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A Macro-Model to Monetary Transmission Analysis in Tunisia

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Abstract

In this paper, we develop a gap model based on a reduced form of the New Keynesian Model. The model offers various scenario structure tools which analyze the dynamics of key macroeconomic variables under diverse shocks and depicts their properties and historical decompositions. This framework rationalizes the monetary transmission mechanism as well as the effects of major shocks influencing the macroeconomic variables and can assess the role of monetary policy in reacting to observed and anticipated changes in inflation and other economic variables. This model provides a useful framework detailing monetary policy and helping policymakers mainly to react strongly to inflation.

JEL Classification: E52, E58, E10, E50
Keywords: Monetary Policy, Central Banks and Their Policies, Macroeconomic Model, Monetary Transmission Mechanism

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I. Introduction

It is well-known that a successful description of transmission mechanisms is the centerpiece of any monetary policy framework, especially in inflation targeting countries or those who prepare the transition to inflation targeting. The main challenges for the monetary authority are to understand the functioning of the economy, to define the policy reactions and the source of shocks and to evaluate the risks resulting from different hypotheses. So, the monetary policy effectiveness depends on the ability of policymakers to make an accurate assessment of the timing and the impact of their policy on prices and the economic activity as a whole. Nonetheless, the monetary authority impacts the short-term interest rate in order to influence the output gap and the inflation rate. Thereby, a representation of the transmission mechanism is the main aim of modeling, as when central banks claim to understand the effect of changes in the nominal interest rate on real variables.

Changes in the central bank policy instrument are transmitted to the target variables through several channels. The Interest Rate Channel is based on the assumption that an expansionary monetary policy causes the real interest rate to fall. This gives incentives to firms to increase their investment and to households to increase their consumer spending. This increase in spending leads in turn to a rise in aggregate demand and thus a rise in inflation (Mishkin, 1995). The credit channel operates via two main channels, which are the bank lending channel and the balance-sheet channel (Bernanke and Gertler, 1995). The bank lending channel emphasizes the monetary policy affects the level of the economic activity not only by modifying short term interest rates, but also by altering the access and terms of bank loans. That is to say, the credit channel in the strict sense affects bank loan supply (Kashyap, Stein and Wilcox, 1993). In the same logic, the bank lending channel arises from an asymmetry of information between borrowers and lenders, which affects the external finance premium by shifting the supply of intermediated credit (Bernanke and Gertler, 1989). Therefore, a drop in the policy rate reduces the cost of borrowing and encourages banks to make loans. Inversely, a tightening monetary policy increases the cost of borrowing by banks and reduces bank incentives to make loans (Bernanke and Blinder, 1992). Regarding the balance sheet channel, the effects are materialized through the impact of the net worth quality on business firms, which leads in the case of deterioration, to an increase in agency costs (Bernanke and Gertler, 1989), so, lenders reduce the amount of credit extended to risky firms. In fact, lower net worth means that less collateral is available to lenders and the losses from adverse selection are accordingly higher. The exchange rate channel captures the effect of the policy rate on the nominal exchange rate. Given price rigidity, the resulting depreciation in the real exchange rate leads domestic residents to import less, and foreigners to buy more domestic goods. Moreover, changes in the nominal exchange rate will immediately feed into higher import prices, providing a powerful direct effect of monetary policy on domestic wages and prices. However, the importance of this channel depends critically on the degree of the economy’s openness. Finally, there is a consensus that monetary policy influences real variables by affecting public expectations. The variables’ expectations responding in part to the history of the macroeconomic variables and these variables themselves are influenced, in turn, by changes in variables’ expectations; this mechanism is called expectation channel. As pointed out by Woodford (2005), “Central banking is not like steering an oil tanker, or even guiding a spacecraft, which follows a trajectory that depends on constantly changing factors, but that does not depend on the vehicle's own expectations about where it is heading. Because the key decision makers in an economy are forward-looking, central banks, affect the economy as much through their influence on expectations as through any direct, mechanical effects of central bank trading in the market for overnight cash.” For monetary policy, to be most effective, it is prominent for the economic agents to rightly understand the central bank actions, especially when expectations are based on macroeconomic models.

For the Central Bank of Tunisia, the primary goal is to preserve price stability. For this purpose, monetary policy decisions are transmitted to the economy through diverse channels, all of them have ultimately an effect on prices of goods and services. Thus, modeling and empirical analysis of monetary policy transmission mechanism provides for policymakers quantitative information regarding the relative importance of monetary policy transmission channels as well as estimates the extent and transmission delays of monetary policy decisions. As far as that goes, this type of models improves the analysis tool used to formulate monetary policy mostly to communicate with the public. Likewise, it is fundamental for central banks to acquire, at least, many tools and models so that they can frame their discussions and points of view about economics outlook. However, developing a framework based only on econometrics approach showed many difficulties to provide exact responses toward the perception of economic functioning and especially for talking about monetary policy transmission mechanisms. In fact, even if econometric models like structural vector autoregression (SVAR) models have known a huge progress in response to developments in the real economy, they still considered as "black boxes" to provide economic explanations of the linkages between variables as they do not refer to any economic theory framework and they typically lack sufficient structure for policy analysis (James H. Stock and

Mark W. Watson, 2001). The VARs approach which is particularly intended to analyze the transmission mechanisms is often criticized for it considering economic agents and especially central banks as "random number generators", (Bernanke and Mihov, 1996). Furthermore, the VARs suffer from "identifying restrictions" issues and often these are ad-hoc, it may be difficult and sometimes impossible, to justify their estimations based on economic theory[2]. In addition, the structural parameters of VARs models are not in fact policy invariant, so their use may lead to a misleading model. This objection commonly called the "Lucas critique"[3] stipulates that any change on macroeconomics regimes affects imperatively change of the economy's structure especially in the behavior of the economic agents.

These criticisms have culminated in the emergence and the popularity of the micro-founded macroeconomics models, used as a tool for policy analysis in many institutions like central banks. In fact, macroeconomic models are built by using the fundamental principles of economic theory, considered as the main strength of this category's models. Otherwise, the micro-foundations of macroeconomic models make them more suitable to economic policy analysis because the structure of relationships between the variables is uninfluenced by the policy framework: Thus, the class of models is basically based on economic theory which contributes in avoiding the Lucas critique, (Woodford, 2003). Likewise, the macroeconomic models have the ability to be constantly refined and developed. The capacity to update the model is crucial in the meaning that central bank changes a target for the short term interest rate as a function of economic conditions (Galí and Gertler, 2007).

The purpose of this paper is to experiment a variant of the reduced form of the New Keynesian Model that links the monetary policy stance to key macroeconomic variables. Then, the model is calibrated to reflect a set of stylized facts of the Tunisian economy. This framework affords an analytical tool for evaluating economic policies and especially provides policy simulations under an entire range of policy scenarios. Likewise, a historical decomposition of shocks helps to better understand the workings of the economy and to describe the various episodes of Tunisian economic cycles. In fact, the results obtained from the simulation of the model based on parameters calibrated for Tunisia correspond to the economic intuition in terms of magnitude and transmission speed of the economic impulses, in particular the return to the stationary state. Moreover, the historical analysis of shocks has

[2] For more details see Sims, C.A., (1998) and Stock, James H. and Mark W. Watson, (2001).
[3] See Lucas (1976).

emphasized the importance of the shocks of the main Tunisian economic variables in the structure of the economic and financial landscape. After introducing the aim of this paper, it will be significant to announce the latter will be presented as follows: Section 2 treats a brief overview of stylized facts characterizing the Tunisian economy, Section 3 describes the core model, Section 4 discusses the calibration and the choice of parameters, Section 5 presents the dynamic responses of the model and section 6 studies the historical shocks decomposition. The final section concludes.

II. The Tunisian Economy: A brief overview

Tunisia is a small open economy which means that the macroeconomic outcomes and policy in Tunisia are assumed to have no discernible impact on international economic markets. However, over the years, the Tunisian economy has become more open and integrated than before, both domestically and abroad which brings the country back into several economic cycles. In fact, Tunisian's strong and sustained economic growth experienced since the beginnings of the 2000s came to a halt in 2011, date of the Tunisian revolution. Tunisian’s real GDP growth averaged 4.2% between (2000-2010), after which it contracted by 1.7% from revolution to 2017. The government undertook an expansionary macroeconomic policy (an economic stimulus), in adopting fiscal stimulus policies to mitigate the socio-economic impact of the revolution, in order to stimulate the economic growth. This policy engendered a fragile growth but unluckily aggravated the inflation that attained 7.8% in 2018 after being characterized for a period, by a relatively weak rhythm of inflation. Indeed, on the beginning of the 2000s years, the average annual rate of prices evolution measured by the Consumer price index maintained around 3%. This decrease is the result of the pursuit of the restraining monetary policy, a rigorous budgetary policy and the management of the interior demand by prudent salary policies. Nevertheless, after 2011, the adoption of fiscal stimulus policies mostly aiming to mitigate the socio-economic impact of the revolution by increasing wages and preserving the consumer’s purchase power, has triggered a vicious circle of price/wage spiral, with internal and external imbalances. Regarding the exchange rate policy, during the last two decades it aimed at the same time to bolster foreign-exchange reserves and to improve the competitiveness, export and the level of investment. Though, the first decade has been characterized by a slow depreciation of the local currency to bring the dinar to its equilibrium path and mostly to support exports and cope with international competition. However, the degree of fluctuation remains low considering the reduction of the Central Bank intervention. The last decade, the exchange rate policy has been re-oriented towards depreciation to support the equilibrium of the balance of payments and to adjust nominal exchange rate. “De facto”, the exchange rate regime could be described as a crawl-like arrangement even if the “de jure” exchange rate arrangement is floating. The Tunisian financial sector is dominated by banks, and the financial market is still underdeveloped. Even more, banks represent around 75% of stock exchange capitalization since the early 2000s. As a consequence, the corporate sector relies mostly on banks as the external source of funds. The Central Bank which is endowed with a set of instruments enabling it to implement its policy had followed a proactive monetary policy to curb inflation that has experienced a strong acceleration mostly after the revolution. Indeed, since 2006 the Central Bank of Tunisia (CBT) has introduced price stability as the primary objective of monetary authorities with the policy interest rate as the main instrument. Previously, monetary policy has been anchored on a monetary program, and the CBT derives annual targets for "M3" from the government’s financial program, as well as monthly base money growth. Just after the revolution, the CBT has adopted an expansionary monetary policy aimed to stimulate demand in a context of the economic decline and scarcity of goods supply.

Reducing the interest rate has consequences on inflation. Furthermore, the deterioration of security and the proliferation of the informal sector made a pressure on prices and on the current account. As well, the increase in wages and the depreciation of the dinar will continue to push up inflation. The resurgence of inflationary pressures has conducted the CBT to follow a contractionary monetary policy by increasing the interest rate in order to decrease the size of money supply and to affect the output gap.

III. The Structure Of The Model

We develop a semi-structural model that has been designed to provide a monetary policy analysis. Macroeconomic models for monetary policy analysis are developed to describe the functioning of economy and the interactions between key macroeconomic variables. The model does not have explicit micro foundations, but it is based on the new consensus on monetary economies, which is reflected in the New Keynesian modeling approach. The New Keynesian model can be used to derive the optimal monetary policy for a central bank which uses short-term nominal interest rates, in order to maintain price stability. So, the model we develop is a reduced-form of the structural New Keynesian model, also called a gap model. The model is in “gap form” because each variable is expressed in terms of its deviation from the steady state. Thenceforth, the model consists of four fundamental behavioral equations and several identities:

1. **IS curve**
2. **Phillips curve**
3. **Exchange rate equation**
4. **Monetary policy rule**

1. IS curve (aggregate demand equation)

The traditional IS curve in an open economy model corresponds to the aggregate spending relationship. Thus, current domestic output depends on backward-looking domestic demand, on the real interest rate, the real exchange rate, and demand in the rest of the world, represented by the Euro Zone:

$$\hat{y}_t = a_1\,\hat{y}_{t-1} + a_2\,mci_{t-1} + a_3\,\hat{y}_t^{*} + \varepsilon_t^{y} \qquad \textbf{(1)}$$

$$mci_{t-1} = a_4\,\hat{\imath}_{t-1} + (1-a_4)\,(-\hat{z}_{t-1}) \qquad \textbf{(2)}$$

where $\hat{y}_t$ is the output gap that represents the deviation of the log of output from its steady state level. $\hat{y}_{t-1}$ is lagged output gap. Parameter a_1 captures the persistence of economic activity and can also be considered as a proxy for habit persistence. mci_{t-1} is the real monetary condition index that is defined as a weighted average of deviations of the lag of long-term real interest rate, $\hat{\imath}_{t-1}$ from its neutral rate, and deviation of the real exchange rate, $\hat{z}_{t-1}$ from its trend level. $\hat{y}_t^{*}$ is the foreign output gap and, ε_t^{y} is an aggregate demand shock. We suggest that $\hat{y}_t$ depends only on lags of real interest rate and real exchange rate. This choice is justified by the specificities of the Tunisian economy, which is characterized by different types of market imperfections especially credit market. In fact, asymmetries in information between borrowers and lenders play a key role in the transmission delays (Ben Bernanke and Mark Gertler, 1995). Adding to that, the degree of stickiness of bank rates[4] is an essential determinant in the transmission of monetary conditions to the real sphere.

2. Phillips curve (aggregate supply equation)

Price dynamics is described by Phillips curve:

[4] See « Les mécanismes de transmission de la politique monétaire en Tunisie, (2014) available at: https://www.bct.gov.tn/bct/siteprod/documents/Etude_BCT_20150113.pdf

$$\pi_t = b_1\,\pi_{t-1} + (1-b_1)\,\pi^e_{t+1} + \ b_2\,rmc_t + \ \varepsilon^\pi_t \qquad \textbf{(3)}$$

$$rmc_t = b_3\,\hat{y}_t + \ (1-b_3)(-\hat{z}_t) \qquad \textbf{(4)}$$

The generalized Phillips curve contains both forward and backward looking elements of inflation. The forward-looking elements of inflation come from the forward-looking behavior of firms in price setting. So that the inflation π_t, measured as the percentage change, quarter-over-quarter; at annual rates of consumer price index, depends on the expected change in the CPI π^e_{t+1}, the change in the CPI over the previous period π_{t-1}, the output gap $\hat{y}_t$ (domestic producers) and $\hat{z}_t$ which reflects deviations of the real exchange rate from its steady-state level. This structure of real marginal costs[5] reflects the fact that Tunisia is a small open economy. That is to say, the fundamental role of monetary policy is to provide a nominal anchor for inflation and basically inflation expectations. Thus monetary policy influences inflation through its effects on output and the exchange rate. As far as that goes, the coefficients on expected and lagged inflation sum to one, implying that any constant level of inflation can be a solution to this equation, as long as the output gap and the real exchange rate gap are zero.

3. Exchange rate equation

We assume that the nominal exchange rate is determined by an alternative version of the uncovered interest rate parity in its forward-looking version. The Uncovered Interest Parity (UIP) is formulated as following:

$$\mathrm{ls}_t = \mathrm{ls}^e_{t+1} + \frac{(-\,\mathrm{R}_t\ + \mathrm{R}^*_t\ +\ \mathrm{p}^*_t)}{4} + \ \varepsilon^{\mathrm{ls}}_t \qquad \textbf{(5)}$$

where ls_t is the nominal exchange rate; ls^e_{t+1} is the expected nominal exchange rate in period t+1; R_t is the domestic nominal interest rate (annualized); R^*_t is the foreign nominal interest rate (annualized); p^*_t is the risk premium; and $\varepsilon^{\mathrm{ls}}_t$ is the exchange rate shock. However, to take into consideration the dynamism and the persistence of the exchange rate, we can add a combination of backward-looking or “persistent model” and forward-looking or “consistent model expectations”, so the rational expectations for the exchange rate can be written in this form[6]:

[5]This presentation of real marginal costs can be derived in DSGE methodology assuming that domestically consumed goods are produced using labor and imports, (Woodford, 2003).
[6] See Benes, J., J. Hurnik, and D. Vavra, (2008).

$$ls^{e}_{t+1} = (1 - e_1)\, \mathrm{ls}^{e}_{t+1} + e_1\, (ls_{t-1} + 2\Delta\overline{ls_t}) \qquad \textbf{(6)}$$

$$\Delta\overline{ls_t} = \overline{\pi_t} - \overline{\pi^*_t} + \overline{\Delta z_t} \qquad \textbf{(7)}$$

The second element between brackets in equation (6) is the persistent element of exchange rate expectations, which highlights the exchange rate in period t+1 as an extrapolation of the past exchange rate using the trend growth rate of the real exchange rate $\overline{\Delta z_t}$ and the inflation differential $\overline{(\pi_t - \pi^*_t)}$. Thus, the UIP is determined as assuming backward-looking expectations for a portion of the economic agents and forward-looking expectations for the remaining.

4. Monetary policy rule

The central bank sets short-term nominal interest rate, as the main policy instrument, to anchor inflation to a target level $\overline{\pi}$ and temper its actions based on deviations of output from equilibrium $\hat{y}_t$. The rule is given by:

$$\mathrm{R_t} = \mathrm{f_1\, i_{t-1}} + (1 - \mathrm{f_1}) * (\mathrm{R_{neutral_t}} + \mathrm{f_2} * (\pi 4_{\mathrm{t+1}} - \pi^{target}{}_{\mathrm{t+1}}) + \mathrm{f_3}\, \hat{y}_{\mathrm{t}} + \varepsilon^{\mathrm{R}}_{\mathrm{t}} \qquad \textbf{(8)}$$

Where $\mathrm{R_t}$ is the nominal short-term interest rate, $\mathrm{R_{neutral_t}}$ is the neutral nominal interest rate,, $\overline{\pi}_{t+1}$ the inflation target, ε^{i}_{t} is a monetary policy shock and remands also to the discretionary actions of monetary authorities. We assume that monetary policy decision is based on a Taylor-type rule then the central bank smoothes interest rates, through adjusting them gradually to the desired value based on deviations of inflation expectation and output from equilibrium[7]. This reflects the main objective of the central bank is price stability but with a significant concern for the output. As far as that goes, introducing a dynamic adjustment policy involved an inertial rule and a sluggish policy adjustment[8]. In other words, the presence of inertia in the monetary policy rule equation indicates where the interest rate is likely to head and helps to define a policy based of both the rate today and the expected path of the interest rate. As far as $\mathrm{R_{neutral_t}}$, (equation 9) assumes that when the economy is in

[7] There are many various rules, and there is no agreement on a single right and optimal rule, each structure and parameter provides different economic perceptions, for evaluating alternative monetary policy rules, see Taylor (1999) and Woodford (2001).
[8] For more details see Glenn D. Rudebusch (2006)

equilibrium, the monetary policy rate is at its neutral level, which reflects the sum of equilibrium real interest rate and the inflation at next period.

$$R_{neutral_t} = \overline{\iota_t} + \pi_{t+1} \quad \textbf{(9)}$$

When the policy rate is equal to this neutral level, the monetary policy is neutral.

IV. Model Calibration

1. Solving model

Solving the linear semi-structural forward-looking model consists mainly in writing the model in a matrix form. Next, the model is solved using the Blanchard-Kahn conditions[9]. All the steps for model's solutions, estimations, simulations and historical shocks decompositions are implemented and executed in the IRIS toolbox in Matlab[10].

2. Calibrating the Model

The model is calibrated to reflect stylized facts of Tunisian economy. The calibration procedure involves choosing functional forms for the micro-evidence or long run growth facts and assigning values to the parameters of the model. Thus, the details of the results from simulations of any model depend on both its structure and its parameters' values. Furthermore, Berg, Karam, and Laxton (2006) specified that "The model is not to be judged primarily by how well the parameters themselves are chosen or how well the model fits the data, however. Rather, the adequacy of a model for policy analysis will depend on how well it captures key aspects of the monetary policy transmission mechanism. For example, the model should provide reasonable estimates of: how long it takes a shock to the exchange rate to feed into the price level; the size of the sacrifice ratio in other words, the amount of output that must be foregone to achieve a given permanent reduction in the rate of inflation, and how the inflation rate responds to the output gap". Therefore, the choice of parameters values must trace the history of economic chapters if the estimated values do not violate the model assumptions and mostly reflects correctly the logic of monetary transmission mechanism. As well, the model is designed primarily to provide a useful economic policy recommendation going forward and not solely to reproduce past policy responses. However, it is important to

[9] See Blanchard and Kahn (1980).

[10] The toolbox is presented on https://iris.igpmn.org/.

take into consideration during the calibration what other central banks have done in establishing properties for models. Similarly, the calibration procedure is based largely on experience of policymakers to retort their views of economy's behavioral features. This aspect guarantees to produce a credible policy analyses and to replicate with a fair approximation data as well.

To sum up, the model calibration comes from an eclectic approach to reflect the dynamics which capture the data sufficiently well compared to other models and technics of estimation. Otherwise, in setting the parameters values, we follow on the one hand the economic theory and on the other hand our economy stylized facts, based, for example, on estimated parameter values in a VAR model and we try to produce a reasonable relationship of economic variables.

3. Parameters choice

In order to determine the model's parameters, results and information from different sources and various empirical methods were exploited, including the judgments based on stylized facts about the Tunisian economy, we can subdivide the parameters in two categories: long run trend (steady state) parameters and short run (dynamics) parameters.

3.1 Long run trend (steady state) parameters

The calibration of long run parameters is crucial to calculate equilibrium or potential values in the model. In general, steady state parameters are chosen based on observed data unless they are determined as a target for monetary policy strategy. Many statistic methods provide a useful guidance for calibration of the steady-state parameters (**e.g.** a simple average of historical data, Hodrick-Prescott Filter…). However, as "the revolution of 2011" has affected the long term Tunisian economy prospects, this needs to be taken into account and to redefine some trends and the sample revolutionary period in order to calculate the steady-state of variables.

All the steady state parameters are summarized in Table 1.

Table 1: Steady state parameters

Parameter	Description	Value
π^{target}	Inflation target	4%
$\bar{\imath}$	Domestic trend real interest rate	0.75%
z^{eq}	Equilibrium real exchange rate appreciation	-3
y^{eq}	Domestic Equilibrium real GDP growth	3.5%
$\overline{\pi^*}$	Foreign inflation target	2%
$\overline{\imath^*}$	Foreign trend real interest rate	0.5%

3.2 Short run (dynamic) parameters

The calibration of parameters affects the dynamic properties of the model and draws the short run dynamics of structural equations. For this reason, calibration of those parameters should result in impulse responses in line with historical simulations of data and the economic intuition. Furthermore, the magnitudes and the speed of convergence to steady state sequel shocks need to match the observed data. The summary of the calibrated parameter values[11] of the equation's model is presented in Table 2.

Table 2: Structural parameters

Parameter	Description	Value
	IS curve	
a_1	Lag of the output gap (Output gap persistence)	0.65
a_2	Pass-through from monetary conditions to real economy	0.15
a_3	Impact of foreign demand	0.32
a_4	The relative weight of the real interest rate in RMC	0.55
$(1-a_4)$	The relative weight of the real exchange rate in RMC	0.45
	Phillips curve	
b_1	Lag of inflation	0.45
$(1-b_1)$	Lead of inflation	0.55
b_2	The impact of real marginal costs on inflation	0.3
b_3	The relative weight of output gap in firms' real marginal costs	0.65
$(1-b_3)$	The relative weight of real exchange rate gap in firms' real marginal costs	0.35
	Exchange Rate Equation	
e_1	Exchange rate persistence and central bank interventions	0.5
	Monetary Policy Rule	
f_1	Policy rate persistence in the Taylor rule	0.6
f_2	Weight put by the policy maker on deviations of inflation from the target in the policy rule	0.5
f_3	Weight put by the policy maker on output gap in the policy rule	0.2
	Speed of convergence of variable trend	
h_0	Persistence shock in risk premium	0.5
h_1	The speed of convergence of domestic variable trend values (persistence between past trend rates and the steady-state)	0.6
h_2	The speed of convergence of foreign variable trend values	0.6
t1	Convergence of variable target	0.5

[11] The calibration procedure is detailed in appendix I.

V. Policy Analysis

It is prominent to assure that the most important aim in monetary policy analysis is to obtain a quantitative view of the transmission mechanisms (speed and magnitude), particularly to check whether the policy rate exerts a sizable effect on the subject variables to the central bank targeting and how central bank shall react if any variable moves away from its steady state. The economy is assumed to be in the long-run equilibrium and then one period shocks are introduced, one at a time. The impulse-response functions reflect a one standard deviation shock. All the references to increase or decrease in any variable are relative to steady state levels (**i.e**. the long-term trend). It is abstract to visualize an economy in equilibrium state because in reality, and as always, the economy undergoes several types of shocks. Yet, the model properties translate the fact that the beginning point is the steady state and all variables suffer from a single shock just to keep things as simple as possible and to treat only one issue at a sole time.

1. Impulse response analysis

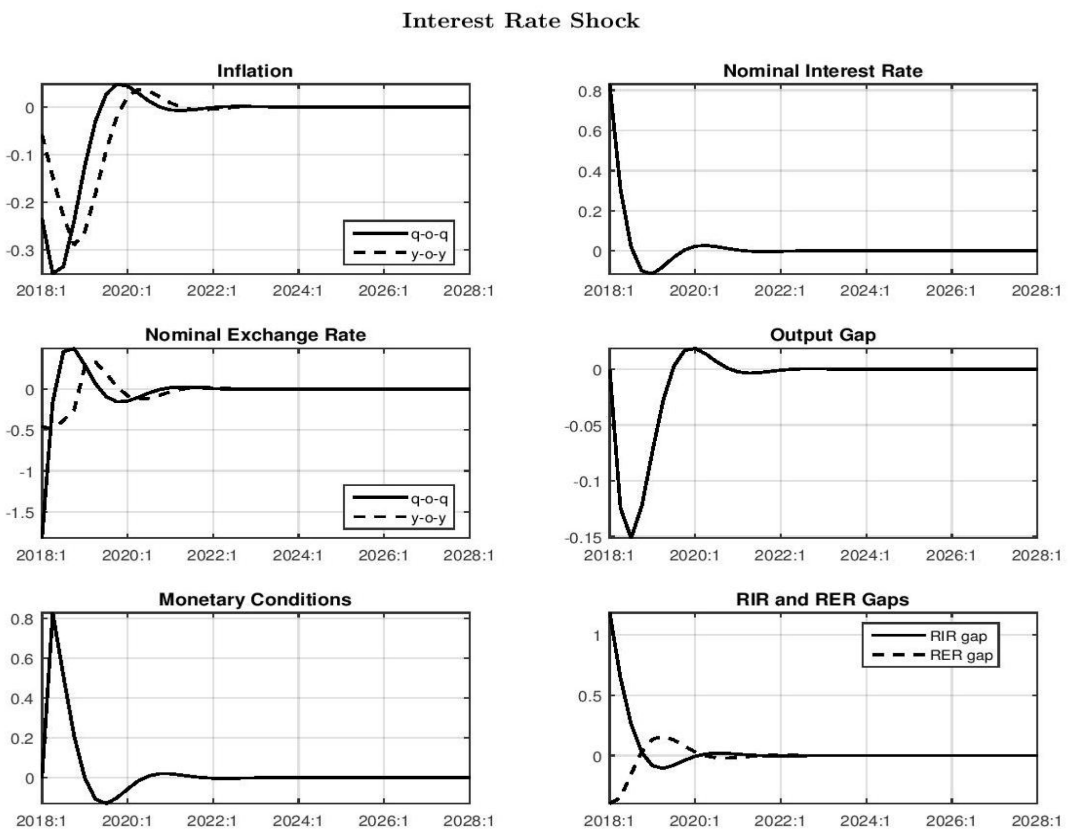
1.1 Monetary policy shock

The effects of monetary policy shocks, ε_t^R, can be understood through the usual monetary policy transmission channels. Following an increase in the nominal interest rate, i.e. the principal monetary policy instrument, the real interest rate increases, due to nominal rigidities[12], which discourages expenditure and contracts output, and this is what forms the last period, the interest rate channel. Likewise, a positive real interest rate, which attracts foreign capital inflow, induces an appreciation of the real exchange rate. Indeed, based mainly on the UIP assumption (equation 5), a positive shock on policy rate appreciates the nominal exchange rate. This appreciation of nominal exchange rate causes drop in a real exchange rate gap, and contributes to tight monetary conditions through the exchange rate channel. Thus, after one period[13], a positive real interest rate and an appreciation of the real exchange rate contract output through the real monetary condition, (equation 8). Both, a decrease in output the current period and the real exchange rate, reduce core and headline inflation (equation 3). These effects are, however, realized, only within the very short run. Over time, and in order to ensure a return to the inflation target, the central bank has to straighten its monetary policy decisions, especially consolidate a low inflation expectation which enlarges the reduction in the output gap. Thereby, in line with the expectations channel of monetary policy, the higher

[12] Changes in nominal prices can have important real effects in "Keynesian" models because this class of models assumes nominal rigidities in prices and/or wages. King and Wolman (1999), Rotemberg and Woodford (1997)
[13] The delay of transmission is due to market imperfections.

the credibility of the central bank, the lower the need to move its policy rate to achieve target. In fact, the interest rate goes through a cycle, and for a while it is below its long-run equilibrium value. On the long run, all variables come back to their steady-state level. After a monetary policy shock, the delay of return to equilibrium is estimated at a horizon of three years. This result is in line with our expectations regarding the understanding of our economy. However, the succession of shocks as well as the effect of exogenous factors makes it difficult for the central bank's mission to ensure a rapid return to the stationary state and prolong the situation of disequilibrium.

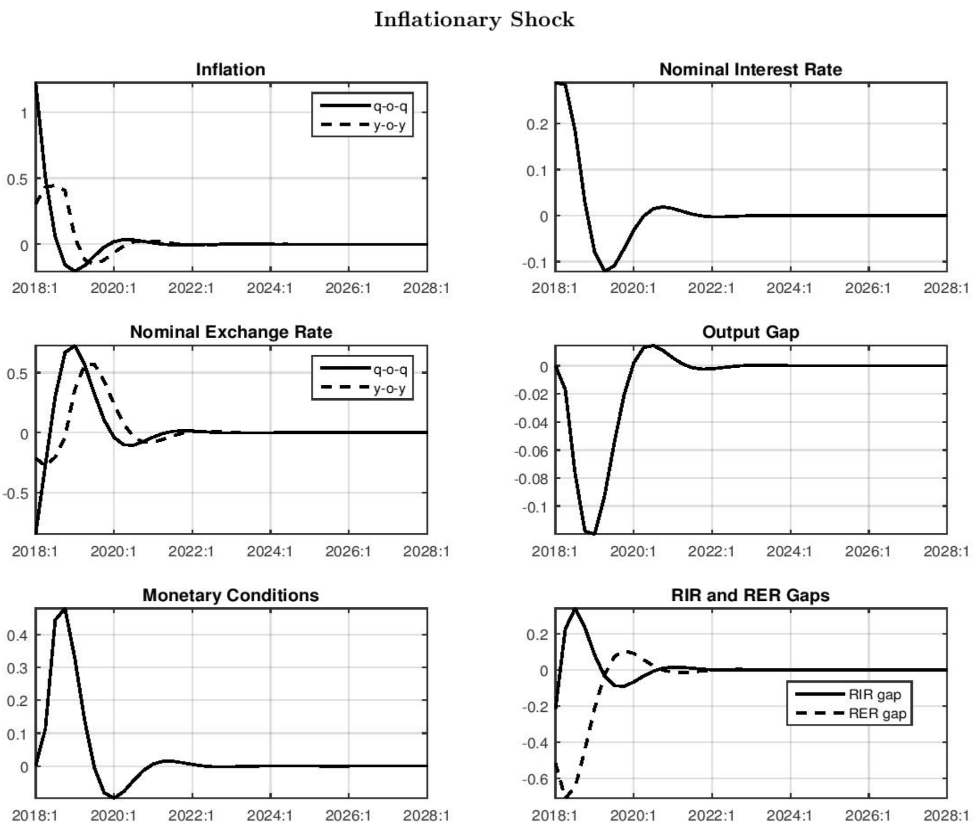
Figure 1



1.2 Inflationary shock

Let's consider the effects of a cost-push shock, ε_t^{π}, implying a rise in inflation. The central bank reacts by increasing the nominal interest rate which in turn appreciates the nominal exchange rate and contracts output through the similar mechanisms than previously. However, we observe that the reduction in output as well as the overshoot of inflation drives the nominal interest rate below its steady state in the medium term. Yet, to stabilize the economy with a non-aggressive increase in the interest rate and to avoid the trade-off between price stability and negative output gap, the reinforcement of the expectations concerning future inflation and the anticipations channel functioning play a crucial role in price setting. We notice that when parameter b1 is calibrated to a small value (**e.g.** b1= 0.2), inflation mostly depends on expected inflation. In that case, as soon in Figure 14 in the appendix, in response to the same inflationary shock in the figure 2, the central bank reacts less strongly to increase the policy rate. Furthermore, the return to equilibrium of all macroeconomic variables is quick and refers to the central bank's ability to further emphasize anticipations of inflation. Indeed, inflation is well determined, though expected inflation mostly when the central bank is credible and transparent.

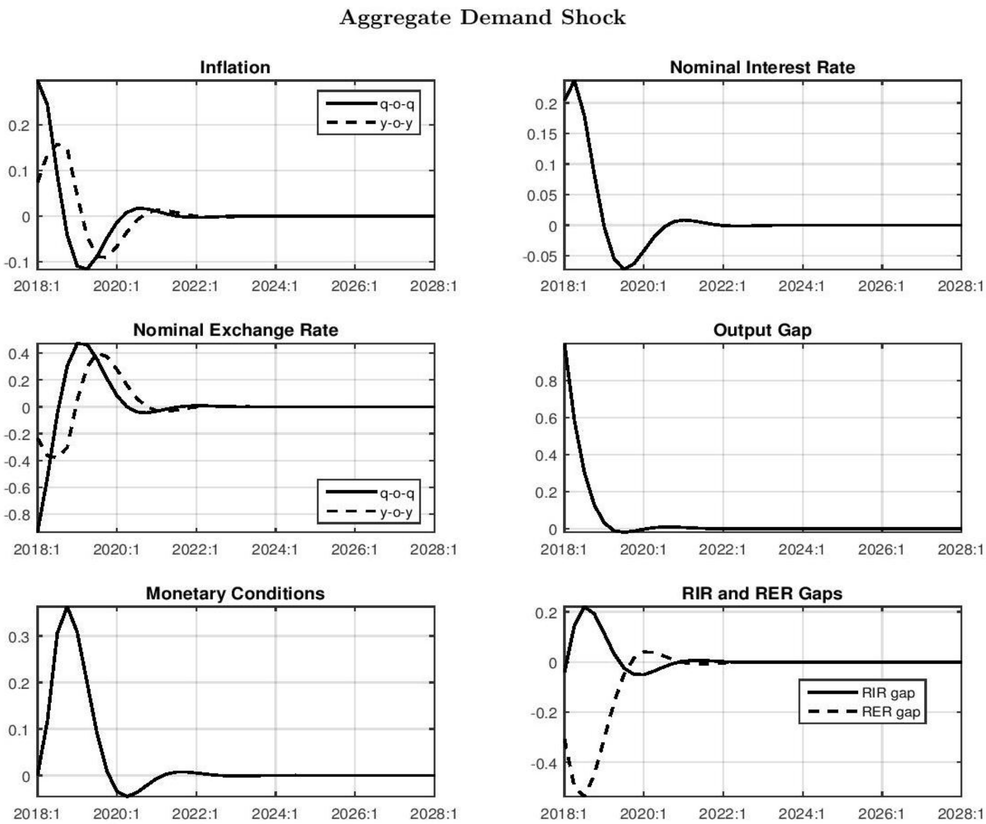
Figure 2



1.3 Demand shock

A positive demand shock, ε_t^y, raises output gap, which implies an increase in marginal costs, and as a consequence inflation goes up. Both the increase in the inflation rate and output pushes the central bank to increase the policy interest rate (equation 8). A rise in the nominal interest rate greater than the rise in inflation causes an appreciation of the nominal exchange rate. Nominal appreciation causes real exchange rate appreciation. All these changes involve a reduced demand through the effect of the tightening monetary conditions. In fact, monetary conditions index captures the degree of pressure which monetary conditions exert through the real interest rate and real exchange rate change on the economy, and hence on inflation. So, a rise in the monetary index is interpreted as a tightening of monetary conditions. Then, a rise in the real interest rate increases the MCI and decreases aggregate demand (interest rate channel), as does an appreciation of the real exchange rate (exchange rate channel). Over the medium term, output goes back to its potential level; consequently, the excess demand is eliminated. In fact the return to the steady state for the output gap and the exchange rate ensure the competitive equilibrium and allows inflation to become low and stable.

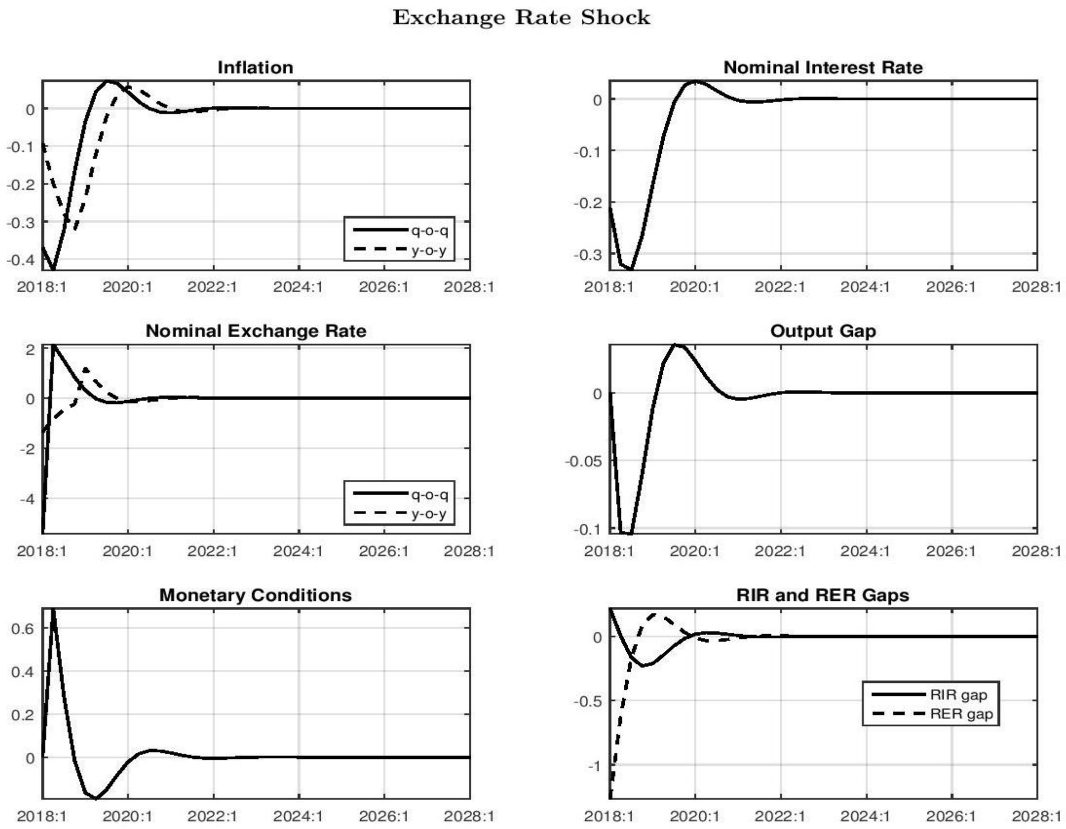
Figure 3



1.4 Exchange rate shock

The appreciation of nominal exchange rate causes a decrease in the real exchange rate gap, which further contributes to tight monetary conditions, (equation 4). This appreciation expands output through the growth in the MCI which is interpreted as a tightening in monetary conditions. The initial appreciation decreases the inflation rate especially through the price of imported goods. In parallel, smaller marginal costs, derived from a smaller level of output which decelerates this impact on inflation (exchange rate channel). The central bank responds to the decrease in both inflation and output by reducing policy rate, which stimulates capital inflows and foreign investment and causes nominal exchange rate appreciation. In addition, the growth of output and inflation reduces the exchange rate misalignment and accelerate the establishment of the equilibrium.

Figure 4



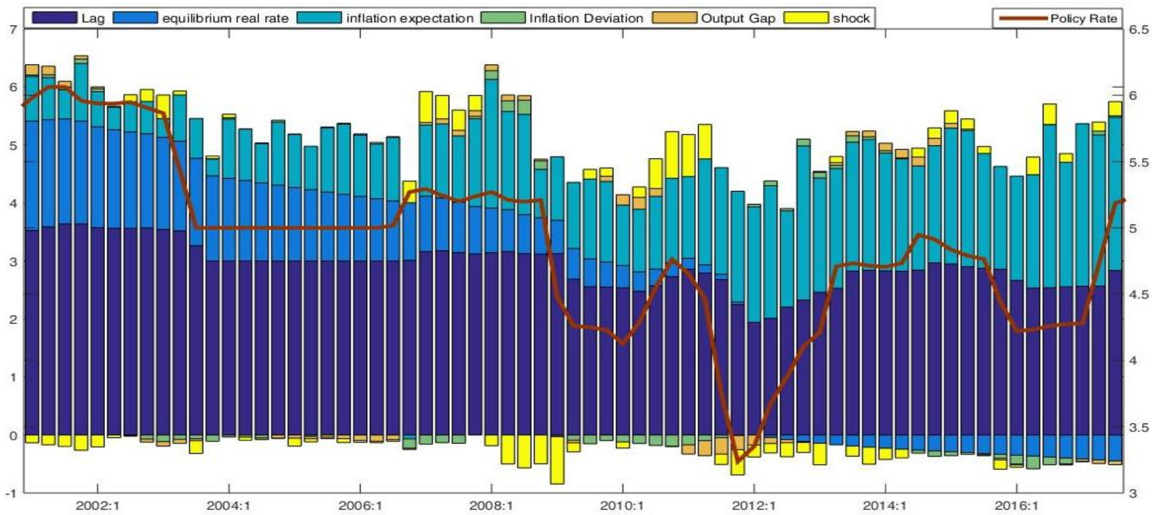
2. Historical variable decomposition:

It is useful to assess the model through the evolution of some key variables of the Tunisian economy like output gap and inflation compared to the explanatory variables developed in the model. To get done, we preceded by checking especially this two variables by the contributions of their mains determinants. Otherwise, we decompose the dynamics of each variable to the different determinants estimated by the model. This signifies that, the "model-simulated impact" of this different elements permits to understand the causal factors of the historical evolution of inflation and cycle business.

2.1 Variable decomposition - Policy rate

Based on how the model traces the monetary policy rule, the monetary policy stance is subdivided into two major phases. Before the revolution, the equilibrium real rate largely explained the change in the policy rate. Also, the presence of inflation expectation has helped to shape the stance of monetary policy even to a lesser degree than that observed after the revolution, which confirms that the central bank has always kept an eye on the evolution of inflation even with the absence of an explicit rule of monetary policy. Indeed, it is very perceptible that the Tunisian Central Bank is giving the ultimate interest in its monetary policy decisions to the evolution of future inflation, especially during the last years when inflationary pressures are increasingly threatening. This explains that recent developments are governed by the inertia of the principal instrument of the central bank and inflation expectations apart from a short period where the output gap played a role in the easing of monetary policy. Likewise for the equilibrium real rate, the rigidity of prices, which makes Tunisia go through an episode of negative real interest rates, explains the negative contribution of this parameter observed in the recent period.

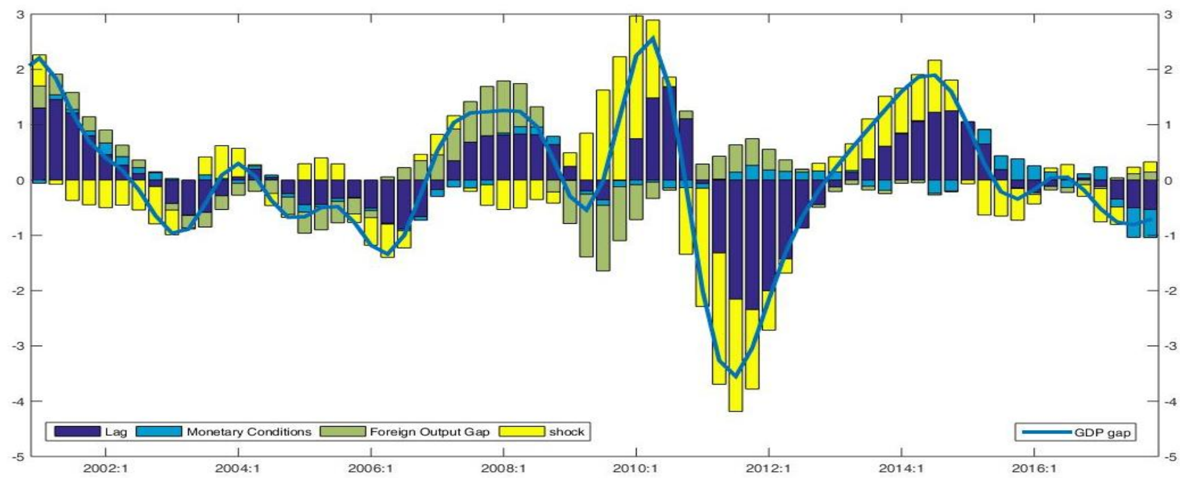
Figure 5: Determinant – Policy rate



2.2 Variable decomposition - Output gap

Figure 6 shows the historical decomposition of the output gap by focusing on its determinants described in equation 1 (Euler equation). In fact, the feature of Tunisian output gap is driven especially by its lags. Adding to that, an important share of output gap fluctuations is explained by the evolution in the foreign output. Likewise, the linkage between the Tunisian GDP and the strong international economy can explain the positive gap of the mid 2000s. In fact, the situation in global economic activity, notably the exports to the Eurozone[14], affects directly Tunisia's exports and consequently the Tunisian output. However, despite difficult international economic conditions, marked by the financial crisis and the world economic recession, Tunisia's economy has managed to face the international crisis and maintain the activity near to its potential by diversifying sources of growth and following efficient economic and monetary policies. Nevertheless, it is important to note that the Tunisian economy has suffered from the succession of exogenous shocks, for several quarters, generated by the Tunisian revolution of 2011 and triggering a recession. Furthermore, the Tunisian economy has been impacted by the crisis in Libya, which was its number two trading partner after the European Union. It is crucial to emphasize on the fact that monetary conditions, reflected by an accommodative monetary policy, have contributed repeatedly to boost the economic growth, "Countercyclical monetary policy".

Figure 6: Determinant – Output Gap



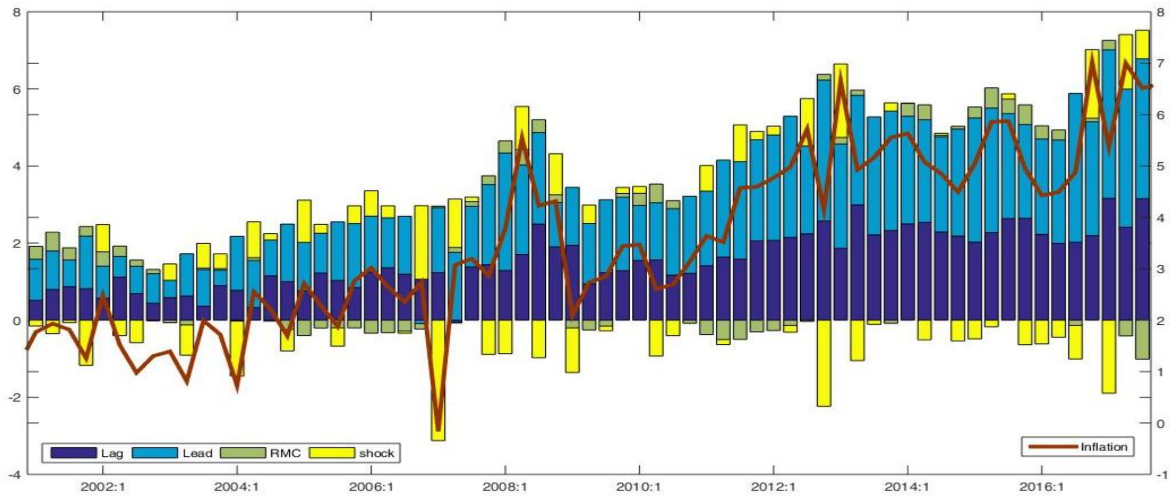
2.3 Variable decomposition - Inflation

The figure 7 places a particular focus on the role of inflation expectations in the inflation dynamics in Tunisia. A key remark, that economic agents are forward-looking. However, without a clear inflation targeting framework adopted by the central bank, an expected high inflation becomes more to weight on the pricing setting of economic agents. Similarly, the structure of dynamics inflation related to the New Keynesian Phillips curve reveals a high degree of persistence, which pushes us to wonder about the different sources of this persistence and in particular, its intrinsic inflation persistence, which may derive from a

[14] In 2017, nearly 75 % of Tunisian exports is directed to the Eurozone

price formation process coming from the dynamics of the output and from monetary policy. Regarding the real marginal costs, despite their low share on the fixation prices, they contributed to explain, in the last period, when inflation accelerated and for the most part and given the delays in transmission, that Inflation today depends on the whole sequence of expected future output gaps.

Figure 7: Determinant – Inflation



VI. Historical Shocks Decomposition

This section discusses the historical shock decomposition of variables from an historical perspective, as well as their developments in terms of the shock contributions. Such decomposition reflects the cumulated effects of both the contemporaneous and lagged shocks. In fact, based on Kalman filter[15] and smoother procedures in the IRIS Toolbox[16], we decompose the dynamics of each series into shocks' contribution and initial conditions. Thus, the decomposition of the interest variables into the different structural shocks allows identifying the source and the major shocks that hitting the economy. From the structure of model, the filtration of data's evolution founded on the Kalman filtration technique serves as a useful tool for identification of unobserved shocks driving inflation (price dynamics), interest rate (monetary policy stance) and output (the business cycle). The description and source of

[15] See Kalman R. E, (1960).
[16] See Movellan J. R., (2011).

the principal data used for this exercise are presented in (Table 3). Three shock decompositions are advanced.

Table 3: Data description

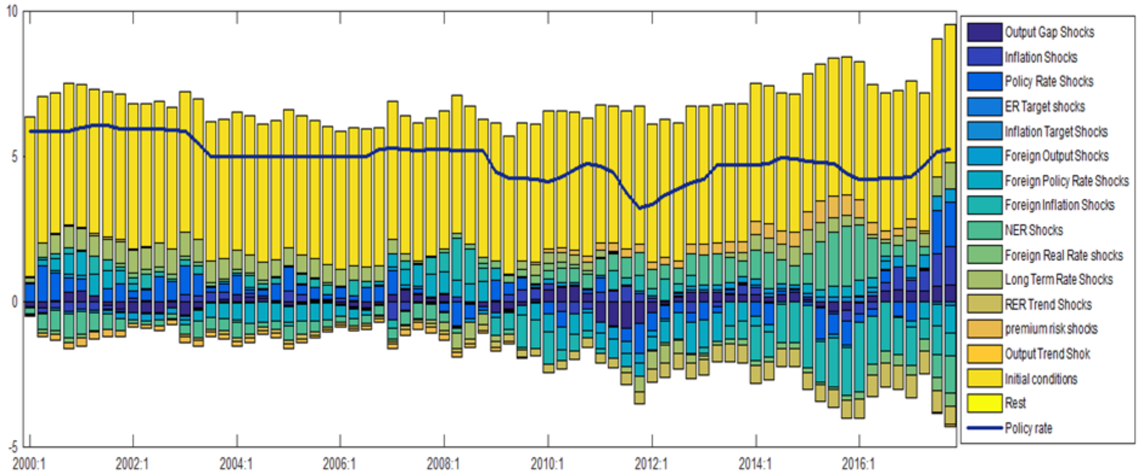
Variable	Data description	Source
CPI	Tunisia Consumer price index **(Index, 2010=100)**	National Institute of Statistics
Real GDP	Real Gross Domestic Product (excluding agriculture) of Tunisia, **constant 2010 prices in national currency (TND).**	National Institute of Statistics
Policy rate	Policy Rate of Tunisia	Central Bank of Tunisia
NEER	Nominal Effective Exchange Rate **(Index, 2010=100)**	Central Bank of Tunisia and DATASTREAM (IMF-International Financial Statistics)
Foreign Real GDP	Real Gross Domestic Product of Euro area (**Chain linked volumes (2010), million euro)**	Eurostat
Foreign CPI	Euro Area Consumer Price Index **(Index, 2015=100)**	Eurostat
Foreign Policy rate	Policy Rate of Euro area	European Central Bank

1. Shock decomposition – Policy rate

As presented in Figure 8, the decomposition in terms of interest rate shocks can be illustrated in four major phases:

In the first phase situated between 2000-2007, the interest rate policy has been driven positively, especially, by its own shocks and the long term interest rate shock. However, even if the observed interest rate in this period is of a high level, the exchange rate shocks exerted a negative pressure in monetary policy followed by the central bank. The next period, that coincides with the subprime mortgage crisis and that becomes a global financial crisis, demonstrated the importance of foreign shocks for the Tunisian economy and proves its character to be considered as a small open economy. Then, just after 2011, date of the Tunisian revolution, the monetary policy framework had, to a great degree, been driven by exchange rate depreciation and the emergence of the premium risk. Moreover, at the beginning of this period, the output gap shocks, due to the recession of the economy, had significantly impacted, in a negative way, the evolution of interest rate. At the end of the period 2016-2017, monetary policy had to contend with the resurgence of inflation combined with the successions of interest rate shocks. At the same time, exchange rate shocks play an important role, especially after the revolution in the contribution of rate formation, even though the Tunisian economy is not sufficiently open and influential internationally. Nevertheless, the impact of the exchange rate on the formation of prices in Tunisia plays an indirect role in the central bank's reaction to the depreciations observed as a result of the revolution.

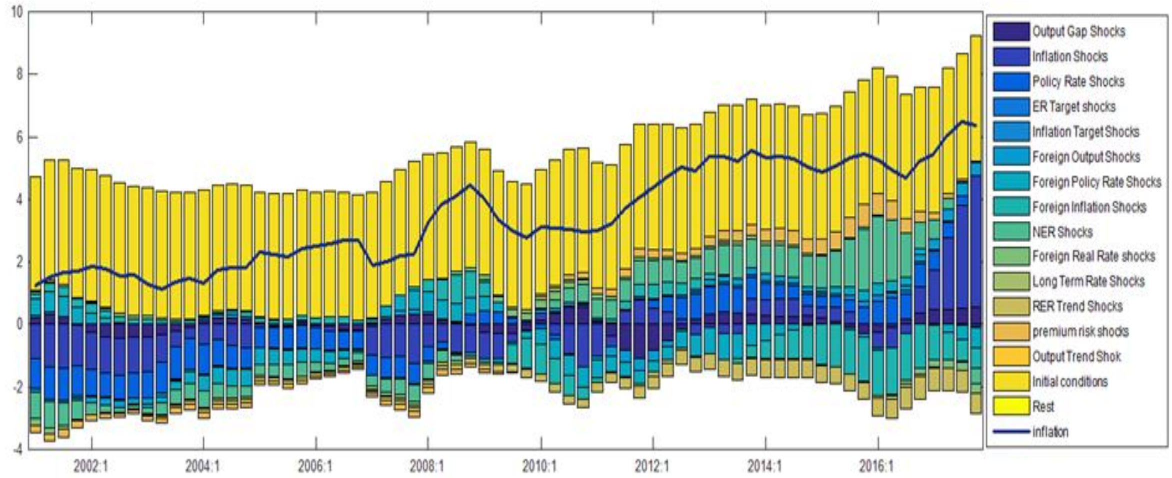
Figure 8: Shock Decomposition – Policy Rate



2. Shock decomposition – Inflation

Throughout a period before the Tunisian revolution in 2011, inflation was low and stable and the dynamics of inflation were driven by its own shocks. As well at that time, monetary conditions shocks have contributed to keep inflation close to its implicit target. This is perceptible through the contributions of monetary policy shocks in the evolution of inflation. Unfortunately, towards the end of this phase, inflation had to contend with a scenario of global financial crisis which has resulted in positive foreign monetary conditions shocks. During the second phase, which came just after the revolution, inflation had to undergo its own upward shocks, and this was particularly during the last two years. As far as that goes, the strong domestic demand and the large depreciation observed since 2012, as well as shocks to the risk premium associated with the worsening of the internal environment, resulted in a persistently high inflation rates (around 6%). In parallel, the policy rate shocks have a positive contribution to inflation, which results from the monetary policy framework adopted by the central bank during that period reflecting lower interest rates than those guaranteeing a return to equilibrium. Nevertheless, foreign inflation contributed to pulling down the rate of inflation in Tunisia which explains in a way the depreciation of the exchange rate which contributed positively in the rise of the prices observed after the revolution.

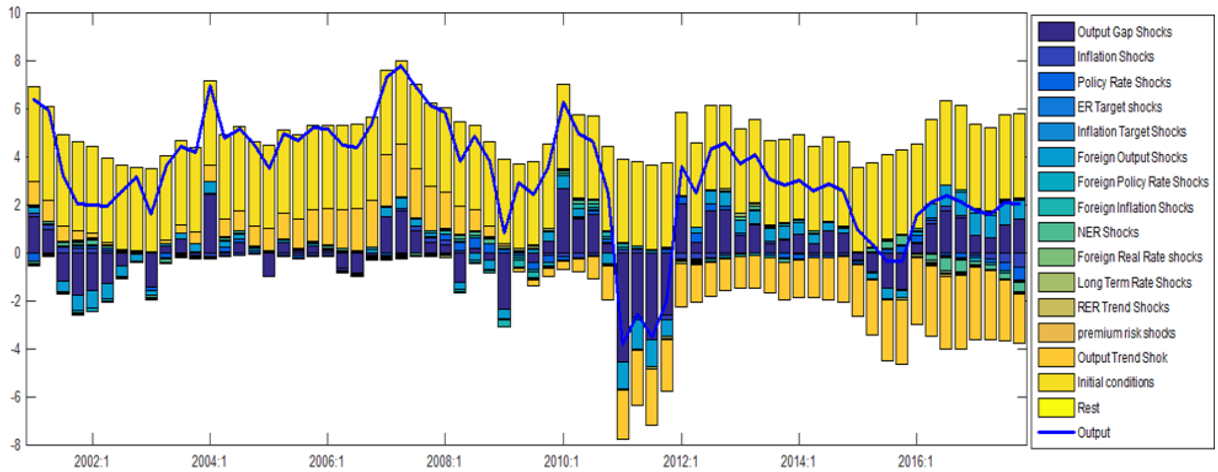
Figure 9: Shock Decomposition – Inflation



3. Shock decomposition – GDP growth

Both output gap and output trend shocks play the key role on economic fluctuations, reflecting the importance of demand shocks on the Tunisian economy. More substantially, foreign output shocks explain an important fraction of the upswing or downswing of Tunisian output; this observation is verified in several episodes, especially during the recessions' period such as the one observed in the global financial crisis. However, in the period following the revolution and following the worsening of the current account, the exchange rate shocks contributed to put a negative pressure on economy. Similarly, the shock that has impacted the trend of activity in Tunisia following the revolution continues contributing negatively to the growth of the Tunisian economy.

Figure 10: Shock Decomposition – GDP growth



VII. Conclusion

The aim of this paper is to present a framework for monetary policy analysis based on a reduced-form of the New Keynesian Model applied to the case of the Tunisian economy using appropriate long run and short run parameters. The key advantage of this model is its ability to expose alternative scenarios of the monetary policy stance and capture the Tunisian specific features of transmission mechanisms allowing supporting monetary policy decision-making. Adding to that, it allows us to describe the key contributors of the evolution of different macroeconomic variables in Tunisia, especially the shocks which explain these movements. So, this permits us to acquire a better knowledge of economics' functioning and improves the decision-making process in the central bank. However, a number of strategic orientations must be taken in consideration, such as the fixation of exchange rate framework and its role compared to the key interest rate of the central bank, the functioning of the fiscal policy and its integration into the model. Implementing a model such as the one presented here establishes attempting to conduct forward–looking monetary policy and is essential in the context of central banks that prepare to opt for new monetary policy framework based on inflation targeting regime.

Appendix

Appendix I: Parameter Values for Tunisia

Firstly, it is important to specify the poverty of the econometric and statistical studies on the Tunisian economy, which makes it difficult to understand and quantify the macroeconomic relations in Tunisia and to assign benchmarks for calibration. For this reason we have carried out several tests and estimations to better reinforce our judgment of the economy and to calibrate the model.

1. Aggregate Demand Parameters

As explain in section III, the output gap depends upon its own lag. So, for fixing the backward-looking coefficient a_1 we start simply with running an OLS regression of a log of output on its lagged value and a trend[17]. Generally, the results show a coefficient consistent with our intuition and the results of the other models in the world. For a_3, the coefficient is simply based on the share of the export on GDP. As to the MCI, the value varies between -0.9 and -0.1 to respect the linear homogeneity condition. Based on expert assessment especially with the weakness of the impact of monetary policy on activities, we fix the parameter to 0.15. However, MCI is weighted average of real interest rate gap and real exchange rate gap. Based on recent estimation from a study[18] developed in the Central Bank of Tunisia, it was agreed to set 0.6 for real interest rate and 0.4 to real exchange rate. This choice is explained by the recent proactivity behavior of monetary policy and adopts a new strategy axed on interest rate activation.

2. Aggregate Supply Parameters

The grandeur of b_1 indicates the inertia in dynamics inflation process. It's important for any central bank to know what policy to target especially if inflation is considered « highly persistent ». Similarly, a high level of b_1 is to say that the central bank changes its inflation objective but the economic agents are uncertain of the change. As far as, a less persistent inflation means that the agents are certain about the long-run inflation objective and the long-run inflation expectations are well anchored. To determinate both b_1 and $1 - b_1$, we proceed to an estimation using OLS Philips curve equations, but we add a constant to the equation and do not impose the unit restriction on the sum of the inflation's coefficients.

[17] Different measures are used to calculate a trend in this estimation: linear, Hodrick-Prescott…

[18] See «Construction d'un indicateur des conditions monétaires pour la Tunisie, (2012) available at: https://www.bct.gov.tn/bct/siteprod/documents/etude_bct.pdf

b_2 reflects the impact of real marginal cost on inflation; to fix this parameter, we run an OLS regression of the rate of inflation on output gap and we complete with our assessment. b_3 and $1 - b_3$ measure the coefficients of the relative weight of output gap and real exchange rate gap in real marginal cost expression. Our calibration is based on the share of imported goods in the CPI basket.

3. Monetary Policy Parameters

The start point of the calibration of the monetary policy parameters is the estimation of the original Taylor rule with different specifications. The results show different specifications that are mainly related to the choice of sample. This aspect made the calibration task very difficult. Nevertheless, we opted only for the recent period to determine the magnitude of different parameters. As explained in section III, we assume that monetary policy rule follows standard formulations, and we allow the central bank to smooth interest rates, which gives 0.6 to f_1. Concerning the reaction functions, Taylor rule react to two parameters namely inflation and output gap. However, we follow the same reasoning to fix f_2 and f_3 to consider the last period as benchmarking for our specifications, which allow for these parameters 0.5 and 0.2 respectively. This confirms the direction and determination of Central Bank of Tunisia to focus its strategy on inflation targeting.

4. Exchange Rate Equation

The value of “e1” matters for policy stance. When $e_1 = 0$, the real exchange rate will be a function of the future sum of real interest differentials (and risk premium) and will provide a direct and rapid channel through which monetary policy will operate. Isard and Laxton (2000) show that, under uncertainty about the value of e_1, it will be prudent to assume that it is slightly below 0.5 because of larger and asymmetric costs that would result from assuming

Appendix II: Identities and Definitions

$i_t = R_t - \pi_{t+1}$

$\overline{\text{dot}\_z_{t+1}} = \bar{\imath} - \overline{\imath *} - \text{prem} + shock\_prem$

$dot\_s^{target} = \text{t1} * dot\_s_{t-1}^{target} + (1 - t1) * (\pi^{target} - ss\_dot\_\pi^{*} + \overline{\text{dot}\_z)} + \varepsilon^{dot\_s\_target}$

$ls^{target} = ls_{t-1}^{target} + dot\_s/4^{target}$

$\pi^{target} = \text{t1} * \ \pi_{t-1}^{target} + (1 - t1) * ss\_\pi^{target} + \varepsilon^{\pi\ target}$

$\hat{\imath} = \text{i} - \bar{\imath}$

$\text{lz} = \text{ls} + l\pi^{*} - l\pi$

$\widehat{lz} = \text{lz} - \overline{lz}$

$\text{dot\_z} = 4 * (\text{lz} - lz_{t-1})$

$\widehat{ly} = \text{ly} - \overline{ly}$

$\overline{ly} = \overline{ly_{t-1}} + \ \overline{dot\_y}/4$

$\text{dot\_y} = 4 * (\text{ly} - ly_{t-1})$

$\text{dot4\_y} = \text{ly} - ly_{t-4}$

$\text{l}\pi = l\pi_{t-1} + dot\_\pi/4$

$\text{dot4\_}\pi = \{\text{dot\_}\pi \quad + dot\_\pi_{t-1} + dot\_\pi_{t-1} \ + \ dot\_\pi_{t-2} \ + \ dot\_\pi_{t-3} \ \}/4$

$\text{ls} = ls_{t-1} + dot\_s/4$

$shock\_prem = \text{h0} * shock\_prem_{t-1} + \varepsilon^{prem}$

$\overline{dot\_z} = \text{h1} * \ \overline{dot\_z_{t-1}} + (1 - h1) * \ \overline{ss\_dot\_z} + \varepsilon^{dot\_z\_eq}$

$\overline{lz} = \overline{lz_{t-1}} + \overline{dot_z/4}$

$\bar{\imath} = \text{h1} * \overline{\imath_{t-1}} \ \ + (1 - \text{h1}) * \overline{ss\_\imath} + \ \varepsilon^{i\_eq}$

$\overline{dot\_y} = \text{h1} * \overline{dot\_y_{t-1}} \ \ + (1 - \text{h1}) * \overline{ss\_dot\_y} + \ \varepsilon^{dot\_gdp\_eq}$

$\widehat{ly^{*}} = \text{h2} * \widehat{ly_{t-1}^{*}} - \varepsilon^{ly\_gap^{*}}$

$R^{*} = \text{h2} * \overline{R^{*}{}_{t-1}} \ \ + (1 - \text{h2}) * (\overline{\imath^{*}} + \overline{dot\_\pi^{*}}) + \ \varepsilon^{R^{*}}$

$i^{*} = R^{*} - dot\_\pi^{*}$

$\overline{\iota^*} = \text{h2} * \overline{\iota^*_{t-1}} + (1 - \text{h2}) * \overline{ss\_\iota^*} + \varepsilon^{i^*}$

$\widehat{\iota^*} = i^* - \overline{\iota^*}$

$dot\_\pi^* = \text{h2} * \overline{dot_{\pi}{}^*{}_{t-1}} + (1 - \text{h2}) * ss\_dot\_\pi^* + \varepsilon^{dot\_\pi^*}$

$l\pi^* = l\pi^*_{t-1} + dot\_\pi^*/4$

Where:

lπ = log of price level; ls = log of nominal exchange rate;

lz = log of real exchange rate; ly = log of gdp ;

_eq trend (equilibrium);

ss_ = steady-state;

dot_= Q-o-Q change;

dot4_ = Y-o-Y change

Figures

Figure 11: Gross Domestic Product (excluding agriculture)

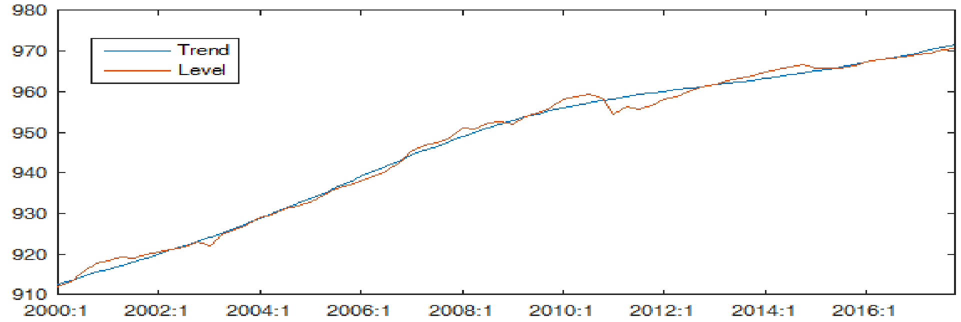


Figure 12: Nominal Effective Exchange Rate

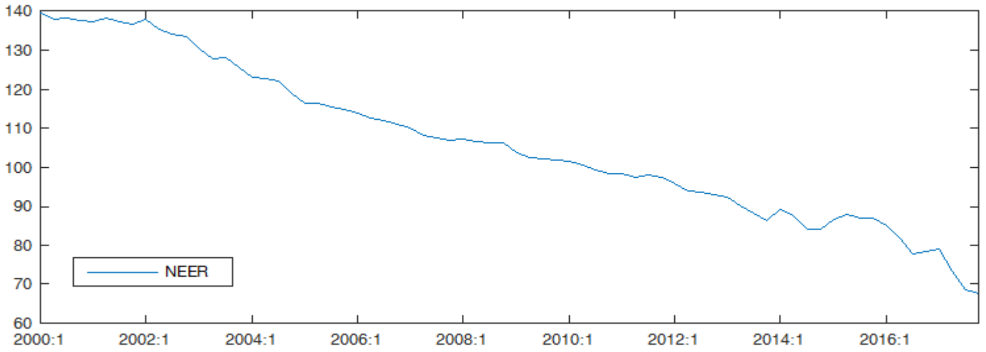


Figure 13: Inflation rate

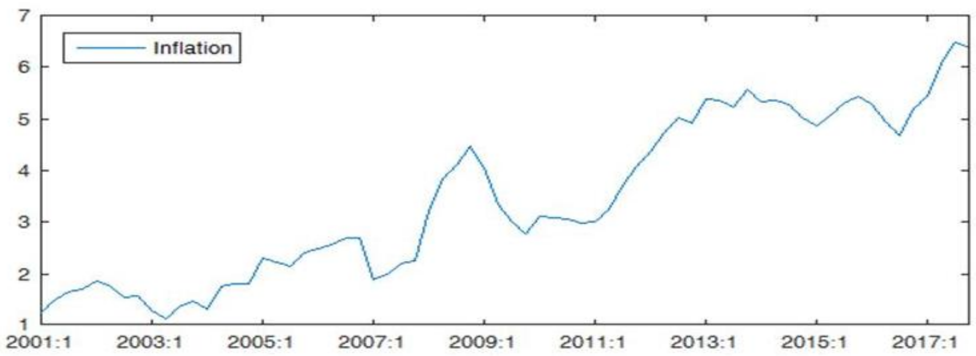
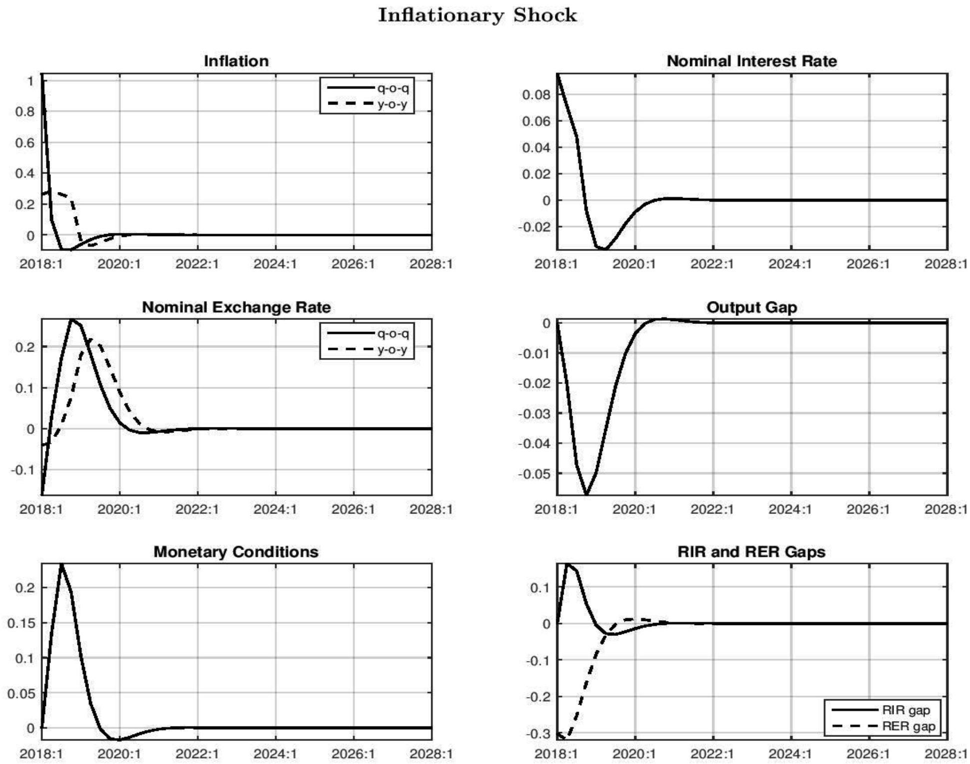


Figure 14: Hypothesis "b1" = 0.2 in the Phillips curve



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