Medium-Term Forecasting Model for Tunisia *

Moez LAJMI †
Sihem EL KHADHRAOUI‡

July 2014

Abstract

This work aims at building a medium-term forecasting model for Tunisia. The model which has a New Keynesian theoretical foundation is based on the Global Projection Model developed by the IMF while endeavouring to take into account the specificities of the Tunisian economy. The Bayesian estimation results suggest that the model can provide broadly a consistent economic interpretation of macroeconomic developments. Usual determinants of inflation are not enough to explain the dynamics of inflation. The impact of the output gap is quite slow and weak. However, the impact of supply shocks was persistent, especially during the post-revolution period. Although the interest rate began to be increasingly active in recent years, the effects of this instrument remained limited.

JEL Classification : E17, E37, E52, E58.

Keywords: Inflation, Monetary Policy, Forecasting, Macroeconomic Modeling.

---

*This study was conducted by the Central Bank of Tunisia (Monetary Policy Strategy Directorate) and Banque de France (BdF) in partnership with the National Bank of Poland (NBP) in the framework of the twinning project aiming at implementing a monetary policy framework based on inflation targeting at the CBT. The purpose of the study is to develop a medium-term forecasting model. The study was prepared under the supervision of Mr Michel JUILLARD and Ms Hélène EHRHART (Department of Studies and International Relations at Banque de France). The authors would like to thank Mr Mohamed Salah SOULEM and Mrs Rym KOLSI for their helpful comments and contribution in the translation of the paper. The opinions expressed in this document are those of the authors. They do not involve in any way the CBT.

†Deputy Director of Study and Modeling of the Monetary Policy. Email: moez.lajmi@bct.gov.tn

‡Head of Modeling and Medium Term Forecasting. Email: sihem.elkhadhraoui@bct.gov.tn
Contents

1 Introduction 4

2 Macroeconomic development and monetary policy in Tunisia 5
   2.1 Monetary and exchange rate policy ....................................................... 5
      2.1.1 Interest rate policy ........................................................................ 5
      2.1.2 Exchange rate policy ...................................................................... 5
   2.2 Economic growth .................................................................................... 7
   2.3 Inflation ................................................................................................. 8

3 Structure of the model 9
   3.1 Phillips curve ......................................................................................... 10
   3.2 IS curve .................................................................................................. 11
   3.3 Uncovered interest rate parity ................................................................. 13
   3.4 Monetary policy rule ............................................................................. 14
   3.5 Foreign country (Euro Zone) .................................................................. 14

4 Estimation of the model 15
   4.1 Data ....................................................................................................... 15
   4.2 Bayesian estimation ............................................................................... 16
   4.3 Choice of priors ..................................................................................... 17
   4.4 Results .................................................................................................... 18

5 Simulations and monetary policy analysis 19
   5.1 Decomposition of the output gap and inflation ..................................... 19
   5.2 Impulse responses functions .................................................................. 20

6 Forecasting 21

7 Conclusions 22

A Appendix 25
   A.1 Description of the Model ...................................................................... 25
   A.2 Description of parameters .................................................................... 26
   A.3 Prior and posterior of the parameters .................................................. 27
   A.4 Trends in core inflation and in the main economic activity sectors ...... 28
   A.5 Impulse responses ................................................................................ 29
   A.6 Key GPM results for selected countries and regions ......................... 31

List of Figures

1 Trends in the main money market interest rates ........................................ 6
2 Euro/Dinar and Dollar/Dinar parities .......................................................... 6
3 Exchange rate indices of the Euro/Dinar .................................................... 6
4 Structure of economic growth in Tunisia .................................................. 7
5 Inflation and core inflation ........................................................................ 9
6 Historical decomposition of the output gap .......................................... 19
7 Historical decomposition of the core inflation ....................................... 20
8 Non conditional forecasting of core inflation (out of sample) ................ 22
9 Core inflation and its trend ...................................................................... 28
10 Added values of main Tunisian economic sectors .................................. 28
11 A one-percent unanticipated shock to nominal interest rate ........................................... 29
12 A one-percent unanticipated shock to inflation ............................................................... 29
13 A one-percent unanticipated shock to output gap .......................................................... 30
14 A one-percent unanticipated shock to Euro Zone output gap ........................................ 30

List of Tables

1 Structure of trade with Europe (27 countries) in % ......................................................... 8
2 Calibrated parameters ........................................................................................................ 17
3 Description of parameters .................................................................................................. 26
4 Prior and posterior parameters .......................................................................................... 27
5 Estimated parameters of selected variables in the GPM model ........................................ 31
1 Introduction

It has been recognized long since that the economic policy in general and monetary policy in particular, need a forward-looking dimension, given the relatively long time with which the effects of its action transmit to the economy. This requires a prospective set of tools, for analysing and forecasting, which synthesizes relevant information for a better assessment of economic prospects in sight. It is important for a central bank to have its own medium-term forecasting model. Such a model is a tool for decision support in the conduct of monetary policy.

This study is part of setting up of an analysis and forecasting device at the Central Bank of Tunisia (CBT). Its main objective is to build a medium-term forecasting model for economic growth and inflation in Tunisia. The model is New Keynesian\(^1\) and based on the assumptions that the expectations of the economic agents are rational in the presence of nominal rigidities and imperfect competition on prices and wages. Its structure is inspired from the Global Projection Model (GPM) developed at the IMF, in particular, in its version presented by Carabenciov and al.(2008)[5]. Nevertheless, the model would sufficiently replicate the specific developments of the Tunisian economy.

Originally designed for the U.S economy, the GPM model was used for analysis and forecasting of inflation purposes. Since then, series of works have followed, in collaboration with the Center for Economic Research and its Applications (CEPREMAP), aiming to integrate other regions and countries. In its latest version, the GPM model covers more than 85% of global GDP, and the forecasts allowed the IMF as well as many experts from central banks to benefit from consistent multi-country projections. Besides the forecast aspect, the GPM model can also be used in exercises of macroeconomic simulations and in the analysis of the transmission of shocks from one country to another. Our model describes a small open economy in the presence of nominal rigidities and forward-looking expectations. The equations formalize the behaviour of aggregate demand, inflation, exchange rate as well as nominal interest rate. Some parameters are estimated while others are calibrated to replicate the important Tunisian economic developments. In this respect, a particular importance was given to the measurement of potential output and the positioning of the actual production in relation to this measure in the presence of several shocks.

The structure of the paper is as follows: The first section outlines the key features of the Tunisian economy during the last decade. The second section presents the structure of the model. The third and fourth parts focus on the estimation technique used, and the analysis results through the decomposition of key macroeconomic aggregates deviations relative to their equilibrium values and functions of impulses responses. We will consider in the last section the description of the forecasting process adopted.

\(^1\)This is a current of contemporary macroeconomics that seeks to provide microeconomic foundations for Keynesian economics.
2 Macroeconomic development and monetary policy in Tunisia

2.1 Monetary and exchange rate policy

The Central Bank of Tunisia (CBT) has pursued since the 1990's a discretionary monetary policy, making use of multiple instruments. This orientation is explained by the attachment of the CBT to several objectives at once. In fact, the CBT aimed at supporting economic activity, preserving the stability of the financial system and the viability of the external position and keeping under control the growth of domestic prices. This approach is justified not only by the ambiguity surrounding the main mission of the CBT which consisted, according to the former Act governing the creation and the organization of the CBT in the preservation of the internal and external value of the national currency, but also by the absence of a reliable analytical framework allowing it to carry out its monetary policy.

Each year, the CBT prepares a monetary program in which is announced a target of growth of the monetary aggregate taking into account a macroeconomic scheme previously established by the Government. Thus, the assessment of inflationary pressure through the monitoring of monetary developments was rather indicative and did not have any significant influence on decisions with regards to key interest rate. It was only from 2006 that the ambiguity surrounding the main mission of the Bank was lifted through consecrating the preservation of price stability as the main objective of monetary policy.

2.1.1 Interest rate policy

Trend in interest rates during the period between 2000 and 2008, shows a strong reluctance from the CBT in the use of the interest rate as a main instrument in the conduct of monetary policy, mainly for financial stability considerations. Thus, apart from the downward trend that has accompanied a moderate increase in inflation since 2000, the key interest rate has been revised upward once in 2006 by 25 basis points. The daily money market rate TMM, which is the reference rate for all financial instruments, remained for a long period of low volatility due to the strong presence of the CBT on the market.

This monetary policy, which can be qualified overall by neutral along with rigidity of the interest rates, has stripped the money market rate its informative content on the liquidity situation and led to reduce substantially its role in the conduct of monetary policy. It was only with the introduction of the standing facilities and a corridor of 100 basis points around the key rate, in February 2009, that TMM has become more flexible.

2.1.2 Exchange rate policy

While focusing on the implicit assumption of a stable equilibrium exchange rate, the monetary authorities adopted, during the period between 1994 and 2000, an exchange rate policy aimed at stabilizing the real
In response to the sharp deceleration of economic activity and the increase in NPL, particularly in the tourism sector.

Support economic activity strongly affected by the contraction in external demand.

Introduction of standing facilities and abandonment of fine tuning operations.

In response to rising inflation.

Alleviation of financial burdens of the enterprises strongly affected by the events occurring after the revolution.

In response to the acceleration of inflation in accordance with the new mission of the BCT.

Corridor

Key Rate

Money Market Rate

Figure 1: Trends in the main money market interest rates

effective exchange rate (REER) through the adjustment of the nominal effective exchange rate (NEER)\(^2\). However, the sharp fall in the euro against the dollar during the years 2000 and 2001, led the authorities to pursue an exchange rate policy more adapted to the new context. Indeed, and in order to preserve or even improve the competitiveness of Tunisian exports, the CBT has opted for a depreciation of the real exchange rate. This strategy has been abandoned since 2008 in favour of more stability of the REER as inflation differential between Tunisia and the Euro Zone was widening.

2An increase of the index means a depreciation of the dinar, while a decrease of the index means an appreciation of the dinar.
This orientation, which was accompanied by an asymmetry in the response of the CBT to the change in the Euro-dollar parity, had mainly two objectives: First to support Tunisian companies, including those benefiting from upgrade programs, to cope with the difficulties caused by an increased openness of the economy\footnote{The entry into force of the second phase of the Association Agreement with the European Union and the phasing out of quotas under the multi-fiber agreement, together with the accession of China to the WTO, in 2001.}, and second, to manage the risks to which was exposed the tourism sector after the events of September 11, 2001 and the attacks of Djerba in 2002 and which has resulted in a strong increase in the rate of non-performing loans of the banking system (around 24\% in 2003).

To deal with a widening current account deficit, the CBT has adopted a more flexible exchange rate policy, by modifying, in 2012, the way of its intervention in the foreign exchange market. These interventions are no longer based on the reference rate calculated on the basis of a basket of currencies but on a fixing based on the interbank rate. This approach aimed at facilitating external adjustment and helping reduce erosion of foreign assets in currency.

### 2.2 Economic growth

Economic activity performed well during the period between 2000 and 2008, despite a 2002 year strongly affected by the sharp decline in the activity of the tourism sector in the wake of the fallouts of the attacks of September 11, 2001 and of Djerba in April 2002. Growth rate evolved during this period around 5\% on average led by the strength of private consumption, main driver of growth in Tunisia.

![Figure 4: Structure of economic growth in Tunisia](image)

If Tunisia succeeded in 2009 to effectively manage the financial crisis thanks to its low degree of integration and the remaining restrictions imposed on the capital flows, the country was unable to avoid the slowdown in the economy which is due to the economic crisis in the Euro Zone.
The structure of trade has made Tunisia a real partner for Europe with shares of exports and imports exceeding those of the other countries of the southern shore of the Mediterranean. These high levels have contributed to increase the vulnerability of the Tunisian economy to the economic situation in Europe. Indeed, according to De Bock and al. (2010)[8] a shock on the economic activity in the Euro Zone generates a significant reaction in terms of growth in Tunisia. This strong dependence, together with other internal factors, have put in difficulty economic recovery after the revolution. The activity is still struggling to recover its strength given the unfavorable situation facing the Euro Zone today.

<table>
<thead>
<tr>
<th>Table 1: Structure of trade with Europe (27 countries) in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exports to Europe</td>
</tr>
<tr>
<td>Tunisia</td>
</tr>
<tr>
<td>Algeria</td>
</tr>
<tr>
<td>Egypt</td>
</tr>
<tr>
<td>Jordan</td>
</tr>
<tr>
<td>Lebanon</td>
</tr>
<tr>
<td>Morocco</td>
</tr>
<tr>
<td>Syria</td>
</tr>
</tbody>
</table>


2.3 Inflation

Despite a monetary policy which was more oriented towards the support of economic activity and the preservation of financial stability, Tunisia has managed during the period between 2000 and 2010, to keep inflation under control through a policy of price administration which succeeded during this period to counter the impact on international prices for commodities and energy and contain inflation within acceptable levels4.

Three features have marked the evolution of the prices during this period:

i. A relatively high volatility and cyclical profile, less noticeable in core inflation, with alternating phases marked, especially, by the evolution of fresh food prices.

ii. The presence of an upward trend caused by the ongoing rise in import prices mainly due to the depreciation of the exchange rate of the dinar.

---

4The only overrun has been recorded during the first half of 2008 and, following the soaring prices of commodities and energy.
iii. The high share of administered prices in the basket for consumption, despite the liberalization process initiated by the Government. Thus, any unexpected adjustment in administered commodity prices is likely to cause a budgetary bias in the control of inflation and to reduce the impact of the interest rate in the transmission of monetary policy impulses.

![Figure 5: Inflation and core inflation](image)

The events which accompanied the revolution in 2011 are reflected by a deterioration of the security situation, a proliferation of informal sector and the establishment of a new balance of social power resulting in disproportionate revision of wages. This very particular context has contributed to the resurgence of inflationary pressures.

### 3 Structure of the model

We consider a semi-structural model for a small open economy. The main equations describe the dynamics of aggregated demand and supply, of the nominal interest rate and the real exchange rate. The space of variables is characterized by a reduced number of observable variables. Four variables for the Tunisian economy were used, which are the quarterly growth rate of the real GDP and of the nominal exchange rate, the inflation rate and the short-term nominal interest rate. For the Euro Zone economy, the choice was limited to three variables which are the output gap, inflation and real interest rate. Worth of note that forecasts of Tunisian variables from the model are conditional of projections of variables in the Euro Zone as established by the GPM.

Broadly, the model relies on the same structure of GPM model notably in its version presented by Carabenciov and al.(2008)[4], as amended by introducing some changes that do not affect the economic

---

5Process of wage formation, strikes, sit-ins, etc.
foundations of the model. In particular, we suppose that:

- Non-stationary variables are expressed in terms of logarithmic difference.
- Shocks on output gap, GDP growth rates and potential are controlled by the ratios of their standard deviations.
- The equilibrium real exchange rate follows an autoregressive process.
- The monetary policy rule is augmented by the real exchange rate.

### 3.1 Phillips curve

Price dynamics is described by a Phillips curve augmented by the real exchange rate. In this version we assume that inflation expectations are partly backward-looking and forward-looking\(^6\) and complementary to unit. This assumption implies that current inflation is influenced in part by expected future inflation. When a firm sets its price, it must be concerned with future inflation developments because it may be unable to adjust its price for several periods (Walsh (2003)[28]).

We assume that the inflation rate can be written as:

\[
\pi_t = \lambda_1 E_t \pi_{t+1} + (1 - \lambda_1)\pi_{t-1} + \lambda_2 y_{t-1} + \lambda_3 dZ_t + \epsilon^p_t
\]  

(1)

where \(\pi\) is inflation, measured by the annualized quarterly change of consumer price index, \(y\) the output gap, \(dZ\) the quarterly growth rate of the real exchange rate. The parameter \(\lambda_1\) measures the influence of the forward-looking expectations on price setting. Parameter \(\lambda_2\) reflects the degree of impact of adjustment in production costs\(^7\) on prices. Parameter \(\lambda_3\) measures the effects of pass-through degree of exchange rate to consumer prices\(^8\). Finally, equation (1) incorporates a stochastic shock \(\epsilon^p\) which can be interpreted as a temporary supply shock\(^9\).

---

\(^6\) Although in its original version, inflation is purely forward-looking (Walsh (2003)[28]), it is also admitted in theory (Gali and al.(2001)[12]) and empirically (Palley (2003)[20], Dupuis (2004)[9], Roeger and al.(2012)[22]) that the adjustment process of inflation can be slow due to an important inertial component.

\(^7\) Cost adjustments could respond to pressures on the production apparatus to meet additional demand. Given the lack of informative time series on these costs, it is often assumed that the output gap is good approximation.

\(^8\) Theoretically, inflation depends on the change in the terms of trade, but assuming the law of single price, the real exchange rate is proportional to the terms of trade (Walsh (2003)[28] and Gali and Monacelli (2004)[13]).

\(^9\) For example, the shocks on commodity world prices and energy prices.
3.2 IS curve

The aggregated demand equation assumes the existence of a potential output level, for the economy as a whole, around which fluctuates the actual output. These fluctuations, which are a key element in the evolution of inflation are assumed to be defined as follows:

\[ y_t = \beta_1 y_{t-1} + \beta_2 E_t y_{t+1} - \beta_3 r r_{t-1} + \beta_4 z z_{t-1} + \beta_5 y_e^{*u} + \epsilon_t^y \]  

(2)

where \( y, r r, z z \) and \( y_e^{*u} \) are respectively the domestic output, the real interest rate, the real exchange rate and Euro Zone output, which are expressed in term of gaps to their long-term levels. This specification reflects the fact that the current production decisions taken at time \( t \), represented by the variable \( y_t \), depend on decisions taken during the last periods and also on the expected future state of the economy, which reflect the perspectives of the activity. The latter may influence households’ expectations about their future revenues and encourage them to consume more. The expected effect of this component is positive and expansive. Furthermore, a positive real interest rate gap compared to its long-term movements has a restrictive effect on domestic demand. An increase in the real costs of credit, caused by an increase in the nominal short-term interest rate, can affect negatively the consumption as well as the investment decisions. Foreign demand influences aggregated demand through changes in the real exchange rate and the foreign output fluctuations compared to their long-run levels. A positive gap in real exchange rate is likely to increase the competitiveness of Tunisian products. Also, a positive Euro Zone output gap stimulates the demand for Tunisian products. Finally, the output gap can be disturbed by a temporary shock, \( \epsilon_t^y \), such as unexpected increases in budget expenditure and/or in foreign demand from other countries outside the Euro Zone.

As they are unobservable, long-term variables are estimated by the model, simultaneously and together with the parameters. To appreciate these variables, it seems necessary to impose certain process which may draw accurately their trajectories. First of all, we assume that the potential output verifies the following definition:

\[ y_t - y_{t-1} = d g d p_t - d g d p_t^* \]  

(3)

where \( d g d p \) and \( d g d p^* \) are the quarterly growth rates of the observed GDP and the potential. The growth rate of the potential is supposed to be equal to \( g_t \) augmented by an exogenous shock. This shock is likely to produce a permanent change in the potential level.

\[ d g d p_t^* = g_t / 4 + \epsilon_t^{d g d p^*} \]  

(4)

In the long run, the growth rate of the potential \( g \) is supposed to be equal to the steady state rate of
growth $g^{ss}$. But it can diverge from this steady state rate of growth following an exogenous transitory shock, $\epsilon^g$, before returning back gradually to equilibrium:

$$g_t = (1 - \rho_g)g^{ss} + \rho_g g_{t-1} + \epsilon^g_t$$

(5)

Worth of note that with such specification of the growth potential, it would be difficult to appraise in a reliable way the estimated output gap, given the important uncertainty implied by the shock which affected the Tunisian economy during the Revolution of January 14th, 2011. A way allowing to reduce this uncertainty consists in taking into account information on residual terms to control their effects on the potential and output gap. This control can be done through the calibration of the ratio between the standard deviations of residual terms of the IS curve and the dynamics of the potential in the following way:

$$y_t = \beta_1 y_{t-1} + \beta_2 E_t y_{t+1} - \beta_3 r_{t-1} + \beta_4 z_{t-1} + \beta_5 y_{t-1} + u^y_t$$

(6)

$$dgdp^*_t = g_t/4 + u^{dgdp^*}_t$$

(7)

$$g_t = (1 - \rho_g)g^{ss} + \rho_g g_{t-1} + u^g_t$$

(8)

where $\epsilon^y_t = \psi_1 \sigma^g u^y_t$, $\epsilon^{dgdp^*}_t = \psi_2 \sigma^g u^{dgdp^*}_t$ and $\epsilon^g_t = \sigma^g u^g_t$. The parameter $\sigma^g$ is the standard deviation of $\epsilon^g$, $\psi_1$ and $\psi_2$ are the ratios of standard deviations of $\epsilon^y$ and $\epsilon^{dgdp^*}$ on $\epsilon^y$ respectively. Higher values of $\psi_1$ would increase potential rigidity and imply more sensitivity of the output gap to the shocks affecting actual production. However, higher values of $\psi_2$ make the potential more flexible. Residual terms $u^y_t$, $u^{dgdp^*}_t$ and $u^g_t$ are supposed to follow N(0,1) distribution.

The long-run movements of the real interest rate, $r^*$, are defined as:

$$r^*_t = (1 - \rho_r)r^{ss} + \rho_r r^*_{t-1} + \epsilon^r_t$$

(9)

$$r^*_t = r_t - r r_t$$

(10)

$$r_t = i_t - E_t \pi_{t+1}$$

(11)

where $i$ and $r$ are the short-term nominal and real interest rates and $r^{ss}$ the steady state real interest rate. This equation implies that, in the long-run, real interest rate can diverge from its steady state level following an exogenous shock $\epsilon^r$.

Finally, we assume that the long-run movements of the real exchange rate follow an autoregressive process:

$$dZ^*_t = \kappa dZ^*_{t-1} + \epsilon^r_t$$

(12)
\[ z_{zt} = dZ_t - dZ_t^* + z_{zt-1} \]  

where \( dZ \) and \( dZ^* \) are the quarterly growth rates of effective and equilibrium real exchange rates. Parameter \( \kappa \) measures the influence of inertia component in the dynamics of real exchange rate, while the residual term \( \epsilon Z^* \) summarizes exogenous shocks which can lead to temporary deviations of \( dZ^* \).

### 3.3 Uncovered interest rate parity

To assess the dynamics of the real exchange rate, the model uses the concept of uncovered parity of interest rate (UIP). Although this concept is questioned in practice, it remains an empirical reference for economists, while providing every time some changes in its assumptions.

By conception, the UIP states that the difference between the expected future and current exchange rates is offset by the differential between domestic and foreign interest rates. This definition requires a perfect substitutability between financial assets in both countries and consequently, a zero risk-premium. The confrontation of this relationship with the observed data has challenged the assumptions of the formation of expectations and the risk-premium.

In a context of uncertainty and absence of full information about financial markets developments, the expectations of the economic agents cannot be purely rational. Therefore, the expectations of the current exchange rate can be written as a linear combination of the backward-looking and forward-looking expectations:

\[ Z^e_t = \phi E_t Z_{t+1} + (1 - \phi) Z_{t-1} \]  

Some risk-premium is usually introduced to explain the UIP deviations. For example, when the interventions of central banks on the exchange market are not expected by the economic agents, they can lead to temporary deviations of the UIP. This is particularly the case if they are intended to support the national currency while the differential in interest rates suggested a depreciation of the latter. Our specification of UIP, in the presence of the backward-looking and forward-looking expectations and the risk-premium, can be written as \(^{10}\):

\[ 4(Z^e_t - Z_t) = (r_t - r^e_t) - (r^*_t - r^e^{uw}_t) + \epsilon_{zz} \]  

where \( r^e_t \) is the Euro Zone real interest rate and \( r^e^{uw}_t \) its equilibrium level. The component \( r^*_t - r^e^{uw}_t \) is an equilibrium risk-premium on yields of Tunisia’s assets. The residual term \( \epsilon_{zz} \) is interpreted as another risk-premium relative to temporary economic developments. The rearrangement of these two

\(^{10}\)The differential real exchange rate is multiplied by four to have the annualized rate in order to make it comparable to the interest rate differentials.
last equations allows us to write:

$$4((\phi - 1)dZ_t + \phi E_t dZ_{t+1}) = (r_t - r_t^{eu}) - (r_t^* - r_t^{eu^*}) + \epsilon_t^{zz}$$

\( (16) \)

$$dZ_t = dS_t + (\pi_t^{eu} - \pi_t)/4$$

\( (17) \)

where \( dZ \) and \( dS \) are the quarterly growth rates of real and nominal exchange rates compared to euro and \( \pi^{eu} \) is the Euro Zone quarterly annualized inflation rate.

### 3.4 Monetary policy rule

Through a monetary policy rule, in particular a Taylor rule\(^{11}\), we try to describe the monetary policy developments in different periods and to learn about the central bank’s behaviour regarding to its short-term interest rate adjustments. The construction of such a rule is based on the calculation of a compatible interest rate with price stability objective. From a normative point of view, the comparison between the interest rate estimated through a Taylor rule and the observed one allows to judge of the adequacy of the monetary policy reactions to the main macroeconomic variables’ developments.

The used rule is a modified version of the GPM6 model that takes into account the growth rate of the real exchange rate. Through this rule, the short-term nominal interest rate is described as follows:

$$i_t = \gamma_1 i_{t-1} + (1 - \gamma_1)((r_t^* + \pi_t^*) + \gamma_2(\pi_t - \pi_t^*) + \gamma_3 y_t + \gamma_4 dZ_t) + \epsilon_i^t$$

\( (18) \)

where \( i \) is the nominal short-term interest rate, \( \pi^* \) the desired level of inflation and \( r^* \) the equilibrium real interest rate. This rule implies that in the long run, the interest rate \( i \) will be equal to its equilibrium level. However, in the short and medium runs, it can move away to react to deviations in inflation or output gap and real exchange rate growth. The discretionary actions of monetary authorities are incorporated into the residual term \( \epsilon_i^t \), which is interpreted as a monetary policy shock.

### 3.5 Foreign country (Euro Zone)

The main trade partners of Tunisia are represented by the Euro Zone countries\(^{12}\). We introduce mainly three Euro Zone macroeconomic indicators: the output gap, the inflation rate and the real interest rate. We assume that these variables may be written as the following processes:

\(^{11}\) J. Taylor proposed a pragmatic rule which describes the behaviour of the interest rate of the Federal Reserve Bank of the United States. Given the simplicity of this rule, it gradually stood out as a reference rule for empirical works.

\(^{12}\) More than 70% of foreign trade is made with Euro Zone countries, in particular, France, Italy, Germany and Spain.
where $y_{eu}$ is Euro Zone output gap, $\pi_{eu}$ the annualized quarterly growth rate of the harmonized CPI, $\pi_{eu}^{ss}$ and $r_{eu}^{ss}$ are the inflation rate and real interest rate respectively at their steady state. The residual terms $\epsilon_{y_{eu}}$, $\epsilon_{\pi_{eu}}$, $\epsilon_{r_{eu}}$ and $\epsilon_{r_{eu}^*}$ summarize the demand, supply and interest rate shocks in the Euro Zone. In terms of forecasting, the Euro Zone economic projections generated by the GPM6 model are used to forecast economic growth and inflation for Tunisia. We note that the GPM6 model integrates the most important economies of the world (more than 85% of the global GDP) and generates monthly new forecasts.

4 Estimation of the model

The model described previously consists of 17 equations and 41 parameters. The estimation by traditional econometric methods seems inappropriate given the size of the sample which is relatively small. To cope with such problem, we opted for the Bayesian method. This technique has become the preferred tool of macro-economists like Smets and Wouters(2003)[24], Fernández and al.(2006)[10] and Wieland and al.(2012)[29]. The Bayesian method consists in combining the information delivered by the data with prior information on the parameters of the model, which is generally carried out on the basis of experts’ knowledge and/or simply deduced from the economic theory.

4.1 Data

The data used to estimate the model are provided by the National Institute of Statistics (INS), CBT and GPM network (CEPREMAP). The estimation period started from the second quarter 2000 to the last quarter 2012. The selected observing variables are:

- The quarterly growth rate of the real GDP excluding agriculture (base year 2005)

- The core inflation rate, defined as the annualized quarterly change of CPI excluding fresh food and administered products prices (base year 2005).

See appendix A.1 for a detailed description of the model.

The agriculture component is excluded because of its volatility which depends on climatic factors.
• The short-term nominal interest rate, measured as the quarterly average of the money market rate (TMM).

• The quarterly growth of nominal bilateral exchange rate (Euro/Dinar) index (base year 2005).

• The Euro Zone output gap measured as the observed Euro Zone real GDP and the potential level estimated by GPM model (6 regions), Cf. Carabencio et al(2011).

• The Euro Zone inflation rate defined by annualized quarterly change of harmonized CPI (base year 2005).

• The Euro Zone real interest rate$^{15}$ which is equal to the difference between Euribor (3 months) and the expected future inflation rate.

4.2 Bayesian estimation

During the last ten years, the Bayesian approach has become widespread among economists and modellers. Two main reasons can explain its success. The first reason is of conceptual order, by taking into account the prior information on the structural parameters of the model. The second reason is rather empirical and relies on the technology which allowed the development of software and numerical calculation techniques facilitating the use of this approach. Empirically, the Bayesian approach starts with the formulation of a model. We then formulate an a prior distribution for the unknown parameters of the model, which is meant to capture our beliefs about the situation before seeing the data. After observing some data, we apply Bayes’ Rule to obtain an a posterior distribution for these unknown parameters, which takes into account both information: the prior and the data (Neal(1998)[19]).

The application of the Bayesian approach supposes that we know the following amounts:

• The prior probability of the parameters, which summarizes the available information on the parameters. It requires the choice of the mean and the standard deviation as well as the appropriate distribution for each parameter.

• The joint probability of observing data given parameters, which is also known as the likelihood.

• The Bayes’ Rule which determines the posterior probability from the prior probability and the likelihood.

\[
p(\theta|Y) = \frac{p(Y|\theta)p(\theta)}{\int p(Y|\theta)p(\theta)\,d\theta} \propto p(Y|\theta)p(\theta)
\]

where \( \theta \) is the vector of parameters and \( p(\theta|Y) \) the posterior probability given the model. \( p(\theta) \) is the prior probability which reflects the prior informations on parameters. \( p(Y|\theta) \) is the likelihood knowing

\[15\]This rate is calculated by the GPM6 model.
the parameters which incorporates information delivered by the data. The inference of the posteriors raises some comments. First of all, the comparison of the prior and posterior variances can inform about the relevance of the information brought by the data compared to that of priors. In a context of few data, the consideration of the prior information allows to improve the estimate accuracy. When we bring of the information, the posterior variance should be lower than the variance of the likelihood estimator. Furthermore, if the prior information is more important than the empirical one (resulting from data) then the expected posterior will be closer to the expected prior than the likelihood estimator (Adjemian (2008)[1]). Finally, from this posterior distribution we can generate impulse responses functions and compute predictive distributions for future observations.

4.3 Choice of priors

The choice of priors is an important step in the Bayesian estimation procedure. It is made in a subjective way and depends on the beliefs of the economist on the parameters describing the behaviour of the variables of interest. The appreciations can provide an acceptable criterion to determine a range of values for the parameter$^{16}$ and to reproduce them in the form of parametrized densities. In practice, for parameters which are assumed to be strictly positive we use the Gamma distribution. Parameters bounded between 0 and 1, are set to have Beta distribution. The Normal distribution seems to be more suitable if parameter beliefs are vague. However, the standard deviations of residual terms are supposed to follow the Gamma-Inverse distribution, which guarantees that they are strictly positive.

Some parameters were calibrated, given the difficulty to identify them in the data. Euro Zone parameters priors were deduced from the GPM6 model. The remaining priors reflect rather our appreciations of the Tunisian economy. The calibrated parameters are presented in the following table:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>Prior</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^*$</td>
<td>Equilibrium inflation rate</td>
<td>4.0%</td>
</tr>
<tr>
<td>$\psi_1$</td>
<td>Ratio of variances of $\epsilon^y$ and $\epsilon^g$</td>
<td>4.0</td>
</tr>
<tr>
<td>$\psi_2$</td>
<td>Ratio of variances of $\epsilon^{dpib^*}$ and $\epsilon^g$</td>
<td>0.1</td>
</tr>
<tr>
<td>$\pi^{eu*}$</td>
<td>Equilibrium Euro Zone inflation rate</td>
<td>2.0%</td>
</tr>
<tr>
<td>$\tau$</td>
<td>Euro Zone output gap persistence</td>
<td>0.5</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Euro Zone inflation persistence</td>
<td>0.5</td>
</tr>
<tr>
<td>$\rho^{eu}$</td>
<td>Euro Zone real interest rate persistence</td>
<td>0.5</td>
</tr>
<tr>
<td>$\rho^{eu*}$</td>
<td>Euro Zone equilibrium real interest rate persistence</td>
<td>0.5</td>
</tr>
</tbody>
</table>

$^{16}$These judgements help to solve several numerical calculation problems.
4.4 Results

Results from the Bayesian estimation are presented in Table 4 and show that parameters are overall consistent with our prior beliefs. First of all, the output inertia of the IS curve is confirmed by the model ($\beta_1 = 0.67$). This persistence is mainly due to the sustainable growth in private consumption over the period of estimation. Furthermore, expectations of future demand have a fairly significant impact on the current level of the output gap ($\beta_2 = 0.12$). Monetary policy impulses, transmitted through the interest rate gap, remain limited; this is because of the steady pace of the nominal interest rate over a long period ($\beta_3 = 0.07$). Moreover, the contribution of foreign demand to aggregate demand is relatively high, reflected by the effects of the deviation of the real exchange rate ($\beta_4 = 0.16$) and the demand situation in Euro Zone ($\beta_5 = 0.20$). Despite the Revolution effects, the impact of the activity in the Euro Zone on the Tunisian economy remained high.

Secondly, the estimated parameters of the Phillips curve, give particular importance to forward-looking expectations ($\lambda_1 = 0.67$) reflecting partly the inflationary trend observed during the past decade (Figure 9). Worth of note that such expectation is crucial in monetary policy conducting when price stability is the main objective. If these expectations are not well anchored to the central bank’s objective, they may lead to higher inflation deviations from the desired level and, consequently, compromise the efficiency of monetary policy actions. The effect of the output gap on inflation in Tunisia is relatively low compared to other countries. Moreover the output gap-inflation relationship was strongly affected by the developments over the post-revolution period. This is because the increase in wages was not accompanied by a proportional improvement in productivity. Broadly, the results indicate that prices adjust mostly to supply shocks.

Thirdly, the estimates of Taylor rule coefficients are globally consistent with our prior beliefs. The smoothing coefficient is relatively high ($\gamma_1 = 0.93$), reflecting the strong rigidity of the interest rate, which is due to monetary authorities reluctance to use this instrument, over past periods. However, the interest rate seems to be sensitive to activity movements ($\gamma_3 = 0.44$), implying the importance of stabilizing the economic activity. Moreover, the response of the interest rate to deviations in the real exchange rate is quite important ($\gamma_4 = 0.16$). This means that monetary policy contributed to limit bilateral exchange rate appreciation through the decrease in the interest rate, to support the competitiveness of Tunisian exports.

Finally, the potential growth rate $g^{ss}$ is estimated at 3.65% which is lower than the prior (4.0%). The uncertainties around this parameter are considerable, given the difficulty to determine in an accurate

---

17 The forward-looking behaviour may be more sensitive to the exogenous shocks, such as, the Djerba attack (April 11th, 2002) and the Revolution of January 14th, 2011.

18 Expectations of higher inflation are a source of increased wage demands that may cause a wage-price spiral which is likely to fuel inflationary pressures. By identifying the sources of formation of expectations, monetary policy can intervene to counteract.
way, if the Revolution had a permanent or temporary effect on the potential. However, the impact of the Revolution on economic activity was significant. The services sector as the main sector of the Tunisian economy, was directly affected by the Revolution and in the same way the industrial sector (Figure 10). The post-revolution period revealed severe fiscal and current account deficits, which can hamper the recovery of the economy and may weaken the potential level.

5 Simulations and monetary policy analysis

This section is intended, at first, review the decomposition of the variables of interest for monetary policy, and analysis in a second step, reaction functions in response to exogenous shocks.

5.1 Decomposition of the output gap and inflation

The results of estimation suggest that real GDP growth often deviates from its trend predicted by the model. The output gap decomposition$^{19}$ reports a high contribution of both domestic and foreign demand shocks. Tunisian output faced several exogenous shocks which impacted its intrinsic dynamics particularly following Djerba attacks in 2002, the tariffs dismantling and entry into force of the Multi-Fiber Arrangement in January 2005, the financial crisis in 2009 and finally the Revolution of 2011. This latter event was accompanied, during the first quarter of 2011, by an almost total shut-down of the activity before beginning a slow recovery. Furthermore, the monetary policy seems to be quite accommodative since 2009 and, in particular, during the post-revolution period.

![Figure 6: Historical decomposition of the output gap](image)

$^{19}$The description of different shocks appearing in the graph is presented in the appendix 2.
The decomposition of inflation deviations from the average rate (4.0%) reflects an important contribution of the supply shocks, in particular during the post-revolution period. Although these shocks are temporary, their effects may persist through the inflation expectations. Finally, the slowdown in economic activity would contribute to easing the inflationary pressures.

Figure 7: Historical decomposition of the core inflation

5.2 Impulse responses functions

The impulse responses remain one of the most suitable to explain the sources of shock propagation. They allow synthesizing most of the information contained in the internal dynamics of the model. Figure 11 (attached) describes the set of impulse responses of key variables to a monetary policy shock. An increase in the nominal interest rate one percentage point standard deviation generates short-term appreciation of the real exchange rate. This tightening of monetary conditions led to a slowdown in the economy after a year. The appreciation of the exchange rate combined with a negative output gap jointly generates an easing of inflationary pressures up to 10 quarters.

In response to a positive supply shock (Figure 12), the real exchange rate appreciates immediately. Monetary policy reacts to these inflationary pressures by increasing the nominal interest rate within two quarters. As a consequence, the output falls gradually and hits its trough about 6 quarters after the shock. An increase in the nominal interest rate, implies an increase of the credit costs, which may reduce consumption and investment.

In addition, an increase in the demand, following a positive output gap shock of one standard deviation (Figure 13), implies pressures on production capacities and consequently tensions on the real costs of

These shocks are largely the result of disorders of domestic distribution channels, speculation and illegal exports to Libya.
production. These push the inflation higher in the short-term. The nominal interest rate increases gradually and hits its peak about a one year after the shock. These developments would imply a slowdown in the economic activity and a decrease of inflationary pressures over the medium-term.

Finally, an additional foreign demand for Tunisian products leads to an increase of the output in the short term (Figure 14). The resulting pressures on production costs contribute to rise inflation. The exchange rate of the Dinar vis-à-vis the Euro appreciates immediately (1 quarter). Then, it starts to depreciate in order to support the economic recovery by foreign demand. Monetary policy does not impede this process and reacts gradually to inflationary pressures. It hits its peak about 6 quarters after the shock.

6 Forecasting

The model presented in this paper is used to perform quarterly inflation and activity growth forecasts over medium term horizon (2 to 3 years). The projection process may be based merely on unconditional forecasts, as it can integrate specialists judgements and appreciations which take into account other important factors omitted by the model. This last approach is often favoured by many central banks and international institutions.

The experts' judgements help to determine the most likely future developments of exogenous and endogenous variables. Regarding exogenous variables, the judgements consist in following news and informations about the economic, price and financial developments in the world, and in particular in the main trade partner countries. They allow to identify uncertainty sources and incorporate them into the baseline forecast as well as in the construction of the fan charts. The judgements on the endogenous variables are often based on the short-term forecasts (one or two quarters) which are derived generally from models that do not necessarily have the same structure as the medium-term forecasting model. In fact, the short-term forecasting models try generally to incorporate a wide range of new informations (monthly economic indicators, surveys,...) in order to reduce the forecast errors. According to past experiences, these models are more efficient in terms of short-term forecasting. For this reason they are used as starting points for medium-term forecasts.

Figure 8 presents dynamic unconditional forecasts for 8 quarters ahead, over the second half of the sample period. It shows that the model is quite able to track the behaviour of inflation, especially when the number of observations (quarters) increases. Over the near-term, the expert’s judgements can outperform the model and may provide a good starting point for the model to carry medium-term forecasting.
7 Conclusions

The model presented in this paper comes to support the existing set of analysis and forecasting tools at CBT. It will be used quarterly to prepare medium-term inflation and growth forecasts for Tunisia. The model specifications appear relatively consistent with the explicit assumptions on long-term movements of variables, expectations and Tunisian data. Using a Bayesian estimation, we obtained broadly consistent results. In particular, the economic fluctuations compared to a long-term trend, incorporate an inertial component relatively important. The impact of the interest rate on activity fluctuations is relatively low. Nevertheless, the effects of the real exchange rate as well as the activity in Euro Zone are clearly significant. Moreover, the estimated parameters of the Phillips curve indicate an important effect of forward-looking expectations, driven by inflationary trend which accelerated during post-revolution period. The output gap influences weakly the inflation dynamics. The exchange rate pass-through is relatively comparable to similar countries. The effects of the supply shocks are high, in particular since 2012 and are likely to exert inflation pressures in the future. The Taylor’s rule parameters appear reasonable, with a relatively high degree of smoothing, reflecting the inertial behaviour of the interest rate over the estimation period. Finally, the further development of the model seems possible and necessary. In particular, it could integrate missing components of the inflation and separate private and public agents’ behaviours. Once completed, the model can be used to carry policy analysis (fiscal and monetary policies) as well as to build forecasts.
References


A Appendix

A.1 Description of the Model

The actual output is equal to logarithmic real GDP excluding agriculture (year base 2005) multiplied by 100:

\[ gdpt = 100 \times \text{Log}(GDP_t) \]  
\[ dgdp_t = gdpt - gdpt_{-1} \]  

- IS curve:
  \[ y_t - y_{t-1} = dgdp_t - dgdp^*_t \]  
  \[ dgdp^*_t = g_t/4 + \psi_2 \sigma^d gdp^* \]  
  \[ g_t = (1 - \rho_g) g^{ss} + \rho_g g_{t-1} + \sigma_g \epsilon^g_t \]  
  \[ y_t = \beta_1 y_{t-1} + \beta_2 E_t y_{t+1} - \beta_3 r_{t-1} + \beta_4 z z_{t-1} + \beta_5 y^*_t - \psi_1 \sigma^d e^y_t \]  
  \[ r^*_t = (1 - \rho_r) r^{ss} + \rho_r r^*_{t-1} + \epsilon^r_t \]  
  \[ y^*_t = \theta y_{t-1} + \epsilon^y_t \]  

- Phillips curve:
  \[ \pi_t = 400 \times (\text{Log}(CPI^{core}_t) - \text{Log}(CPI^{core}_{t-1})) \]  
  \[ \pi_t = \lambda_1 E_t \pi_{t+1} + (1 - \lambda_1) \pi_{t-1} + \lambda_2 y_{t-1} + \lambda_3 dZ_t + \epsilon^\pi_t \]  

- Uncovered interest rate parity:
  \[ dZ_t = \kappa dZ^*_t + \epsilon^{Z^*_t} \]  
  \[ 4((\phi - 1) dZ_t + \phi E_t dZ_{t+1}) = (r_t - \pi_t^u) - (r^*_t - \pi_t^u) + \epsilon^{Z^*_t} \]  
  \[ \pi_t^u = (1 - \tau) \pi_t^u + \tau \pi^u_{t-1} + \epsilon_t^u \]  
  \[ r_t^c = (1 - \rho^c) r^c_{t-1} + \rho^c r_{t-1}^c + \epsilon^r_{t-1}^c \]  
  \[ r_{t-1}^c = (1 - \rho^c) r^c t_{t-1} + \rho^c r_{t-1}^c + \epsilon^{r^c t}_{t-1} \]  

- The monetary policy rule:
  \[ i_t = \gamma_1 i_{t-1} + (1 - \gamma_1) ((r^*_t + \pi^*_t) + \gamma_2 (\pi_t - \pi^*_t) + \gamma_3 y_t + \gamma_4 dZ_t) + \epsilon^i_t \]
## A.2 Description of parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Equation: description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_1$</td>
<td>Output gap: lag of output gap</td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>Output gap: lead of output gap</td>
</tr>
<tr>
<td>$\beta_3$</td>
<td>Output gap: real interest rate gap lagged</td>
</tr>
<tr>
<td>$\beta_4$</td>
<td>Output gap: real exchange rate gap lagged</td>
</tr>
<tr>
<td>$\beta_5$</td>
<td>Output gap: Euro Zone output gap lagged</td>
</tr>
<tr>
<td>$\lambda_1$</td>
<td>Inflation : expected inflation</td>
</tr>
<tr>
<td>$\lambda_2$</td>
<td>Inflation : lag of output gap</td>
</tr>
<tr>
<td>$\lambda_3$</td>
<td>Inflation : real exchange rate gap lagged</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>Nominal interest rate : lag of nominal interest rate</td>
</tr>
<tr>
<td>$\gamma_2$</td>
<td>Nominal interest rate : deviation of inflation from its historical average</td>
</tr>
<tr>
<td>$\gamma_3$</td>
<td>Nominal interest rate : output gap</td>
</tr>
<tr>
<td>$\gamma_4$</td>
<td>Nominal interest rate : real exchange rate depreciation</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Expected real exchange rate : weight of forward-looking component</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>Equilibrium real exchange rate persistence</td>
</tr>
<tr>
<td>$\sigma^*$</td>
<td>Growth rate of equilibrium output : steady state of growth rate</td>
</tr>
<tr>
<td>$r^*$</td>
<td>Equilibrium real interest rate: steady state of real interest rate</td>
</tr>
<tr>
<td>$\rho_g$</td>
<td>Growth potential persistence</td>
</tr>
<tr>
<td>$\rho_e$</td>
<td>Equilibrium real interest rate persistence</td>
</tr>
<tr>
<td>$\rho_e^*$</td>
<td>Euro Zone real interest rate persistence</td>
</tr>
<tr>
<td>$\rho_e^{**}$</td>
<td>Equilibrium Euro Zone real interest rate persistence</td>
</tr>
<tr>
<td>$\epsilon^g$</td>
<td>Shock to equilibrium output growth (e_g)</td>
</tr>
<tr>
<td>$\epsilon^p$</td>
<td>Shock to inflation (e_p)</td>
</tr>
<tr>
<td>$\epsilon^i$</td>
<td>Shock to nominal interest rate (e_i)</td>
</tr>
<tr>
<td>$\epsilon^{r_\text{eu}}$</td>
<td>Shock to equilibrium real interest rate (e_{r_{eu}})</td>
</tr>
<tr>
<td>$\epsilon^{e_{\text{eu}}}$</td>
<td>Shock to equilibrium real exchange rate growth (e_{z_{eu}})</td>
</tr>
<tr>
<td>$\epsilon^{\text{up}}$</td>
<td>Shock to uncovered interest parity : risk premium shock (e_{up_{eu}})</td>
</tr>
<tr>
<td>$\epsilon^{e_{\text{eu}}}$</td>
<td>Shock to Euro Zone output gap (e_{y_{eu}})</td>
</tr>
<tr>
<td>$\epsilon^{e_{\text{eu}}}$</td>
<td>Shock to Euro Zone real interest rate (e_{r_{eu}})</td>
</tr>
<tr>
<td>$\epsilon^{e_{\text{eu}}}$</td>
<td>Shock to Euro Zone equilibrium real interest rate (e_{r_{eu,bar}})</td>
</tr>
</tbody>
</table>

(.) Notation used in Matlab code.
### A.3 Prior and posterior of the parameters

**Table 4: Prior and posterior parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prior Mean</th>
<th>Prior S.D.</th>
<th>Prior Distribution</th>
<th>Prior Mode</th>
<th>Prior S.D.</th>
<th>Posterior Mean</th>
<th>Posterior S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$g^{**}$</td>
<td>4</td>
<td>2</td>
<td>Normal</td>
<td>3.65</td>
<td>0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$r^{**}$</td>
<td>1</td>
<td>0.5</td>
<td>Normal</td>
<td>0.97</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>0.6</td>
<td>0.20</td>
<td>Beta</td>
<td>0.67</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>0.2</td>
<td>0.10</td>
<td>Beta</td>
<td>0.12</td>
<td>0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_3$</td>
<td>0.1</td>
<td>0.05</td>
<td>Beta</td>
<td>0.07</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_4$</td>
<td>0.15</td>
<td>0.05</td>
<td>Normal</td>
<td>0.16</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_5$</td>
<td>0.2</td>
<td>0.10</td>
<td>Normal</td>
<td>0.20</td>
<td>0.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda_1$</td>
<td>0.4</td>
<td>0.065</td>
<td>Beta</td>
<td>0.67</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda_2$</td>
<td>0.1</td>
<td>0.01</td>
<td>Beta</td>
<td>0.10</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda_3$</td>
<td>0.1</td>
<td>0.01</td>
<td>Normal</td>
<td>0.09</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>0.75</td>
<td>0.1</td>
<td>Beta</td>
<td>0.93</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma_2$</td>
<td>1.5</td>
<td>0.3</td>
<td>Gamma</td>
<td>1.21</td>
<td>0.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma_3$</td>
<td>0.5</td>
<td>0.1</td>
<td>Normal</td>
<td>0.44</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\gamma_4$</td>
<td>0.1</td>
<td>0.05</td>
<td>Normal</td>
<td>0.16</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\phi$</td>
<td>0.5</td>
<td>0.1</td>
<td>Beta</td>
<td>0.73</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.5</td>
<td>0.2</td>
<td>Beta</td>
<td>0.42</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho_g$</td>
<td>0.5</td>
<td>0.2</td>
<td>Beta</td>
<td>0.92</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho_r$</td>
<td>0.8</td>
<td>0.1</td>
<td>Beta</td>
<td>0.9</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_g$</td>
<td>5</td>
<td>2</td>
<td>Gamma</td>
<td>0.42</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\epsilon^p$</td>
<td>0.5</td>
<td>Inf</td>
<td>Gamma Inverse</td>
<td>1.01</td>
<td>0.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\epsilon^i$</td>
<td>1</td>
<td>Inf</td>
<td>Gamma Inverse</td>
<td>0.24</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\epsilon^z$</td>
<td>0.1</td>
<td>Inf</td>
<td>Gamma Inverse</td>
<td>0.05</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\epsilon^s$</td>
<td>2</td>
<td>Inf</td>
<td>Gamma Inverse</td>
<td>2.34</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\epsilon^{zz}$</td>
<td>1</td>
<td>Inf</td>
<td>Gamma Inverse</td>
<td>0.47</td>
<td>0.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\epsilon^{u}$</td>
<td>0.5</td>
<td>Inf</td>
<td>Gamma Inverse</td>
<td>1.02</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\epsilon^{u^2}$</td>
<td>0.5</td>
<td>Inf</td>
<td>Gamma Inverse</td>
<td>0.74</td>
<td>0.07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A.4 Trends in core inflation and in the main economic activity sectors

Figure 9: Core inflation and its trend

Figure 10: Added values of main Tunisian economic sectors

*Annual growth rate is around to 5.4%.

**Annual growth rate is around to 3.3%.
A.5 Impulse responses

Figure 11: A one-percent unanticipated shock to nominal interest rate

Figure 12: A one-percent unanticipated shock to inflation
Figure 13: A one-percent unanticipated shock to output gap

Figure 14: A one-percent unanticipated shock to Euro Zone output gap
### A.6 Key GPM results for selected countries and regions

Table 5: Estimated parameters of selected variables in the GPM model

<table>
<thead>
<tr>
<th></th>
<th>IS curve</th>
<th>Phillips curve</th>
<th>Taylor rule</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$y(-1)$</td>
<td>$y(+1)$</td>
<td>$rr(-1)$</td>
</tr>
<tr>
<td>Tunisia</td>
<td>0.67</td>
<td>0.12</td>
<td>0.07</td>
</tr>
<tr>
<td>Latin America</td>
<td>0.49</td>
<td>0.18</td>
<td>0.16</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.37</td>
<td>0.14</td>
<td>0.13</td>
</tr>
<tr>
<td>Chile</td>
<td>0.39</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Colombia</td>
<td>0.65</td>
<td>0.23</td>
<td>0.11</td>
</tr>
<tr>
<td>Egypt</td>
<td>0.45</td>
<td>0.16</td>
<td>0.08</td>
</tr>
<tr>
<td>United States</td>
<td>0.57</td>
<td>0.23</td>
<td>0.19</td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.43</td>
<td>0.15</td>
<td>0.16</td>
</tr>
<tr>
<td>Japan</td>
<td>0.78</td>
<td>0.02</td>
<td>0.15</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.72</td>
<td>0.27</td>
<td>0.12</td>
</tr>
<tr>
<td>Euro Zone</td>
<td>0.75</td>
<td>0.04</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Sources: Carabencio and al.(2011)[6] and Arbatli and al.(2011)[2].