# Core Inflation Measure and Its Effect on Economic Growth and Employment in Tunisia

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*Abstract*

*The aim of this study is to present a measure for the core inflation in Tunisia. This measure consists in a six-variable structural vector autoregression model covering the period 1975Q1-2014Q4. Our results show that the observed inflation rate exceeds the core inflation when demand rises and conversely when there is a low growth. This seems to be reasonable as core inflation has a deterministic tendency and, therefore, the monetary impulse largely accounts for the evolution of inflation. Our findings also support the idea that there is a weak positive correlation between the inflation rate and the industrial production index in the short run. This core inflation is also observed to have a weak effect on unemployment over the short and long runs. Thus, this type of inflation should be taken into account as an important element for the determination of a targeted inflation rate and for future predictions and decisions of the monetary authorities.*

*Keywords: Core Inflation; Exogenous and Endogenous Chocks; Economic Growth; Employment; Structural VAR; Tunisia.*

*JEL Classifications: E22, E23, E24, E31.*

## 1. Introduction

The notion of core inflation plays an important role in the process of monetary policymaking and decision taking. However, the central bank's objective, in terms of the ultimate policy goal, is the price stability in order to reach an inflation threshold that promotes economic growth. This topic remains a hot issue resulting in a controversial debate in the literature of economics as illustrated by many empirical studies (see Haldane, 1995; Svensson, 1997; Ruch and Bester, 2011; Mills, 2013; Reiff and Várhegyi, 2013; Anand et al., 2015). However, this ever running debate has incited us to look for an accurate measure for core inflation, that's to

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say, correcting the influence of the economic cycle. Several recent studies such as Poole and Wheelock (2008) have shown that prices stability cannot contribute to economic growth unless it reduces the uncertainties of the monetary authorities' decisions. In fact, other results (Wynne, 2008) support the view that this kind of stability contributes to a financial stability and hence the growth of economy. Since the mid-1980s, the United States has witnessed a reduction in the volatility of both output growth and inflation in an environment that closely approximates price stability. In addition, the monetary authority can determine an optimal inflation rate. It has tried to define the goals of a monetary policy in terms of price stability. However, the volatility in output and employment is also costly to people. In practice, the central bank cares about inflation and measures the short-run performance of the economy[3]. Consequently, Quah and Vahey (1995) defined the "core inflation" as "that component of measured inflation that has no medium to long run impact on real output". This definition of core inflation also includes the cyclic part due to the demand excess pressure. This identification approach is similar to that of Blanchard and Quah (1989).

Many other studies tried to measure core inflation using diverse statistical approaches. Iriss (1997) and Laflèche (1997) built inflation tendency measures in Canada suggesting inflation measures in any month through the prices mean monthly variation rather than the variation of the mean prices. Scott (1998) summarizes the ideal qualities core inflation should check as: robustness, credibility and ease of implementation. Mills (2013) used multivariate approaches to construct core inflation in the U.K. The objective of Gamber et al. (2015) is to measure the dynamic relationship between headline and core inflation for a broader set of potential core inflation measures than Kiley (2008) and Mehra and Reilly (2009). The core inflation should then represent the inflation tendency reflected in the agents' anticipations. If the central bank objective was to stabilize prices, it would be appropriate for the bank to react to the punctual or non-anticipated shocks having only a temporary effect on inflation and a risk to destabilize the economy. The process could distinguish between the temporary and permanent inflation components.

From a practical viewpoint, the core inflation is often obtained thanks to signal treatment methods that divide the components into permanent and transitory ones. Generally, there are three types of methods to calculate core inflation: smoothing (dynamic univariate methods), exclusion of some price index components (static

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method) and the estimation of the Structural Vector Autoregression (SVAR) (multivariate dynamic method).

Apart from the preceding listed methods, the study of Quah and Vahey (1995) is recognized for relying on an economic logic. The authors exploited the widely acknowledged long run vertical characteristic of Phillips curve to identify the core inflation as the inflation component with no long run impact on the output. Thus, the inflation measure can be split into two parts; one respects the long run neutrality (core inflation), whereas the other does not (the short run or cyclic inflation). This definition of core inflation is based on the idea that there is a perfect dichotomy between the real and nominal variables.

In order to identify the shocks in a better way, some authors enriched the Vector Autoregression (VAR) with supplementary variables. Roger (1995) deduced that as long as the shocks on the general level of prices are seen as punctual events they cannot have a lasting effect on the inflation rate. Iriss (1997) proposed a VAR including the consumption price; the capacity utilization rate; the finished product output price and the importation price. In our study, to guarantee a core inflation that privileges the principles of simplicity and robustness, we took into account Quah and Vahey's multivariate specification.

Because of the lack of a clear concept of core inflation, the choice of an "optimal" indicator among the already presented approaches is still a controversial issue. In such cases, the monetary authorities, aiming at a certain inflation rate, would find it inappropriate to react.[4] There are two main arguments to "perceive" a punctual shock on the level of prices. The first argument is that it can be beyond the "monetary authorities" capacities to avoid a change in the level of the prices, a shift that will be reflected on a temporary modification of the measured inflation rate. Yet, this would not prevent the authorities from reacting to the second round effects that could feed inflation. The second argument is that any movement of prices is seen as a temporary shock. Meanwhile, one of the main challenges facing the monetary authorities, whose first objective is the price stability, is to distinguish between the temporary price shocks and the persisting ones. In fact, there might be some shocks that separate the total inflation from the core one at least in the short run.

Through the above review of the state of the art, it can be clearly remarked that no previous study on core inflation was achieved in the developing countries. We may even dare say that it is limited to Northern American countries and the UK. We

[4] Note that, however, if the target was rather the prices level, even the change of this level would require a change in the monetary policy to restore the targeted prices level.

realized that it could be an appealing challenge to carry out such a study in a developing country - Tunisia - and then set up the foundations of this type of inflation in the literature and pave the way for further potential future research in the field.

Our objective in this study is to find a measure for core inflation in Tunisia. Our choice of such an issue is justified by the lack of a clear concept of core inflation, and thus the choice of an "optimal" indicator is difficult given the fact that the Tunisian central bank focuses on the objective of price stability. This study uses the hypothesis that the measured inflation movements are the result of punctual shocks of prices resulting from the supply side, on the one hand, and from the persistent shocks of the inflation rate generated by the demand due to monetary shocks, on the other. In our work, the measure is obtained from a SVAR proposed by Shapiro and Watson (1988) and Blanchard and Quah (1989). The SVAR methodology imposes some restrictions that provide a decomposition of a particular chronological series into transitory and tendency components. It enables us to decompose shocks on the inflation rate into temporary and persisting shocks. The SVAR methodology consists in estimating a VAR model and identifying the different disturbance types on the basis of the inflation process. To measure the core inflation, Quah and Vahey (1995) imposed a compatible restriction with the hypothesis that the long run Phillips curve is vertical because of the money neutrality in the long-run.

Although, our originality study, relies on Quah and Vahey's (1995) definition of core inflation, is to include the specificity of the Tunisian economy where inflation has not only a monetary origin but also other relating external and structural factors (Boujelbene and Boujelbene, 2010). The measure of the Tunisian core inflation is then obtained through a six-variable: the consumption price index (*CPI*), the industrial production index (*IPI*), the unemployment rate ($u$), the real effective exchange rate (*REER*), the money supply ($M_2$) and the real interest rate ($r$). The model uses quarterly data. We suppose that the observed changes in the estimated inflation are caused by six types of disturbances and that each one has no correlation with the others. In the long-run, the restrictions are imposed to identify the structural innovations of the inflation rate through the consumption price index, defining the core inflation as a component of the estimated inflation. This component results from the impact of the shocks on the inflation rate in the long-run. The shocks on the other variables result from the developments on the supply side and modify the inflation course in a temporary way only. The impulse response analysis and the variance decomposition are used to capture the model dynamic and measure the inflation contribution to the transitory shocks. Then, in our study, we propose an economic validation of the cyclic inflation part. We examine its correlation with the pressure on the output and employment.

The remaining of this paper is organized as follows: the second section deals with the SVAR identification mode as well as the associated econometric methodology. Our empirical results are discussed in the third section. The last section draws some conclusions and forwards some recommendations.

## 2. The SVAR model

Our interest in the VARs, whether they are structural or not, stems from Sims' critic (1980) stressing that the economic theory could not be accurate enough to be able to identify the great structural models. The estimated model is based on the vector autoregressive approach proposed by Shapiro and Watson (1988) and Blanchard and Quah (1989). The SVAR models impose some restrictions on the model variables movements that allow the identification of the structural shock parameters. In order to identify the structural model and decompose the prediction variance, we opted for the common approach imposing the arbitrary decomposition of Choleski (Christiano and Eichenbaum, 1991; Gordon and Leeper, 1994). However, Bernanke (1986) suggested an alternative method that imposes some short run exclusion restrictions on the structural coefficients matrix. Shapiro and Watson (1988), Blanchard and Quah (1989), St-Amant (1996), Iriss (1997) and Jacquinot (2001) impose some long run restrictions on the covariance matrix of the structural innovation vector, whereas Gali (1992) imposes some short and long run restrictions on the structure of the economy to accurately identify the structural innovations. The adopted approach in this study consists in imposing some long run restrictions to allow the decomposition of the inflation rate into temporary and permanent components. This is an implicit technique relying on the deduction that the inflation rate involves a unit root, i.e. the inflation process contains a permanent component.

### 2.1. The VAR modelisation

Let $X_t = [y_t,\ \Delta u_t,\ \Delta er_t,\ \Delta\pi_t,\ \Delta m_t,\ \Delta r_t]'$ be a stationary vectorial process where $y = IPI$, $\pi = CPI$, $er = REER$ et $m = M_2$ and $r$ is the real interest rate. To identify the structural model, the VAR is firstly estimated in its restriction free form; that's to say

$$X_t = \Phi(L) X_{t-1} + \varepsilon_t \tag{1}$$

where $\Phi(L) = (I - \Phi_1 L - \ldots - \Phi_p L^p)$ and $\varepsilon_t$ is an uncorrelated series innovation vector.

Similar to all the equations of the same regressor matrix, the estimation of model (1) needs to apply the Ordinary Least Squares (OLS) to each equation separately after having included the optimal number of lags *p* to eliminate the residue correlation. The estimated restriction free model could then be the inverse of the Wold-moving average representation, that's to say:

$$X_t = C(L)\varepsilon_t \text{ where } C(0) = I \quad (2)$$

In the mobile average representation, each element of $X_t$ is expressed as a linear combination of past and present structural shocks formulated as:

$$X_t = S(L)\upsilon_t \quad (3)$$

where $S(L) \equiv [S_{ij}(L)]$ for $i, j = 1, \cdots, 6$ and $S(L)$ is invertible. Considering the hypothesis that the innovations in $\varepsilon_t$ are a linear combination of the structural disturbances $\upsilon_t$, the structural shocks could be linked to the model disturbances in a reduced form as follows:

$$\varepsilon_t = S(0)\upsilon_t \quad (4)$$

and

$$E[\varepsilon_t \varepsilon_t^{'}] = S(0)E(\upsilon_t \upsilon_t^{'})S'(0) = \Sigma \quad (5)$$

Where $\Sigma$ designs the variance covariance vector of the innovation vector reduced form.

The VAR representation of $X_t$ in terms of structural disturbances is given by:

$$A(L)X_t = \upsilon_t \quad (6)$$

where $A(L) \equiv [A_j(L)]$ for $i, j = 1, \cdots, 6$ and $A(0) = S(0)^{-1}$.

To identify the effects of the structural shocks on the inflation rate, several identification restrictions are required to be included into the model as supplementary variables. From equations (**2**) and (**3**), it can be deduced that the long run impacts of the reduced form of the shocks are linked to the equivalent structural shocks matrix through the bias:

$$S(1) = C(1)S(0) \quad (7)$$

Using the restriction that the shocks have an impact on the inflation rate in the long run and that the transformation of the price variables from the second difference to the first difference implies the following structural decomposition of the inflation rate:

$$\pi_t = C(1)\varepsilon_{perm,t} + C^{\tau}(L)\varepsilon_{perm,t} + C^{\tau}(L)\varepsilon_{trans,t} \qquad (8)$$

The right side of equation (8) is made up of the moving average component of the different types of shocks, where $C(L)$ represents the permanent component and $C^{\tau}(L)$ represents the transitory component of the shocks impact on inflation. The first two components of equation (8) represent the core inflation tendency component whereas the last component captures the movements caused by the transitory shocks. The structural shocks of the model are:

$$\varepsilon_t = \left[\varepsilon^{y}\ \varepsilon^{u}\ \varepsilon^{er}\ \varepsilon^{\pi}\ \varepsilon^{m}\ \varepsilon^{r}\right]' \qquad (9)$$

Where $\varepsilon^{y}$ is the first *real exogenous supply shock* that affects the output, $\varepsilon^{u}$ is the second *real exogenous supply shock* that affects unemployment, $\varepsilon^{er}$ is the only *real exogenous demand shock* that affects the real effective exchange rate. In contrast, $\varepsilon^{\pi}$ is *the endogenous monetary demand shock* which affects inflation, $\varepsilon^{m}$ is *the endogenous monetary supply shock* which affects the monetary growth $M_2$ and $\varepsilon^{r}$ is *the endogenous political monetary shock* that affects the real interest rate. In addition, $\varepsilon^{y}$ and $\varepsilon^{er}$ represent the shocks that have a permanent impact on the output. Vectors $\varepsilon^{\pi}$ and $\varepsilon^{m}$ are two shocks with a transitory effect on the output and a permanent one on inflation. Therefore, they are associated with the monetary shocks. Hypothetically, only the monetary authorities could influence the inflation tendency.

We have used here the same restriction as Lalonde et al. (1998). Finally, the vectors $\varepsilon^{u}$ and $\varepsilon^{r}$ represent the shocks that have a transitory effect on both output and inflation. The representation of the random walk in the model is:

$$X_t = \Gamma(0)\,\varepsilon_t + \Gamma_1\,\varepsilon_{t-1} + \Gamma_2\,\varepsilon_{t-2} + \ldots = \Gamma(L)\,\varepsilon_t \qquad (10)$$

For the sake of simplification, the structural shock variances are normalized as follows:

$$E(\varepsilon_t \varepsilon_t') = I_6 \qquad (11)$$

To identify the structural model, its reduced autoregressive form should be firstly estimated as:

$$X_t = \sum_{i=1}^{p} \Pi_i X_{t-i} + e_t \qquad (12)$$

Where $p$ is the number of lags, $e_t$ is the reduced form of innovations, and $E(e_t e_t')=\Sigma$.

Knowing that the model is stationary, the mobile average representation of the above equation is:

$$Z_t = e_t + C_1\, e_{t-1} + C_2\, e_{t-2} + \ldots = C(L)\, e_t \tag{13}$$

and the reduced form of the innovations is related to the structural residues by:

$$e_t = \Gamma(0)\,\varepsilon_t \tag{14}$$

and

$$E(e_t e_t') = \Gamma(0)\Gamma(0)' \tag{15}$$

because $E(\varepsilon_t \varepsilon_t') = I_6$.

Finally, the long run impact matrix of the reduced form of the residues represented by C (1) is linked to the equivalent structural residues matrix by $\Gamma(1)$ within the following relation:

$$\Gamma(1) = C(1)\,\Gamma(0) \tag{16}$$

The identification of the structural model requires imposing many restrictions to identify the 36 elements of $\Gamma(0)$. The Blanchard-Quah decomposition consists in imposing restrictions on the long run structural shock effect matrix $\Gamma(1)$ instead of imposing a predetermination structure of the different variables by practical restrictions on the contemporaneous effect of the structural shock matrix $\Gamma(0)$ (Blanchard and Quah, 1989, p.656):

$$\begin{array}{cc} & \begin{bmatrix} \varepsilon^y & \varepsilon^u & \varepsilon^{er} & \varepsilon^{\pi} & \varepsilon^m & \varepsilon^r \end{bmatrix} \\ \begin{bmatrix} y \\ u \\ er \\ \pi \\ m \\ r \end{bmatrix} & \begin{pmatrix} r_{11} & 0 & 0 & 0 & 0 & 0 \\ r_{21} & r_{22} & 0 & 0 & 0 & 0 \\ r_{31} & r_{32} & r_{33} & 0 & 0 & 0 \\ r_{41} & r_{42} & r_{43} & r_{43} & 0 & 0 \\ r_{51} & r_{52} & r_{53} & r_{54} & r_{55} & 0 \\ r_{61} & r_{62} & r_{63} & r_{64} & r_{65} & r_{66} \end{pmatrix} = \Gamma(1) \end{array} \tag{17}$$

Since $\Sigma$ is systematic, we have to impose some other supplementary restrictions. Consequently, we would suppose that this matrix is triangular. Taking into account these restrictions, the equation system made up of the above relations can be solved and the structural model is identifiable. The equation (16) illustrates the imposed restrictions on the long run of the structural shock effect matrix at the level of the different variables of the model. In the matrix (17), the structural shocks are on the horizontal axis and the variables at level are on the vertical axis.

### 2.2. Computation of the VAR response functions

Let us consider the vector autoregressive model with the following $p$ order where $X_t$ is the dimension $n$ written under the following structural form:

$$A(L)X_t + c = \eta_t \tag{18}$$

where $V(\eta_t) = \Sigma_\eta$ the diagonal matrix, and $A(L) = \sum_{j=0}^{p} A_j L^j$ .

The VAR($p$) can be rewritten under a moving average form as follows:

$$X_t = \mu + D(L)\eta_t \text{ with } D(L) = \sum_{j=0}^{\infty} D_j L^j \tag{19}$$

Let us establish a relation between the impulse response writings. We are interested in their sponsors of the given horizon "$s$" of a variable consecutively to a unit shock on the $j^{th}$ component of $\eta_t$ , then to any other element left constant of the system.

The response to the $\eta_{j,t}$ will make up the $j^{th}$ column of matrix $D_s$, resulting from the representation of the infinite moving average (**19**). In fact, these matrices can be interpreted as $D_s = \partial X_{t+s} / \partial \eta_t$ and the element of the $i^{th}$ line and of the $j^{th}$ column of matrix $D_s$ will rightly represent this response in $t + s$, of $X_i$ to an orthogonal shock on $X_j$.

$$D_{ij,s} = \frac{\partial X_{i,t+s}}{\partial \eta'_{j,t}} \tag{20}$$

These responses indicate the variables reaction to the shocks that an economist will try to interpret, but the question is how to reach them concretely. The model is estimated according to this form:

$$X_t = d + B(L)X_t + e_t \tag{21}$$

where $V(e_t)=\Omega$, $B(L)=\sum_{j=1}^{p} B_j L^j$ and $B_i = A_0^{-1} A_i$. The representation $MA(\infty)$ is then:

$$X_t = \gamma + C(L)e_t \text{ with } C(L)=\sum_{j=0}^{\infty} C_j L^j \tag{22}$$

where the result of this representation is:

$$e_t = A_0^{-1}\eta_t \tag{23}$$

and that $\Omega = P\Sigma_\eta P'$ with $P = A_0^{-1}$ (**24**)

Since the residues are a linear combination of the shocks $\eta_t$ (equation **23**), then equations (**18**) and (**22**) will be taken into account:

$$D(L)=C(L)P \tag{25}$$

**2.3. The Core inflation**

**2.3.1. Definition and restraints identification**

The chosen variables logarithms are stationary in difference but not co-integrated. We will retain the VAR in first difference, except for *y*, of the order *p* with $X_t = [y_t,\ \Delta u_t,\ \Delta er_t,\ \Delta\pi_t,\ \Delta m_t,\ \Delta r_t]'$ where $t = 1,\dots,T$. Equation (**19**) will be rewritten as follows:

$$\begin{pmatrix} y_t \\ \Delta u_t \\ \Delta er_t \\ \Delta\pi_t \\ \Delta m_t \\ \Delta r_t \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \\ \mu_5 \\ \mu_6 \end{pmatrix} + \begin{pmatrix} D_{11}(L) & D_{12}(L) & D_{13}(L) & D_{14}(L) & D_{15}(L) & D_{16}(L) \\ D_{21}(L) & D_{22}(L) & D_{23}(L) & D_{24}(L) & D_{25}(L) & D_{26}(L) \\ D_{31}(L) & D_{32}(L) & D_{33}(L) & D_{34}(L) & D_{35}(L) & D_{36}(L) \\ D_{41}(L) & D_{42}(L) & D_{43}(L) & D_{44}(L) & D_{45}(L) & D_{46}(L) \\ D_{51}(L) & D_{52}(L) & D_{53}(L) & D_{54}(L) & D_{55}(L) & D_{56}(L) \\ D_{61}(L) & D_{62}(L) & D_{63}(L) & D_{64}(L) & D_{65}(L) & D_{66}(L) \end{pmatrix} \begin{pmatrix} \eta_{1,t} \\ \eta_{2,t} \\ \eta_{3,t} \\ \eta_{4,t} \\ \eta_{5,t} \\ \eta_{6,t} \end{pmatrix} \tag{26}$$

with $D_{ij}(L)=\sum_{m=0}^{\infty} D_{ij,m} L^m$.

The inflation growth is decomposed:

$$\pi_t = \mu_4 + D_{41}(L)\eta_{1,t} + D_{42}(L)\eta_{2,t} + D_{43}(L)\eta_{3,t} + D_{44}(L)\eta_{4,t} + D_{45}(L)\eta_{5,t} + D_{62}(L)\eta_{6,t} \tag{27}$$

We define $\eta_{4,t}$ as the shock that respects the long run neutrality - meaning that the other variables have no impact. These results lead us to write the core inflation growth ($\pi_t^{sj}$) as follows:

$$\pi_t^{sj} = \mu_4 + D_{44}(L)\eta_{4,t} \tag{28}$$

In other words, the core inflation is the observed inflation component associated with $\eta_{4,t}$, the shock that has no long-run impact on the output. Since the endogenous variables are stationary in difference, the shock $\eta_{4,t}$ has, by definition, no long-run effect on the first differences $y_t$, $\Delta u_t$, $\Delta er_t$, $\Delta m_t$ and $\Delta r_t$, but we hope that this neutrality restriction is checked by the variables in level. For this reason, the restriction is written as $D_{ij}(1) = \sum_{m=0}^{\infty} D_{ij,m} = 0$, $i \neq 4$ and $j \neq 4$. This means that the upper right-hand entry corner of $D(1)$ is null, or, in other words, that $D(1) = A(1)^{-1}$ is triangular inferior. This last restriction, issuing from the core inflation definition, will be used to solve the identification problem. This problem is to determine a unique transition of the reduced form of (**21**) to the structural form (**18**). This form, then, includes enough "$n^2$" parameters to characterize the likelihood function; thus, we have to find $n^2$ identification restriction. We need to determine a unique matrix $P = A_0^{-1}$ that allows the reduction of the non-observable orthogonal shocks from the VAR observable residues, and the passage in a unique way from the reduced to the structural form.

The choice of the form (**17**) is justified by Choleski's decomposition $C(1)\Omega C(1)'$. Therefore, knowing that $D(1) = C(1)P$ is triangular inferior and $\Omega = PP'$, and since $\Omega$ and $C(1)$ are known, $P$ is easily obtainable from Choleski's decomposition. In this study, we focused on the responses of $D_s$ that characterize the responses of the output and inflation ($X_{1,t}$ et $X_{4,t}$ in our previous notations) to our two independent shocks $\eta_{1,t}$ et $\eta_{4,t}$. The SVAR identification restriction springs from our definition of the core inflation.

### 2.3.2. Core inflation computation and historical decomposition of the conditioned prediction

The objective of the historic decomposition is to simulate the model dynamically predicting a given horizon $t + s$, relative to the available information at $t$, in order to prove the contribution of each part to the series historic evolution. The moving average representation can then be rewritten to separate any prediction error explained by the shocks of $t + 1$ at $t + s$, of the prediction based on the available information at *t*. Knowing the importance of each shock, it would be possible to predict the evolution of each series if one of the shocks were null. The core inflation would be obtained while annulling the shocks $\eta_{j,t}\ \forall\ j=1,2,3,5,6$. If $D_{i^*,s}$ was the $i^{th}$ line of $D_s$, the precision error of $X_{i,t}$ at $t+s$, $\varpi_{i,t+s}=X_{i,t+s}-E\left(X_{i,t+s}\right)$ where $E_t$ is the conditional expectation at *t* and written as follows (see Sims, 1980):

$$\varpi_{i,t+s}=\sum\nolimits_{\sigma=1}^{s} D_{i^*,\sigma}\,\eta_{t+s-\sigma} \tag{29}$$

because

$$E_t\left(X_{i,t+s}\right)=\sum\nolimits_{\sigma=s+1}^{\infty} D_{i^*,\sigma}\,\eta_{t+s-\sigma}+\mu_i \tag{30}$$

When projecting a horizon *s*, $X_{i,t+s}$ would be decomposed $X_{i,t+s}=\varpi_{i,t+s}+E_t\left(X_{i,t+s}\right)$. or also,

$$\begin{aligned} X_{i,t+s} &= \sum_{\sigma=0}^{s-1} D_{i^*,\sigma}\eta_{t+s-\sigma}+\sum_{\sigma=s}^{\infty} D_{i^*,\sigma}\eta_{t+s-\sigma}+\mu_i=\sum_{\sigma=0}^{s-1} D_{i1,\sigma}\eta_{1,t+s-\sigma}+\sum_{\sigma=0}^{s-1} D_{i2,\sigma}\eta_{2,t+s-\sigma}+\sum_{\sigma=0}^{s-1} D_{i3,\sigma}\eta_{3,t+s-\sigma} \\ &\quad +\sum_{\sigma=0}^{s-1} D_{i4,\sigma}\eta_{4,t+s-\sigma}+\sum_{\sigma=0}^{s-1} D_{i5,\sigma}\eta_{5,t+s-\sigma}+\sum_{\sigma=0}^{s-1} D_{i6,\sigma}\eta_{6,t+s-\sigma}+\sum_{\sigma=s}^{\infty} D_{i^*,\sigma}\eta_{t+s-\sigma}+\mu_i \end{aligned} \tag{31}$$

Equation (**31**) makes explicit the decomposition of $X_{i,t+s}$ into the prediction error $\varpi_{i,t+s}$ and the reference trajectory. Therefore, the contribution of each innovation to the historic evolution of the series appears clearly.

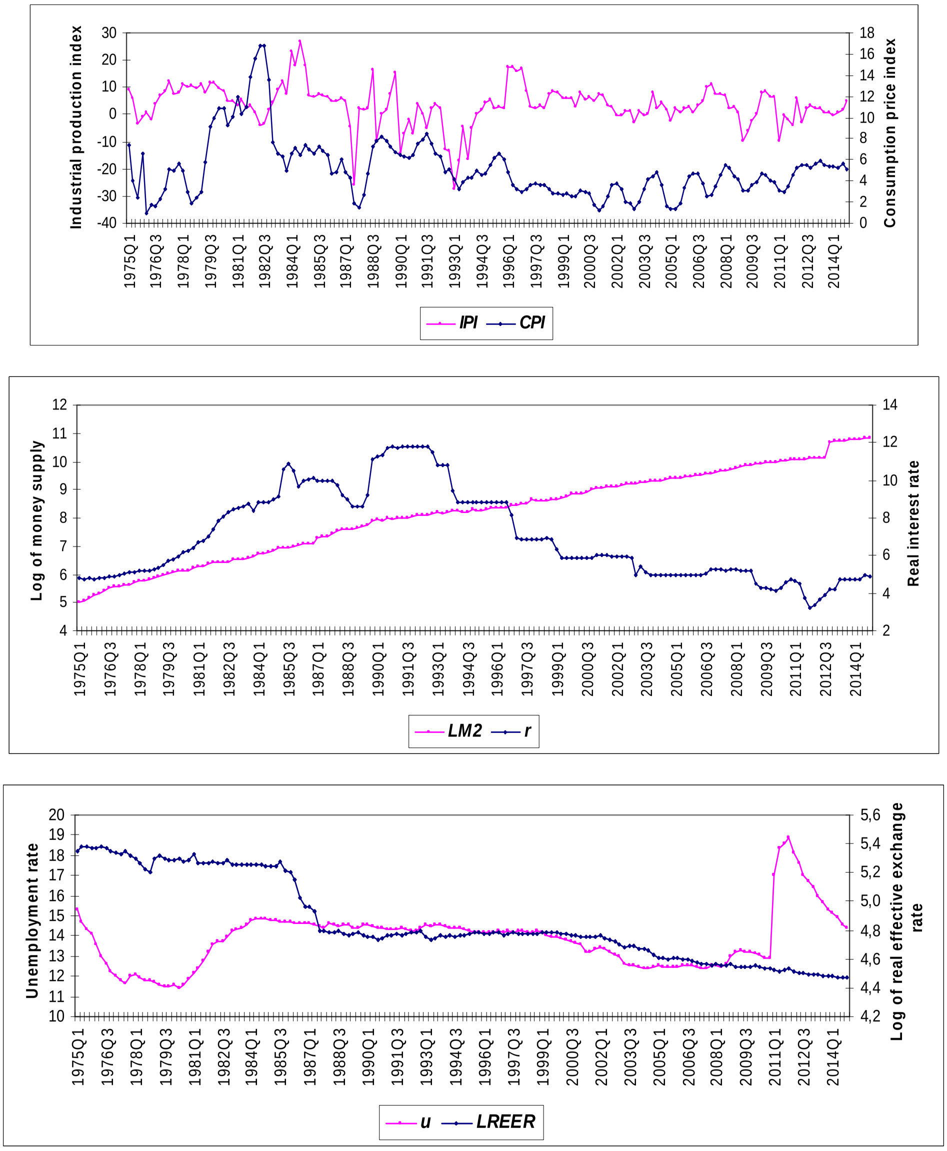
Due to the conditional projection, modifying the evolution of $\eta_t$ makes it possible to rewrite history. We have seen that the core inflation is obtained by retaining only one structural component of inflation $\eta_{4,t}$. Our objective is then to reconstruct the inflation past evolution by annulling the $\eta_{j,t}\ \forall\ j=1,2,3,5,6$. Adding a new shock to the reference trajectory finally allows the computation of the core inflation:

$$\pi_t^{sj}=\sum_{\sigma=0}^{s-1} D_{44,\sigma}\,\eta_{4,t+s-\sigma}+\sum_{\sigma=s}^{\infty} D_{4^*,\sigma}\,\eta_{t+s-\sigma}+\mu_4 \tag{32}$$

## 3. Empirical results

This section deals with the treatment of the data and the analysis of the time series proprieties. The decomposition results of the shocks endured by the inflation rate into punctual price shocks and persistent shocks were presented.

**Graph 1 Variables Evolution**




In our study, we examined the quarterly data of the Tunisian economy over the period 1975Q1-2014Q4. The measure of the Tunisian core inflation was achieved using the consumption price index (*CPI*), the industrial production index (*IPI*), the total unemployment rate (*u*), the real effective exchange rate (*REER*), the money supply (*$M_2$*) and the real interest rate (*r*). The data relative to the *CPI*, *IPI* and *$M_2$* were collected from the Tunisian Central Bank. The last variable is expressed in millions of Tunisian Dinars (at constant prices of 2005). As for the total unemployment rate *u*, we used the statistics of the National Institute of Competitiveness and Quantitative Studies. The *REER* and the *r* were collected from the International Monetary Fund (IMF). We express the money supply and the real effective exchange rate in terms of a natural log. All these variables are presented in graph 1.

### 3.1. Proprieties of the data chronological series

Phillips (1995) showed that the impulse responses and the variance decomposition in the VAR models with integrated variables give incoherent estimations and tend towards the random variables The proprieties of the data chronological series were examined with Augmented Dickey and Fuller (1981), Phillips and Perron (1988) and Perron (1989) tests to determine the differentiation order of a macroeconomic series following its evolution over time.

#### 3.1.1. The Augmented Dickey-Fuller and Phillips-Perron stationary tests

According to graph 1, we remark that the overtime evolutions of the industrial production index (*IPI*) shows a cyclical movement that appears stationary. Furthermore, the money supply (*$M_2$*) shows a unique ascending tendency. This leads us to test their stationarity by the ADF and PP tests. The test results of this chronological series are given in table 1.

**Table 1 ADF and PP tests**

| Variables | In level | | | | In first difference | | | | Integration order | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ADF | | PP | | ADF | | PP | | | |
| | Test value | Critic value | Test value | Critic value | Test value | Critic value | Test value | Critic value | ADF | PP |
| IPI | -2.78 | -1.94 | -5.87 | -1.94 | - | - | - | - | 0 | 0 |
| $LM_2$ | -2.92 | -3.43 | -2.91 | -3.43 | -12.6 | -3.43 | -12.5 | -2.58 | 1 | 1 |

*Source: Authors' estimates from the data source.*

The ADF and PP tests suggest that the IPI is stationary in level. However, the two tests show that the $LM_2$ is stationary in first difference.

### 3.1.2. Perron test

Regarding the general tendency of the log of real effective exchange rate (*REER*), the real interest rate (*r*), the total unemployment rate (*u*) and the consumption price index (*CPI*), we notice that their overtime evolutions show slope and intercept shifts depending on their aspects. This leads us to introduce two dummy variables for each one: the first indicates the intercept shift $DU_t$ and the other the slope shift $DR_t$. The results are summarized in Table 2. These results show that the *LREER*, *r*, *u* and the *CPI* are stationary in first difference.

**Table 2 Perron test results**

| *Perron test in the variables taken at level* | | | *Perron test in the variables taken at first differences* | | |
|---|---|---|---|---|---|
| Dependent variable: $\Delta LREER_t$ | | | Dependent variable: $\Delta^2 LREER_t$ | | |
| Variables | Coefficients | t-statistics | Variables | Coefficients | t-statistics |
| *Intercept* | 0.39 | 3.48 | *Intercept* | -0.005 | -1.32 |
| $LREER_{t-1}$ | -0.07 | -3.52 | $\Delta LREER_{t-1}$ | -0.88 | -8.56 |
| *Trend* | -0.0002 | -2.09 | *Trend* | 0.0001 | 1.83 |
| $DR_t$ | -0.02 | -3.58 | $DR_t$ | -0.01 | -1.80 |
| $\Delta LREER_{t-1}$ | 0.17 | 2.28 | $\Delta^2 REER_{t-1}$ | 0.07 | 0.85 |
| $T_B$ =1984 Q4 | | $\lambda$=0.3 | | $\alpha$=1% | t= -4.39 |
| Dependent variable $\Delta r$ | | | Dependent variable $\Delta^2 r_t$ | | |
| Variables | Coefficients | t-statistics | Variables | Coefficients | t-statistics |
| *Intercept* | 0.19 | 1.62 | *Intercept* | 0.06 | 0.67 |
| $r_{t-1}$ | -0.02 | -1.49 | $\Delta r_{t-1}$ | -0.85 | -8.66 |
| *Trend* | 0.001 | 0.91 | *Trend* | 0.002 | 1.77 |
| $DR_t$ | -0.25 | -2.41 | $DR_t$ | -0.30 | -3.00 |
| $\Delta r_{t-1}$ | 0.25 | 3.14 | $\Delta^2 r_{t-1}$ | 0.12 | 1.50 |
| $T_B$=1991 Q1 | | $\lambda$=0.4 | | $\alpha$=1% | t= -4.34 |
| Dependent variable $\Delta u_t$ | | | Dependent variable $\Delta^2 u_t$ | | |

| Variables | Coefficients | t-statistics | Variables | Coefficients | t-statistics |
|---|---|---|---|---|---|
| *Intercept* | 1.08 | 3.12 | *Intercept* | -0.008 | -0.14 |
| $u_{t-1}$ | -0.082 | -3.19 | $\Delta u_{t-1}$ | -0.72 | -7.69 |
| *Trend* | -0.5 $e^{-4}$ | -0.07 | *Trend* | 0.3 $e^{-4}$ | 0.04 |
| $DU_t$ | -0.15 | -2.31 | $DU_t$ | -0.18 | -2.87 |
| $DR_t$ | 295.2 | 2.31 | $DR_t$ | 372.2 | 2.87 |
| $\Delta u_{t-1}$ | 0.36 | 4.53 | $\Delta^2 u_{t-1}$ | 0.06 | 0.76 |
| $\Delta u_{t-2}$ | 0.001 | 0.02 | $\Delta^2 u_{t-2}$ | - | - |
| $T_B$=2010 Q2 | | $\lambda$=0.9 | | $\alpha$=1% | t= -4.41 |
| Dependent variable $\Delta CPI$ | | | Dependent variable $\Delta^2 CPI_t$ | | |
| Variables | Coefficients | t-statistics | Variables | Coefficients | t-statistics |
| *Intercept* | 1.36 | 3.88 | *Intercept* | 0.42 | 1.66 |
| $CPI_{t-1}$ | -0.15 | -3.70 | $\Delta CPI_{t-1}$ | -0.91 | -8.69 |
| *Trend* | -0.9 $^{-3}$ | -0.29 | *Trend* | 0.004 | 1.35 |
| $DU_t$ | -0.3 $e^{-3}$ | -1.82 | $DU_t$ | -0.4 $e^{-3}$ | -2.39 |
| $\Delta CPI_{t-1}$ | 0.15 | 1.89 | $\Delta^2 CPI_{t-1}$ | -0.008 | -0.09 |
| $\Delta CPI_{t-2}$ | 0.10 | 1.22 | $\Delta^2 CPI_{t-2}$ | - | - |
| $T_B$=1982 Q2 | | $\lambda$=0.2 | | $\alpha$=1% | t= -4.41 |

*Source*: *Authors' estimates from the data source.*

Note: *$\Delta$ is the first difference operator and $\Delta^2$ is the second difference operator.*

Most of the system variables are integrated of order zero [I(0)] or one [I(1)]. The conventional cointegration methods (Engle and Granger, 1987 and Johansen, 1991) require the determination of the integration degree of the used variables and the integration of the variables of the same order. Therefore, we applied the SVAR. The Perron test also suggests that the consumption price index does have a unit root, which suggests that there is a permanent component in the inflation process. This suggestion is also backed by Mishkin (1995).

### 3.2. Impulse response and variance

Even if the two innovation types can influence the variables, the economy seems to be disrupted by a more important number of shocks. This hypothesis means that, on the one hand, only one type of shocks would command the core inflation, which seems to be reasonable enough, and, on the other hand, there would not be one real shock only. However, since we focus mainly on inflation, we believe that the last interpretation should not disrupt the results even if it would make the interpretation of a real shock less certain.

In practice, our VAR model has the following features. First, relying on the *AIC* and *SBC* tests, the lag number is fixed to 8. The estimation period extends from the first quarter of 1976 to fourth quarter of 2014. This choice was made for two different reasons; robustness of the deterministic components and feasibility of the economic results. Concerning the first point, no deterministic tendency is significant[5] over the retained period. Over such a long period, the presence or absence of such a tendency could sometimes alter the results considerably. As for the second point, the generally retained restriction procedure is the ex-post validation of the short run inflation series computed by the model. Taking into account the idea that the inflation rate in the short-run should evolve in a cyclic phase, we would choose the model for which the correlation between the cyclic part of the observed inflation and the tensions on the output capacities is the best.

#### 3.2.1. Impulse responses

The graphs 2 to 4 indicate the responses of inflation, output and unemployment to a standard deviation shock on $\eta_{j,t}\ \forall\ j=1,\ldots,6$. The abscissa represents time and the ordinate represents the logarithmic series.

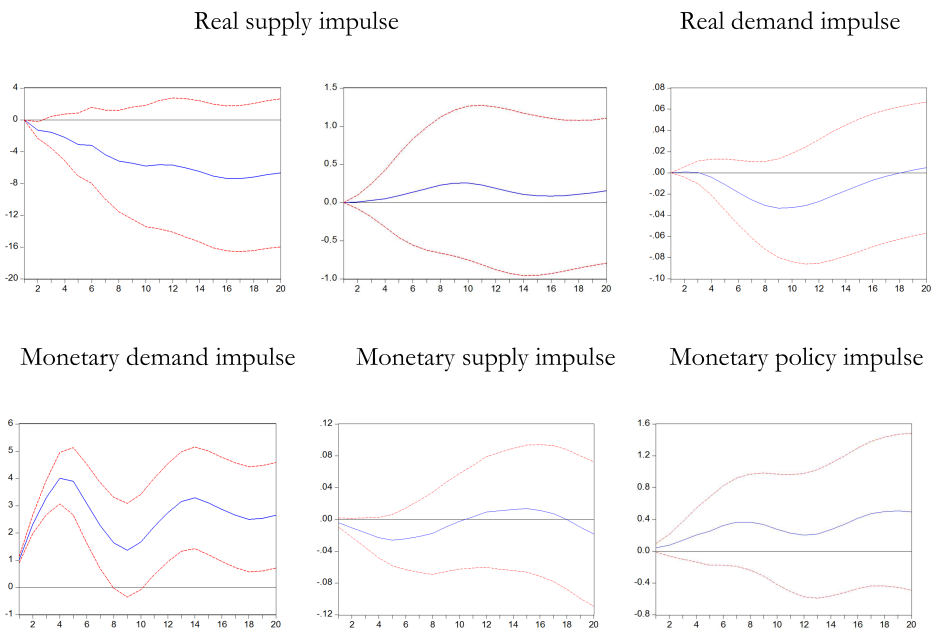
The standard deviations are obtained through Monte Carlo method with 500 replications. Generally, the results are remarked to be relatively close. Concerning inflation, the monetary shock $\eta_{4,t}$ has a permanent significant effect. This is coherent with the idea that this component is expected to command the inflation long run evolution. The effect does not stabilize quickly enough but only after about eight years. Concerning this impact of the real shock $\eta_{1,t}$ and $\eta_{2,t}$, the stabilization impact is reached within a short time, at a slightly higher level than zero. For the Tunisian economy, the hypothesis that the impact is not significantly different from

[5] Similarly, we have not looked for stationarizing the series through the introduction of potential ruptures in the constants. The idea was not to disrupt the identification of stochastic shocks through the introduction of deterministic shocks.

zero cannot be rejected. It was imposed that $\eta_{4,t}$ has an effect on the long-run industrial output level.

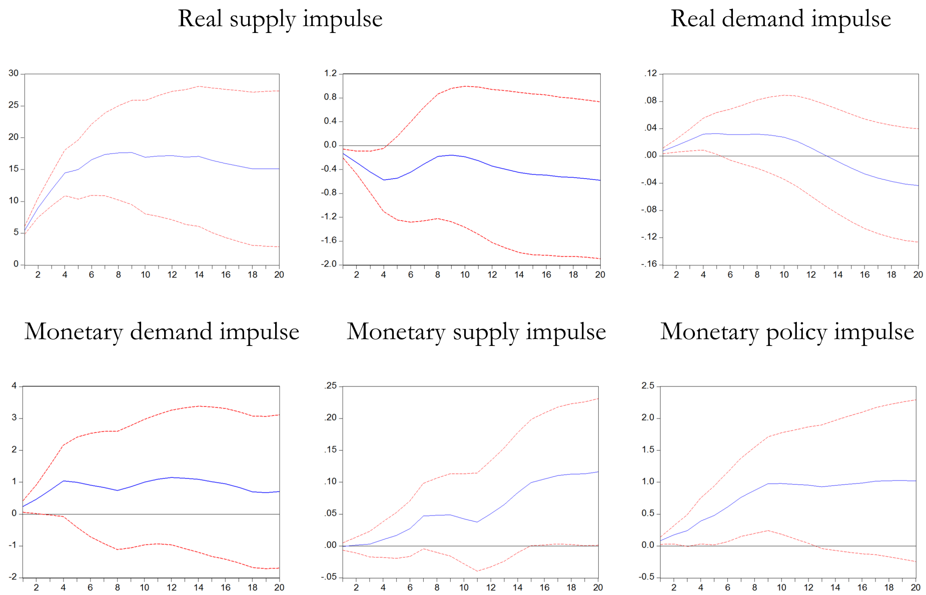
Therefore, we can deduce from the impulse shock that $\eta_{1,t}$ has a statistically significant long-run effect on inflation[6]. This propriety allows the clear distinction of the shock long-run effect $(\eta_{1,t})$, on the industrial output and $\eta_{4,t}$ on the measured inflation. This characteristic, checked ex-post without being imposed beforehand, demonstrates how the identification criterion is well founded.

**Graph 2 Observed inflation impulse responses**




6 The long run neutrality of $\eta_{1,t}$ on $\pi_t$ is not certain at all. However, if $\eta_{1,t}$, $\eta_{3,t}$, $\eta_{4,t}$, $\eta_{5,t}$ et $\eta_{6,t}$ could influence the long run observed inflation, it would totally put the identification process into question. Similarly, no constraint was imposed at the short / medium runs.

**Graph 3 Output impulse responses**




Since the neutrality constraint is imposed on the output in the long-run, the short-run remains free. The shock $\eta_{4,t}$, which is not neutral on the output in the long-run, has a significant effect. The impact of this shock stabilizes slowly. The relative short adjustment period to the situation in the long-run suggests a Phillips curve close to the vertical as a return to the equilibrium situation is quick. As the responses depend on the estimated VARs characteristics, the VAR is written with $\tau_{yt}$, $\tau_{ut}$, $\tau_{ert}$, $\tau_{\pi t}$, $\tau_{mt}$ and $\tau_{rt}$ giving the long-run tendencies $y_t$, $u_t$, $er_t$, $\pi_t$, $m_t$ and $r_t$, respectively.

$$\tau_{yt} = B_{y,y}(1)\tau_{yt} + B_{y,u}(1)\tau_{ut} + B_{y,er}(1)\tau_{ert} + B_{y,\pi}(1)\tau_{\pi t} + B_{y,m}(1)\tau_{mt} + B_{y,r}(1)\tau_{rt}$$
$$\tau_{ut} = B_{u,y}(1)\tau_{yt} + B_{u,u}(1)\tau_{ut} + B_{u,er}(1)\tau_{ert} + B_{u,\pi}(1)\tau_{\pi t} + B_{u,m}(1)\tau_{mt} + B_{u,r}(1)\tau_{rt}$$
$$\tau_{ert} = B_{er,y}(1)\tau_{yt} + B_{er,u}(1)\tau_{ut} + B_{er,er}(1)\tau_{ert} + B_{er,\pi}(1)\tau_{\pi t} + B_{er,m}(1)\tau_{mt} + B_{er,r}(1)\tau_{rt}$$
$$\tau_{\pi t} = B_{\pi,y}(1)\tau_{yt} + B_{\pi,u}(1)\tau_{ut} + B_{\pi,er}(1)\tau_{ert} + B_{\pi,\pi}(1)\tau_{\pi t} + B_{\pi,m}(1)\tau_{mt} + B_{\pi,r}(1)\tau_{rt}$$
$$\tau_{mt} = B_{m,y}(1)\tau_{yt} + B_{m,u}(1)\tau_{ut} + B_{m,er}(1)\tau_{ert} + B_{m,\pi}(1)\tau_{\pi t} + B_{m,m}(1)\tau_{mt} + B_{m,r}(1)\tau_{rt}$$
$$\tau_{rt} = B_{r,y}(1)\tau_{yt} + B_{r,u}(1)\tau_{ut} + B_{r,er}(1)\tau_{ert} + B_{r,\pi}(1)\tau_{\pi t} + B_{r,m}(1)\tau_{mt} + B_{r,r}(1)\tau_{rt}$$

Which long-run matrix B(1) is the following:

**Table 3 B(1) long-run impact Matrix**

| B(1) | $\tau_{yt}$ | $\tau_{ut}$ | $\tau_{ert}$ | $\tau_{\pi t}$ | $\tau_{mt}$ | $\tau_{rt}$ |
|---|---|---|---|---|---|---|
| $y_t$ | 4.31 | -2.11 | 0.10 | 2.07 | 0.14 | 1.56 |
| $u_t$ | 0.07 | 0.44 | 0.04 | 0.00 | 0.10 | -0.06 |
| $er_t$ | 0.01 | 0.00 | 0.02 | 0.00 | -0.01 | 0.00 |
| $\pi_t$ | -0.12 | 0.13 | 0.22 | 0.86 | -0.57 | 0.23 |
| $m_t$ | -0.01 | -0.01 | 0.01 | 0.01 | 0.03 | 0.01 |
| $r_t$ | 0.04 | 0.07 | -0.06 | -0.05 | -0.03 | 0.33 |

*Source: Authors' estimates from the data source.*

The coefficients of the residues variance-covariance are respectively:

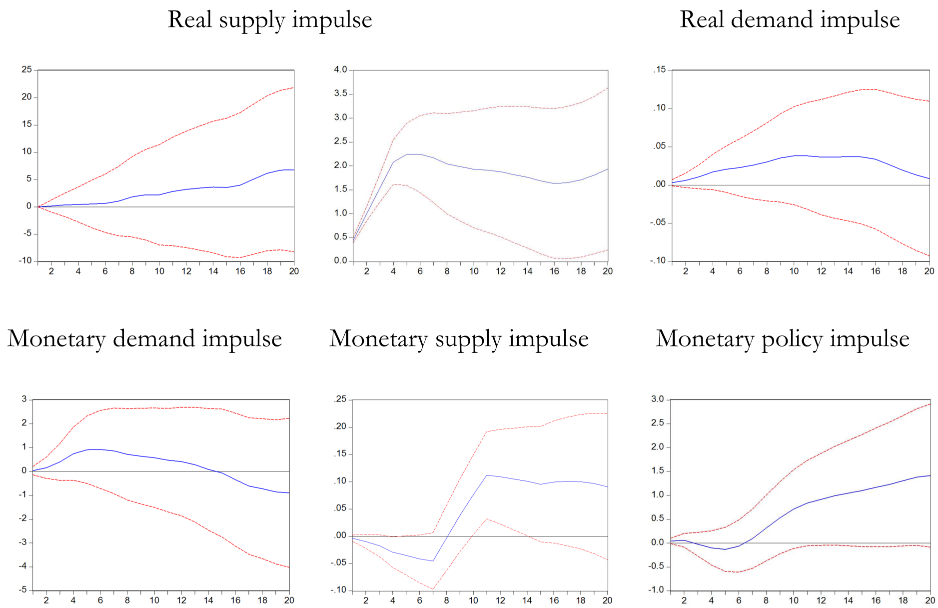
**Table 4 Residues variance-covariance matrix**

| $\Omega_{jj'}$ | $y_t$ | $u_t$ | $er_t$ | $\pi_t$ | $m_t$ | $r_t$ |
|---|---|---|---|---|---|---|
| $y_t$ | 29.78 | -0.72 | 0.04 | 1.29 | -0.01 | 0.45 |
| $u_t$ | -0.72 | 0.21 | 0.00 | -0.02 | 0.00 | 0.01 |
| $er_t$ | 0.04 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| $\pi_t$ | 1.29 | -0.02 | 0.01 | 1.20 | -0.01 | 0.04 |
| $m_t$ | -0.01 | 0.00 | 0.00 | -0.01 | 0.00 | 0.00 |
| $r_t$ | 0.45 | 0.01 | 0.00 | 0.04 | 0.00 | 0.12 |

*Source: Authors' estimates from the data source.*

However, the orthogonality of the process leads to the transition matrix $P$ as previously written, with $P_{i,j}$ the components of this matrix. The diagonality of the transition matrix indicates the prevailing effect of $\eta_{1,t}$ on the output, of $\eta_{2,t}$ on unemployment and $\eta_{4,t}$ on inflation starting from the short-run (see equations **25** and **26**).

**Graph 4 Unemployment impulse responses**




The structures of the matrices B(1) and *P* will determine the evaluation of the long-run multiplier, $D(1)=C(1)P$. It is written in the following analytical form:

$$\lim_{k\to\infty}\frac{\partial y_{t+k}}{\partial \eta_{1,t}}=D_{1,1}(1);\ \lim_{k\to\infty}\frac{\partial y_{t+k}}{\partial \eta_{4,t}}=D_{1,4}(1);\ \lim_{k\to\infty}\frac{\partial \pi_{t+k}}{\partial \eta_{1,t}}=D_{4,1}(1);\ \lim_{k\to\infty}\frac{\partial \pi_{t+k}}{\partial \eta_{4,t}}=D_{4,4}(1)$$

According to Jacquinot (2001), the multiplier $(\partial y_t/\partial \eta_{4,t}).(\partial \pi_t/\partial \eta_{4,t})^{-1}=\partial y_t/\partial \pi_t$ (see graphs 2 to 4) that indicates the relative effect of a monetary impulse on the output and inflation has a double interpretation according to the retained horizon. In the short-run, this impulse magnitude provides us with an indication about the shape of the curve linking growth to inflation. Therefore, in the short-run, the importance of the Phillips effect is measured: an important multiplier is synonymous of a sensitive Phillips effect and a weak slope of the Phillips curve $(\partial y_t/\partial \pi_t=0)$ means that the Phillips curve is vertical. In the long-run, the required span, for which the multiplier has to be close to zero, evaluates the return time for the Phillips curve (Putnam and Azzarello, 2015). Thus, the Tunisian economy seems to be an economy for which the long-run effect is the most important and needs a longer time to stabilize (largely over five years).

### 3.2.2. Variance decomposition

The prediction error at horizon *s* between the observed series and the prediction at the horizon $t+s$ periods was obtained from equation (**19**). This error is at the same time the result of both structural and non- structural components. The percentage of the variance prediction error due to the monetary impulse $\eta_{4,t}$ is computed. The variance decomposition is the percentage of the variance which is presented by $\eta_{4,t}$

**Table 5 Variance Decomposition of the prediction error**

| Period | Standard Error | Exogenous shocks | | | Endogenous shocks | | |
|---|---|---|---|---|---|---|---|
| | | *Real supply* | | *Real demand* | *Money demand* | *Money supply* | *Monetary policy* |
| | | IPI | Δu | ΔLREER | ΔCPI | $\Delta LM_2$ | Δr |
| 1 | 5.457 | 4.684 | 0.099 | 7.967 | 87.249 | 0.000 | 0.000 |
| 2 | 6.680 | 3.556 | 0.524 | 4.990 | 89.659 | 0.592 | 0.679 |
| 3 | 7.420 | 4.411 | 1.763 | 4.362 | 86.307 | 2.627 | 0.529 |
| 4 | 7.942 | 5.219 | 3.667 | 3.586 | 79.434 | 6.886 | 1.208 |
| 5 | 8.090 | 4.767 | 3.805 | 4.088 | 72.257 | 12.531 | 2.552 |
| 6 | 8.306 | 4.106 | 3.189 | 3.660 | 70.211 | 14.523 | 4.312 |
| 7 | 8.554 | 3.751 | 2.901 | 3.744 | 71.400 | 13.989 | 4.214 |
| 8 | 8.654 | 3.656 | 3.006 | 3.698 | 72.386 | 13.247 | 4.007 |
| 9 | 8.679 | 3.757 | 3.023 | 3.632 | 71.934 | 13.577 | 4.076 |
| 10 | 8.734 | 3.881 | 2.974 | 4.137 | 70.757 | 14.253 | 3.998 |
| 11 | 8.837 | 3.775 | 2.940 | 4.493 | 70.680 | 13.969 | 4.144 |
| 12 | 8.860 | 3.622 | 2.837 | 4.986 | 69.966 | 13.504 | 5.086 |
| 13 | 8.888 | 3.482 | 2.888 | 5.598 | 68.875 | 13.018 | 6.139 |
| 14 | 8.916 | 3.447 | 3.237 | 5.662 | 68.149 | 12.849 | 6.658 |
| 15 | 8.968 | 3.481 | 3.443 | 5.634 | 68.036 | 12.792 | 6.614 |
| 16 | 9.005 | 3.471 | 4.141 | 5.577 | 67.541 | 12.625 | 6.645 |
| 17 | 9.105 | 3.533 | 4.765 | 5.546 | 66.871 | 12.423 | 6.862 |
| 18 | 9.226 | 3.681 | 4.841 | 5.539 | 66.506 | 12.317 | 7.116 |
| 19 | 9.278 | 3.678 | 5.000 | 5.542 | 66.345 | 12.285 | 7.151 |
| 20 | 9.290 | 3.684 | 5.007 | 5.537 | 66.362 | 12.270 | 7.140 |

Cholesky Ordering: IPI Δu ΔLREER ΔCPI ΔLM2 Δrr

*Source*: *Authors' estimates from the data source.*

Note: *Δ is the first difference operator.*

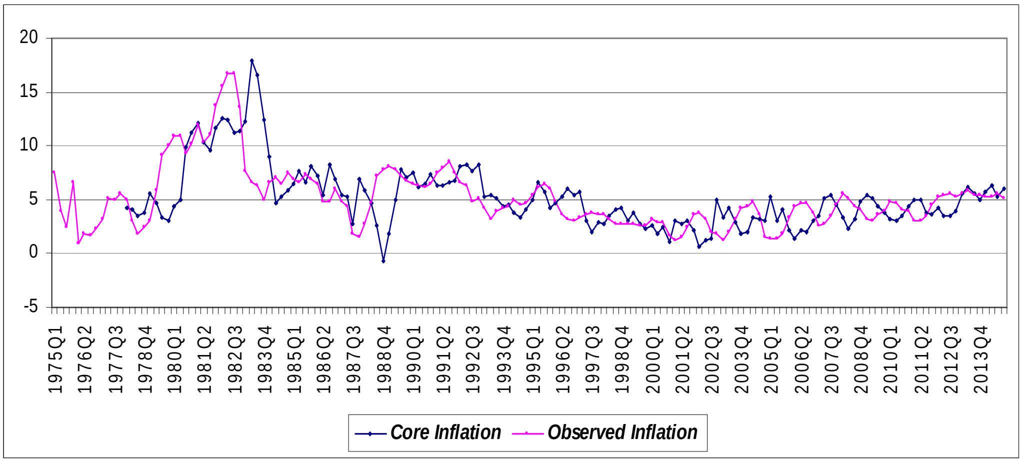
Generally, the sum of the contributions of the shocks is equal to 100% for any given series. Since the identification restriction imposes a long run independence of $y_t$ on $\eta_{j,t}$, its contribution to $y_t$ should be close to 3.68% in the long run. The short/medium runs are under no restrictions, yet, up to 56% of $\pi_t$ is explained by $\eta_{4,t}$. However, we observe a weak effect on unemployment in the short, medium and long runs. Bearing in mind the absence of a significant effect of $\eta_{2,t}$ on inflation, this seems to be logical.

### 3.3. Headline Inflation and Core Inflation

Core inflation ($\pi_t^{sj}$), as a component of inflation explained by the set of long-run shocks on output ($\eta_{j,t}$), is obtained by annulling $\eta_{1,t}$ in equation (**31**); i.e. in economic terms after eliminating the correlated component with the industrial output.

Graph **5** represents the observed inflation as well as the core inflation. At a first glance, the two series have evolved closely, which means that core inflation represents the "heavy" tendency of inflation. The other reason might be that the core inflation takes into account the reversals of the observed inflation. This means that core inflation may have a deterministic tendency and, therefore, the monetary impulse largely accounts for the evolution of inflation. During the weak inflation periods, (mainly the beginning of the nineteen eighties), the core inflation often exceeded the observed one mainly during the period 1982-1988 with the clear impact of the oil shocks and the period of an internal economic difficulty of 1981-1982. Headline inflation is persistently above the core inflation during the periods of oil-price shocks, including those of the Gulf War of 1991. As energy price shocks died out (two years after), the headline inflation fell below the core inflation, although the effects are not symmetric. However, we notice that this lag remained positive during the nineties probably because of favorable supply impulse (Quah and Vahey, 1995).

**Graph 5 Observed Inflation and Core Inflation Evolution**




During the study period, we observe that the core inflation exceeds the observed one at 50.6% in times of accelerating demand and conversely in periods of recession. In other words, the difference between the core and observed inflations is procyclical. We can see in the first quadrant of graph 1, the short run evolution of the inflation rate and the industrial production index; this might explain the reason for this procyclical phenomenon. This graph also shows that there is a weak positive correlation between these two variables (5.2%). This propriety was effectively checked, which validates our core inflation computation. As the core inflation is the observed inflation characterized by a situation of $\eta_{1,t}$ shocks, in the short run, inflation ($\pi_t^{sr}$) correlating with the cycle, is exclusively explained by this type of shocks:

$$\pi_t^{sr} = \sum_{\sigma=0}^{s-1} D_{41,\sigma}\,\eta_{1,t+s-\sigma} + \sum_{\sigma=0}^{s-1} D_{42,\sigma}\,\eta_{2,t+s-\sigma} + \sum_{\sigma=0}^{s-1} D_{43,\sigma}\,\eta_{3,t+s-\sigma} + \sum_{\sigma=0}^{s-1} D_{44,\sigma}\,\eta_{4,t+s-\sigma} + \sum_{\sigma=0}^{s-1} D_{45,\sigma}\,\eta_{5,t+s-\sigma} + \sum_{\sigma=0}^{s-1} D_{46,\sigma}\,\eta_{6,t+s-\sigma}$$

Examining $\eta_{j,t}$ was crucial to understand the inflation short-run evolution. The examination of the shock, which is constructively orthogonal to the other shocks and of a unit variance, is rather illustrative but not interpretable. Comparatively, we could then deduce that the output residue is more and more negative starting from the eighties onwards.

### 4. Conclusion

In this study, our results revealed that the observed inflation exceeds the core inflation in times of rising demand and in periods of low growth as well. Both observed and core inflations have evolved closely. The other reason might be that the core inflation takes into account the reversals of the observed inflation. This seems to be reasonable as the core inflation has a deterministic tendency and, therefore, the monetary impulse largely accounts for the inflation evolution. During the light inflation rate periods, the core inflation often exceeded the observed one mainly during the period 1982Q1-1988Q4 with the clear impact of internal economic difficulties of 1981-1983. Our results also show that there is a weak positive correlation between the inflation rate and the production index in the short-run.

Therefore, it is recommended that the Tunisian monetary authorities focus on the core inflation as a guideline for future monetary policies. This inevitably means that any political action should rely on certain fundamental measures of the core inflation for future predictions and decisions (Dandan Liu and Smith, 2014). This suggests that these authorities establish and adopt explicit targeted inflation rates as an objective of any monetary policy taking into account the core inflation. According to Rich and Steindel (2003) the "Central Bank is concerned with movements in a consumer price measure which many formal indexing arrangements, notably for wages and government taxes and benefits, are connected to indexes of consumer prices".

Finally, this paper reveals that the core inflation contains more information about future inflation and inflation expectations, while the observed inflation rates are noisy as they quickly respond to changing macroeconomic conditions.

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