

***Indicate the significance level at 1%.



Econometric results show the expected signs with the remarkable significance of the residual term. the figure shows that the reaction function of the Tunisian monetary authorities according to the dynamic rule illustrates in a manner acceptable the estimated interest rate dynamically according to equation (7).the graph shows that the inclusion of the delayed interest rate determines the best central bank reaction function. the coefficient of the inflation, equal to 1.061 greater than 1. Indeed, according Gerdesmeier and Roffia (2003) «a parameter of inflation higher than 1 implies that the short-term interest rate must increase when the rate of inflation increases, this has a stabilizing effect on inflation.». the coefficient of the output gap equal to 0.119 is insignificant. these results confirm that the objective of the CBT is to target inflation.

- *Estimates of the Forward-looking taylor rule*

By introducing inflation expectations, our approach is to consider that the active period of monetary policy is one year we assume that the BCT reacts to (π_{t+12}). We can rewrite equation (7) as follows:

$$TMM_t = c + \rho TMM_{t-1} + \phi_\pi(\pi_{t+12} - \pi^*) + \phi_y(y_t - \ddot{y_t}) + \varepsilon_t \qquad (8)$$

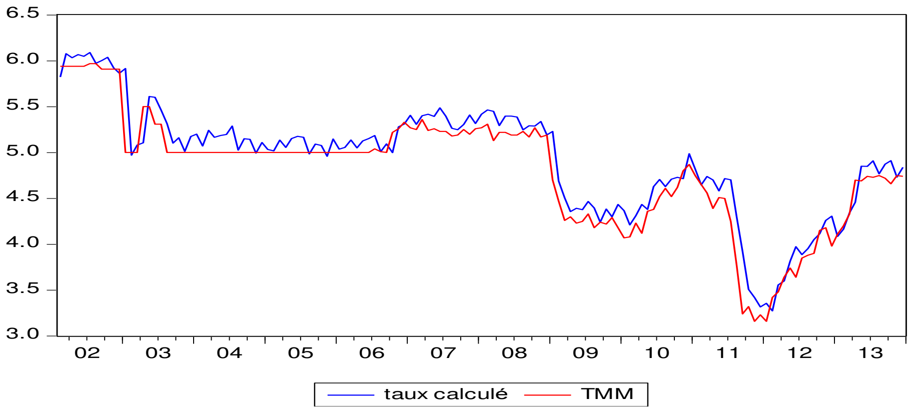
Table.4 Estimation results of the forward-looking rule for Tunisia

Variable	Coefficient	t-Statistic	probability
C	0.320891**	2.146215	0.0336
α_{tmm}	0.934976***	31.05279	0.0000
α_{π^a}	-0.014815	-1.607156	0.1103
α_y	0.013426	1.048151	0.2964
R^2	0.942718	-	-
$\bar{R}^2$	0.941482	-	-
J	0.000000	-	-

*Indicate the significance level at 10%.

**Indicate the significance level at 5%.

***Indicate the significance level at 1%.



The coefficients related to the gap between expected inflation in a year and the implicit inflation target and the output gap is not significant. Also the figure shows the evolution of TMM and calculated rate still present differences between the two curves. Therefore, equation (7) can't be regarded as the reaction function Tunisian monetary authorities.

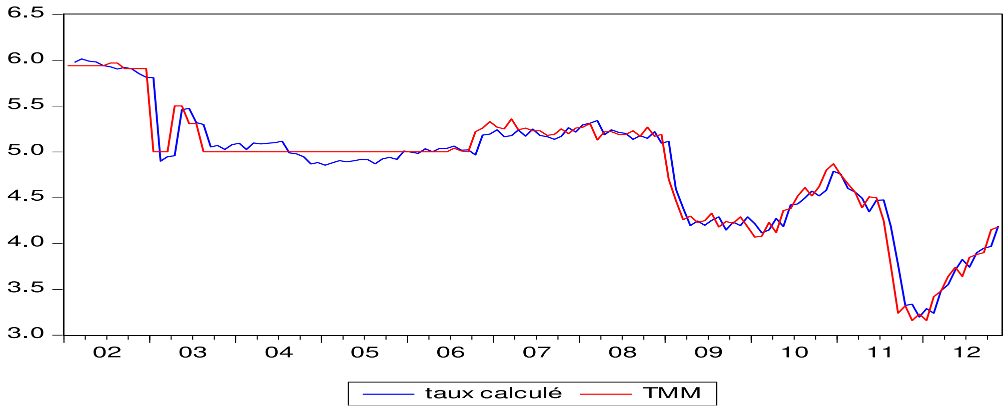
- *Estimates of the dynamic reaction function increased exchange rate*

Variable	Coefficient	t-Statistic	probability
C	-0.448043	-1.360963	0.1760
α_{tmm}	0.951601***	29.66180	0.0000
α_{π}	0.042753*	1.723419	0.0873
α_{y}	0.004442	0.283249	0.7775
α_{e}	0.006473*	1.798400	0.0746
R^2	0.944530	-	-
$\bar{R}^2$	0.942712	-	-
J	8.97E-43	-	-

*Indicate the significance level at 10%.

**Indicate the significance level at 5%.

***Indicate the significance level at 1%.



6.Conclusion

Taylor is the first who has made a rule of conduct of monetary policy expressed in terms of short-term interest rates. Several researchers have criticized this rule on many points. On the basis of these criticisms different rules resulted from the latter called "Taylor rule type" or "rules to Taylor."

Within this work, we estimate the CBT reaction function using monthly data from 2002 to 2014 M1 M14. Our results show that the Taylor rule in the dynamic version explains the policy rule of the CBT. Then we add the exchange rate to this rule, we find that adding this variable improve the results.

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