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This paper investigates the possibility of constructing a composite leading indicator (CLI) of Tunisian inflation. For doing so, partial information about future inflation rate provided by a number of basic series is analyzed first. Based on the correlation analysis, a few of these basic series are chosen for construction of composite indicator. Empirical results show that the deviation from long-term trend of two monetary aggregates (M1 and M3), short-term interest rate (TMM), real effective exchange rate and crude petroleum production, are important leading indicators for inflation rate in Tunisia. Accordingly, based on monthly data on these basic series, one composite indicator is constructed and its performance is assessed by using turning point analysis, granger causality tests, and impulse response functions. The results indicate that our composite indicator is useful in anticipating changes in inflation rates in Tunisia.

Keywords: Tunisia, Inflation, Leading indicators, Composite index,

JEL classifications: E31; E32; E37

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1. Introduction

Since the early 1990's, the Central Bank of Tunisia (BCT) has adopted the monetary targeting strategy (MTS) as its official framework for conducting monetary policy. Like many other central banks, under such a monetary framework, the BCT typically attempted to control inflation through intermediate targets.[2] Of course, in Tunisia, the BCT has been called upon to perform many functions and its objectives have not been always focused. Price stability however has been one of the crucial objectives of monetary policy.[3]

During the last twenty years, the Tunisian economy has been characterized with an environment of price stability and low inflation. However, it is largely admitted that this relatively good record has nothing to do with the MTS implemented by monetary authorities. In fact, the BCT strategy could be considered as a complete failure since the targets pursued and announced have often been missed. This failure could be attributed to several factors. First, as stated before, price stability has not always been the only objective of the BCT monetary policy. Other objectives included maintaining the external value of the Tunisian dinar to enhance the competitiveness of the economy as well as supporting the government policies of employment and growth. Apart from these two important goals, the BCT has also made conscious attempts in recent years to promote financial stability. Second, the method the BCT uses in deriving the targets is not based on a money demand function; it is rather based on the BCT staff experience, and it turned out to be either too expansionary or too contractionary. It is also recognized that the performance of Tunisian MTS has been significantly undermined by several other factors including the lack of operational autonomy of the central bank, fiscal largesse, a weak transmission mechanism, and a weak financial system (Boughrara 2007).

Given these limitations and the lack of performances of the MTS, the Tunisian authorities are considering the option of switching to an inflation targeting regime (IT). In contrast to MTS, which seek to achieve low and stable inflation by targeting intermediate variables, IT involves targeting inflation directly. The literature offers several different definitions of IT. The European Central Bank (ECB) defines it as "a monetary policy strategy aimed at maintaining price stability by focusing on deviations in published inflation forecasts from an announced inflation target" (ECB 2004). Mishkin (2000) emphasizes that an IT regime encompasses five main elements 1) the public announcement of medium-term numerical targets for inflation; 2) an institutional commitment to price stability as the primary goal of monetary policy, to which other goals are subordinated; 3) an information inclusive strategy in which many variables, and not just monetary aggregates or the exchange rate, are used for deciding the setting of policy instruments; 4) increased transparency of the monetary policy strategy through communication with the public and the markets about the plans, objectives, and decisions of the monetary authorities; and 5) increased accountability of the central bank for attaining its inflation objectives. Svensson (2002) defines IT in terms of three characteristics: 1) there is a numerical inflation target, in the form of either a point target or a target range; 2) central bank's inflation forecast has a prominent role and the instrument is set such that the inflation forecast conditional in the instrument setting is consistent with the target; 3) there is a high degree of transparency and accountability. All these definitions emphasize the fact that the forecasting of inflation (either explicit or implicit) plays a critical role in the conduct of monetary policy under IT.

Recently, a number of alternative methods have been proposed to explain, capture, and forecast the behaviour of inflation. These methods can be divided into several broad categories. Firstly, there are forecasts that emerge from structural models of the economy. Secondly, information on inflationary expectations (derived either indirectly from asset prices or directly via surveys) can be useful, provided agents do not make systematic errors. Thirdly, a judgmental approach is possible where various macroeconomic indicators are examined and assessed on the basis of past experience. Finally, more recently there has been a revival of interest in the leading indicator approach, which draws upon the methodology developed by the National Bureau of Economic Research (NBER) being well represented by Burns and Mitchell (1938), Moore (1961) and more recently, Stock and Watson (1989). Attention has also focused on defining a composite leading

[2] Till recently, the monetary policy formulation has focused on the determination of the proper growth of the M2 aggregate according to the quantity equation of money. In 2003, the BCT began to set targets for the growth rate in the broad M3 aggregate on the basis of the macro framework received from the *Institut d'Économie Quantitative* (IEQ).

[3] Under Article 33 of the May 2006 Central Bank Law, the priority objective of monetary policy is to safeguard price stability. This amendment removed the ambiguity regarding whether the domestic stability of the currency had priority over its external stability since the former Article 33 stated that: "*The ultimate objective of monetary policy is to safeguard the value of the currency by keeping inflation down to a rate close to the rate observed in partner and competitor countries*."

indicator/Index (CLI). To a great extent this last method is similar to the third, with the difference that it seeks to systematically look at the relationship between inflation and various macroeconomic series and to construct composite indicators by combining more than one series (Bikker and Kennedy 1999).

This paper does not concentrate on the question of whether Tunisia is ready or not for the implementation of an IT regime.[4] In fact, we believe that the Tunisian economy does not fulfill the “preconditions” for a successful adoption of IT. Rather, an attempt is made to identify a few macroeconomic leading indicators for tracking inflation rate in Tunisia and to combine them with a view to construct a CLI for capturing future path of inflation rate. The inspiration in doing this is three-fold. One, forecasts about the inflation rate and its turning points are very important inputs in the economic agents' decision-making environment, whether they be individuals or policy makers. An early signal for major turn in inflation rate will allow the economic agents to adjust their calculations about the anticipated new environment and take feasible necessary actions. Such an advance signal can also help the Tunisian monetary authorities to undertake appropriate measures to achieve their policy objectives in the context of the IT regime. Secondly, we believe that constructing a monetary condition index (MCI), as is done in several industrialized countries, incorporating interest rates and exchange rates is theoretically inappropriate. Given the stage of the Tunisian economy, the capacity of the two variables mentioned above to reflect the reality in respective markets is doubtful. Thirdly, recently, leading indicators based approaches have become very popular. They are used in predicting future path and turning points of many other economic variables such as currency exchange rate, output and business cycle, etc.. (Kaminsky, Lizondo and Reinhart, 1997; Lahiri and Moore, 1991).

The paper is structured as follows. The next section presents a review of the literature on leading indicators of inflation. The third section describes the variables and the data used. We present the reference series for inflation in Tunisia as well as the basic series for the candidate leading indicators. The fourth section assesses the efficiency of these basic series for capturing behaviour of inflation rate. The fifth section deals with the construction of the CLI using Principal Component Analysis (PCA) and describes the empirical results. In addition, we evaluate, in this section, the performance of the constructed by using turning point analysis, Granger causality tests and impulse response functions. The final section contains a summary and conclusions.

2. A review of the literature on leading indicators of inflation

The leading indicator approach was pioneered by the NBER and was popularized by the study of Burns and Mitchell (1946) in the US. This approach has since been utilized in a number of works, but mostly applied to business cycles. Applications of the leading indicator methodology to inflation are, however, relatively new, rare and confined predominantly to industrialized countries. To our knowledge, the first work on composite leading indicators of inflation was undertaken by Moore and Kaish (1983). Their leading inflation index is a composite of three main components (a measure of tightness in the labor market, a measure of tightness in total credit markets and a measure of changes in industrial commodity prices) which were selected on the basis of their theoretical relevance and their historical record in predicting cyclical peaks or troughs in US consumer price inflation. Moore and Kaish (1983) found that this CLI reflects changes in inflation rate cycles reasonably well, and that it was more reliable than any of the three components taken alone. Since then, several other works, mainly related to the US, utilizing the leading indicator approach, have been produced. Niemira (1986), for example, proposed a CLI for tracking inflation in the US. This index is composed of four economic series; vendor performance, the ratio of employment to population, the National Association of Purchasing Management’s (NAPM) price survey index and the Federal Reserve’s trade-weighted dollar index. Roth (1991) evaluated five different leading indicators of inflation, three of which are composite indices of US Department of Commerce. The other two are the growth rate of M1 and the ratio of capacity utilization to the foreign value of the dollar. He found that the indicators, particularly the composite indexes, anticipate past turning points quite well. Dasgupta and Lahiri (1991) used estimates of ex-ante real interest rates to derive inflationary expectations from nominal rates, and used the inflationary expectations for both quantitative and turning-point predictions of US inflation. They also offered an extensive comparison between the performance of their interest rate-based indicator of inflation and the CLI of inflation developed in Niemira (1986). They conclude that the performance of the CLI can be significantly enhanced if inflation forecasts based on interest rates are included. More recently, Webb and Rowe (1995) have developed a CLI of US inflation based on seven economic

[4] This issue has been recently addressed by Boughrara (2007).

series which were selected among thirty potential candidates including measures of Labor Utilization, money aggregates, interest rates and commodity price. According to them, the constructed index performs quite well.

Recently, several other studies have attempted to construct CLI's for industrialized countries other than the US. Drawing from the seminal work of Moore and Kaish (1983), Klein (1986) developed CLI's for forecasting changes in inflation rates in Canada, the UK, West Germany, France, Italy, and Japan. He found that the constructed leading index was useful in anticipating changes in inflation rates in all these countries with the exception of France and Italy. Bikker and Kennedy (1999) presented short and long-term CLI's of underlying inflation for seven European countries (Belgium, Germany, France, Italy, The Netherland, Sweden and the UK). The CLI's are based on leading basic series such as sources of inflation, series containing information on inflation expectations and prices of intermediate goods and services. They found that the generated CLI's can be very useful in predicting future price fluctuations. More recently, Binner et al (2005) have evaluated the performance of CLI's turning points of inflation in the Euro area. Their findings suggest that the cyclical pattern of the different CLI's reflect very closely that of the inflation cycle for the Euro area.

A few studies offer CLI's of inflation for single countries. Artis et al (1995) and Binner et al (1999) proposed short and long-term CLI's for the UK. In both studies the CLI's are obtained by combining seven basic series, three of them are nominal variables (Mo, import unit values and commodity prices), while the remaining four are real (vacancies, unemployment, retail sales and industrial production). These indicators are shown to provide sensible leading information on turning points for inflation. Seitz (1997) constructed an index of leading indicators on inflationary trends for Germany. The index is composed of five basic series namely, the M3 money supply, the capital market rate, the change in capital market rate, the unit labour costs and the inflow of orders in the manufacturing sector. The author concluded that the CLI anticipates the general price movements quite clearly, although early identification of inflation turning points with a constant horizon is not always possible. For Australia, Moosa (1998) presented an index based on five economic series; the price index of materials used in manufacturing industry, the Australian dollar effective exchange rate, the percentage of manufacturing firms operating at full capacity, the 90-day commercial bill rate and the M1 money supply. The performance of Moosa's index seems quite satisfactory since it is shown to have led the annual Australian inflation rate in six troughs and five peaks over a period of twenty years.

3. The variables and data

In order to construct a LCI, we need first to identify the reference series that might be considered as representative of inflation. In Tunisia, the official measure of inflation is based on the consumer price index (CPI) series though a different available measure (the producer price index (PPI) may be chosen as an alternative. The CPI is however often used in other studies since it is usually produced and announced on a timely basis. It is also generally not revised, and is usually transparent, easily available, and understandable by the public. Thus, in this paper, the CPI is chosen to calculate the reference series. We restrict the analysis to monthly data because this is available with much shorter lags and thus more suitable for a continuous forecasting exercise. Moreover, this gives us a sufficient number of observations and thus degrees of freedom. The choice of the sample period, which runs from January 1994 to December 2006, has been largely determined by data availability.

Still, the CPI series cannot be used directly as reference series since, as like many other economic series, it is dominated by strong trend component. To extract/ generate inflation cyclical, there is a need to apply some transformation to original CPI series. Two types of cycles can be considered; the growth rate cycle and the business cycle. The growth cycle is defined as the price cycle expressed as the percentage change, on an annual base, of the price index. A major problem is however associated with this approach. It arises from the fact that series of growth rates computed over short unit periods (monthly) tend to be very erratic. Their irregular components are often dominant and obscure their underlying cyclical movements. Thus in this paper, deviation cycle is preferred. It can be obtained by estimating the deviation of CPI from its long-term trend. The trend may be calculated in different ways. Here, it is obtained using the Hodrick-Prescott (1980) filter with $\lambda = 14400$. As is shown (figure 1), the –recalculated- reference series (the price cycle) exhibit periodical movements, a condition that is essential in the leading indicator approach.

Having chosen the reference series, now we turn to identify the potential leading indicators of Tunisian inflation. Although our approach is largely statistical, economic theory did provide us with a host of candidate indicators that may, either directly or indirectly, influence the inflation process. Three broad categories of leading indicators are used in this paper. They are listed in Appendix A. Firstly; there are those variables which reflect monetary conditions in the economy (Monetary and credit aggregates, interest rates). Underlying the use of such variables is the view that, if inflation is essentially a monetary phenomenon, then monetary variables should be leading indicators. Thus, several variables including quasi-money (QM), M1, M2, M3, M4, Domestic credit (CREDIT) and money market rate (TMM) have been used. While growth in monetary/credit aggregates is expected to have positive impact on inflation rate, the effects of growth in money market rate is anticipated to be negative.

The second category includes exchange rates. These are important because they are direct determinants of the costs of imports to domestic consumers, also representing a constraint on the prices set by domestic producers of import-competing goods. Four different measures of exchange rates are used. These are the bilateral exchange rate; dinar per SDR (ERSDR) and dinar per US dollar (ERDOLL), the Nominal Effective Exchange Rate (NEER) and the Real Effective Exchange Rate (REER). According to the existent literature, depreciation in the Tunisian dinar may be a signal for rise in inflation. It is also known that by the very nature of compilation of exchange rate data, while a rise in ERSDR (ERDOLL) dollar indicates a depreciation of Tunisian dinar, increase in NEER or REER points towards the appreciation. Thus while growth in ERSDR (ERDOLL) is expected to have positive impact on inflation rate, the growth in NEER or REER will be expected to have impact in opposite direction.

The final category includes variables which reflect the relationship between aggregate demand and supply in the economy. To the extent that demand is approaching capacity output and still rising, so we might anticipate that this would lead to inflationary pressures in the future. In this respect, variables such as industrial production (IP), mining production (MP) and crude petroleum production (CPP) are used as measures of demand pressure. Most of the series for the candidate indicators show some trend in their mean process and thus they are transformed to generate cyclical movements with a view to capturing the future cyclical behaviour of the reference series. As stated earlier, useful transformations can be achieved by taking growth rate cycle or deviation cycle and the later is used in this study (see figures in appendix B). Further, as required by the type of analysis used in this paper, all transformed series are normalized to give them a common span, such that they are expressed in comparable scale.[5]

4. Leading indicators of inflation: a correlation analysis

Several time series techniques have been used by empirical studies dedicated to forecasting inflation and more specifically to identifying potential leading indicators. These include univariate models (ARIMA, Bilinear, State-Dependant, etc.) or multivariate methods (VAR, Structural VAR, cointegration and error correction, etc Roth (1991), Moosa (1998). Two additional methods have been widely used to assess the leading character of series: Turning point analysis and correlation analysis (Bikker and Kennedy, 1999). The first highlights the turning points: the average number of periods (months in our study) by which the variable pre-dates (leads) turning points in target series. To that end, all turning points in all variables (considered to be potential leading indicator) have to be identified and numbered according to those of target series. The standard deviation of the leads of the turning points serves as a measure of the reliability/ stability of the variable as leading indicator. 'Missing' observed turning points in target series or a false alarm (that is indicating a turning point of target series that did not subsequently occur) would, in general, lead to disqualification of a variable. The second analysis is to calculate correlation coefficients between a series and reference series for different leads. The magnitudes of the correlation help assess the information content in a series about future values of target series. Note that while this criterion uses all available observations, the first criterion ignores some information (as it concentrates only on turning points). However, they generally produce similar results [Bikker and Kennedy 1999]. In this study the choice of basic series for construction of composite indicator is made by assessing leading characters of various series by using correlation analysis.

[5] The normalization of any series, say X(t), is done as below: X*(t) = [X(t) - MinX] / [MaxX - MinX] where X*(t) is the normalized series, MinX and MaxX are minimum and maximum values of X(t) respectively.

Table 1: Correlations between potential basic series and reference series at different leads

Basic Series*	Maximum Correlation	Lead Associated with Maximum correlation
Monetary and credit aggregates, interest rates		
QM	0.1628	12
M1	0.2114	22
M2	0.1652	24
M3	0.2135	24
M4	0.1362	12
CREDIT	0.1815	22
TMM	-0.2843	8
Exchange Rates		
ERSDR	0.1288	19
ERDOLL	0.1691	20
NEER	-0.1092	8
REER	-0.3013	12
Demand pressure		
IP	0.0775	6
MP	0.1609	16
CPP	0.2211	22

Notes:*Deviations from long-term trend of the respective series.

At least two conditions must be satisfied for a basic series to be considered as a good leading indicator. First, the correlation coefficient between this lagged basic series and the reference series for a given lag/lead has to be sufficiently high, in other words, the higher this coefficient is and the better is the characteristic of the basic series. Second, the lead time has to be long enough to meet some minimum to serve as a forecast instrument. In our study, and following Bikker and Kennedy (1999), a minimum requirement is established of a lead of six months in order to be able to generate forecast of the inflation rate well in advance. On the other hand, leads higher than 24 months are not considered here. These restrictions on lead times are somewhat arbitrary and one can consider various other truncation rules in lead times as well. However, empirical results obtained by truncating leads of lower by six months or higher by 24 months are quite satisfactory though further improvement is not surprising. Thus, the coefficients of correlation are estimated for different leads and the lead which produces the maximum correlation determines the series' most preferable lead time. This allows the candidate series to be judged, both on the basis of the extent to which they lead inflation and on the strength of the relationship between the cyclical patterns of the candidate series and inflation.

Table 1 gives the maximum correlation coefficients, in absolute terms, between basic series and the reference series as well as the basic series' corresponding lead (in months).[6] As stated before, these estimates are obtained by using monthly data on CPI and other variables covering the period from January 1994 to December 2006. As can be seen among five alternative monetary aggregates M1 and M3 have maximum correlations coefficients with positive signs (around 0.22) with respective leads of 22 and 24 months. Short term interest rate (TMM) has a correlation with reference series of -0.28. However, its (maximum) lead (8 months) appears to be rather modest. Among exchange rates series, the maximum correlation (-0.3), is associated with REER for lead of 12 months. Finally, among three different variables reflecting the effects of demand pressure on inflation, it appears that CPP has the highest correlation coefficient for lead of 22 months.

Five basic series (M1, M3, TMM, REER and CPP) are finally chosen for constructing the composite indicator. The lead periods of these important basic series are as indicated in Table 1. It is notable that the variables chosen for our composite index were similar to those which have been found useful in research for other industrialized countries. In particular Roth (1991), Webb and Rowe (1995), Seitz (1998), Moosa (1998), Binner et al (1999) and Binner et al (2005) find that monetary aggregates are useful additions to CLI's in the US, Germany, Australia and the UK. Like Bikker and Kennedy (1999) for EU countries and Roth (1991) for the US, among others, we also included measures of interest rate and exchange rates.

[6] Where the correlation function contains both positive and negative correlations, we present the maximum correlation (in absolute terms) over the leads with the appropriate sign.

5. A CLI of Tunisian inflation

Having identified the potential leading indicators of inflation, we now turn to the construction of the CLI. The existing literature offers a quite rich menu of alternative ways to combine variables to build a leading indicator all having pros and cons. Firstly, the basic series can be aggregated using their arithmetic mean. This approach is often used, because it is very simple and easy to apply and to interpret. An implication of the arithmetic mean is that the weights of the components are completely arbitrary. Secondly, a linear regression can be utilized to find the best set of coefficients to be used as weights on the composition of the indexes. An alternative way of deriving the CLI is the Principal Component analysis (PCA), which assumes that the first few principal components of the selected basic series, which explain as much as possible of the variation of the basic series, may be taken to represent the price cycle. The CLI based on the PCA is also a weighted average of the basic series, where the weights are proportional to the absolute values of the so called factor loadings. In this study, the PCA is considered for constructing the composite index.

5.1 Constructing the CLI

In our study, The CLI is constructed using weights derived from the PCA. In using this method the data had to be further transformed so as to obtain consistent results. In this respect, the basic series were synchronized, that is lagged according to their leading characteristics and their lead-periods given in table 1.

The next stage in the process is the calculation and application of appropriate weights derived from the PCA. The PCA involves the construction, from an original set of variables Xj (j=1,2,...k), a new set of variables Pi(i=1,2,...k) called principal components (PCs). These new variables are linear combinations of the X's:

$$P_1 = a_{11}X_1 + a_{12}X_2 + \quad \dots \quad + a_{1K}X_K$$
$$P_2 = a_{21}X_1 + a_{22}X_2 + \quad \dots \quad + a_{2K}X_K$$
$$\dots \qquad \dots \qquad \dots$$
$$P_K = a_{K1}X_1 + a_{K2}X_2 + \quad \dots \quad + a_{KK}X_K$$

The weights applied to the original series (a_{ij}) in the construction of the PCs are known as factor loadings. They are chosen so that the PCs satisfy the following conditions: (i) they are uncorrelated (orthogonal), in other words, there is zero multicollinearity among the PC's and (ii) the first PC will account for the maximum possible proportion of the variance of the set of X's, the second PC accounts for the maximum of the remaining variance and so on until the last the PC absorbs all the remaining variance not accounted for by the preceding components. In practice, the (few) first(s) principal component (s) usually captures sufficient variation to be an adequate representation of the original set.

Table 2 summarizes the eigenvalues of the five calculated PC's and their proportional explanatory contributions applied to the reference series. The eigenvalues indicate that the first principal component (P_1) explains about 32 percent of the standardized variance in Tunisian inflation, the second principal component (P_2) explains another 21 percent, the third principal component (P_3), another 19 percent, and so on. Based on the results reported in table 2, all five PC's are chosen for further computation of the CLI. These PC's are summarized in table 3.

Table 2: PCA, Eigenvalues,[7] proportion explained, and cumulative proportion

PC's	Eigenvalue	Difference	Proportion explained	Cum. value	Cum. Proportion
P_1	1.60	0.55	0.32	1.60	0.32
P_2	1.05	0.06	0.21	2.65	0.53
P_3	0.98	0.22	0.19	3.64	0.72
P_4	0.76	0.16	0.15	4.40	0.88
P_5	0.59	---	0.11	5.00	1.00

[7] Eigenvalues represent the column sum of squares for a factor, sometimes referred to as a latent root. It represents the amount of variance accounted for by a factor.

Table 3: PCA, Eigenvectors (loadings)

Variables	P_1	P_2	P_3	P_4	P_5
M1	0.38	0.42	0.61	-0.41	-0.35
M3	0.60	0.02	-0.21	-0.33	0.70
TMM	0.50	-0.09	0.31	0.80	0.04
REER	0.19	0.68	-0.61	0.21	-0.28
CPP	-0.44	0.59	0.32	0.19	0.55

Having chosen the PC's, now we turn to the construction of the CLI. This can be done by following two possible approaches. In the first approach the CLI is obtained by regressing target series on summation of the five PCs. Thus, the composite index, say $CI_1(t)$, is calculated from the relationship:

$CI_1(t) = a + b\,[\,P_1(t) + P_2\,(t) + P_3(t) + P_4\,(t) + P_5(t)\,]$

Where a and b are estimated from the following regression equation

$Y(t) = a + b\,[P_1(t) + P_2\,(t) + P_3(t) + P_4\,(t) + P_5(t)] + e(t)$; e(t) being the residual series.

In the second approach, the CLI is constructed by regressing the target series, Y(t) on the five PCs so chosen and the estimated value of Y(t) is treated as the composite index. Thus the form of this composite index, denoted by $CI_2(t)$, looks like

$CI_2(t) = a + b_1P_1(t) + b_2\,P_2(t) + b_3P_3(t) + b_4\,P_4(t) + b_5P_5(t)$

where a, b_1, b_2 ,b_3 ,b_4 and b_5 are estimated coefficients in the regression equation

$Y(t) = a + b_1P_1(t) + b_2\,P_2(t) + b_3P_3(t) + b_4\,P_4(t) + b_5P_5(t) + e(t)$; e(t) being the residual series.

In this paper, we consider the second approach since it is more general. Now regressing the inflation rate series on constant and the five PCs, the estimated structure of the CLI turns out to be:

$CI\,(t) = 0.47 - 0.02\,P_1\,(t) - 0.0018\,P_2\,(t) + 0.04\,P_3\,(t) – 0.1\,P_4(t) + 0.19\,P_5(t)$

5.2 Performance of constructed CLI

The ultimate test of the value of an indicator is its performance over time. There are a number of criteria upon which an indicator can be assessed. One possible way of evaluating the forecasting performance of the CLI is by comparing turning points for this indicator with those of inflation.

5.2.1 *Relationship between the CLI and inflation turning points*

Figures 1 and 2 plot the inflation rate and the calculated CLI with the cycles identified. Periods for declining inflation (CLI) are represented by the shaded areas and periods of rising inflation (CLI) by the unshaded areas. Peaks and troughs are indicated by the left-hand and right-hand edge, respectively, of a particular shaded area. The criteria used to date the inflation (CLI) cycles identified in Fig. 1 (Fig.2) include those commonly found in the literature (Roth, 1991; Artis et al 1995). These are;

Criterion 1: peaks always follow troughs and troughs always follow peaks.
Criterion 2: the turning point is the most extreme point between upswings and downswings.
Criterion 3: the length of time over which the change from upswing to downswing (or vice versa) takes place is required to be at least 3 months.
Criterion 4: the size of the change, namely the absolute difference between a trough and a peak point, cannot be smaller than 1.5 percentage points.
Criterion 5: where there are two or more turning points with equal values, we select the most recent point.

Three main characteristics of the cycles in inflation rate and in the CLI indentified in figures 1 and 2 are noteworthy. First, over the studied period, 10 complete inflation cycles are identified. Secondly, there are differences in amplitude between the cycles. Finally, the duration of cycles varies, and asymmetries between upswings and downswings are evident. Elements of asymmetry are also identified in inflation cycles for other countries (Roth, 1991; Artis et al, 1995)

Figure 1: Inflation rate (price cycle)

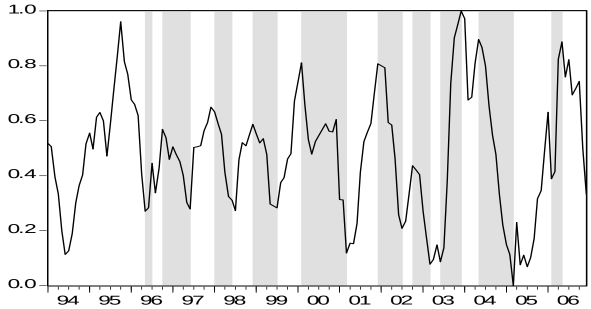
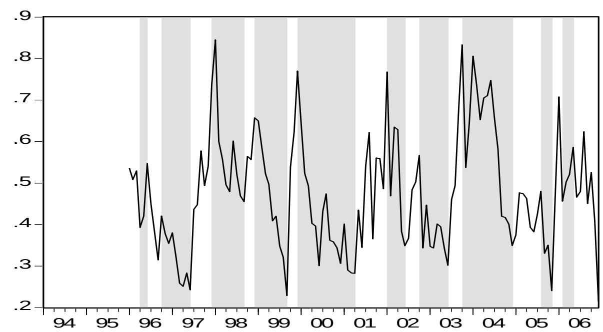


Figure 2: Composite leading indicator



Roth (1991) describes a perfect indicator as one which would “turn before each turn in inflation, lead inflation the same number of months each time, and turn only before turns in inflation”. The performance of our indicator, assessed by this criterion, is summarized in Table 4. It reports the turning points in inflation over the sample period and the extent to which the turning points in the indicator leads (-) or lags (+) the inflation turning points. The comparison between the turning points in the inflation series and the indicator shows that the latter gave reliable signals of turning points in inflation. In 2 cases out of 19 (Feb. 2000 and Dec. 2003), our CLI turned before 2 periods before turnings points in inflation. In 3 cases out 19, (May. 1996, Jul. 1996 and Jan. 1998) the indicator turned before 1 month before turnings points in inflation. Finally, in 7 cases out of 19, (Oct. 1996, Jun. 1997, Dec. 1998, Oct. 2002, Jun. 2003, Feb. 2006 and May. 2006) the indicator and inflation turned at the same time. Moreover, data in table 4 also indicates that the constructed CLI misses three inflation turning points and that it turns one period after inflation turning points in 4 cases, (Jul, 1999, Mar. 2001, Dec. 2001 and May. 2004) out of 19. Table 4 also provides the average number of months that turns in the indicator lead or lag turning points in inflation and the standard deviation of these leads or lags. It indicates that, over the period studied, the indicator predicted all turning points with an average lead of 0.5 months with a standard deviation of 0.7 months.

Table 4: Turning points in the inflation rate series and the CLI

Inflation Trough (T) and Peaks (P)	CLI Trough (T) and Peaks (P)	Number of Months that the CLI Turning Points Lead (-) or Lag (+) Inflation Turning Points
May. 1996 (T)	Apr. 1996 (T)	-1
Jul. 1996 (P)	Jun. 1996 (P)	-1
Oct. 1996 (P)	Oct. 1996 (P)	0
Jun. 1997 (T)	Jun. 1997 (T)	0
Jan. 1998 (P)	Dec. 1997 (P)	-1
Jul. 1998 (T)	M[a]	M
Dec. 1998 (P)	Dec. 1998(P)	0
Jul. 1999 (T)	Sep. 1999(T)	+1
Feb. 2000 (P)	Dec. 1999(P)	-2
Mar. 2001 (T)	Apr. 2001(T)	+1
Dec. 2001 (P)	Jan. 2002(P)	+1
Jul. 2002 (T)	M	M
Oct. 2002 (P)	Oct. 2002 (P)	0
Jun. 2003 (T)	Jun. 2003(T)	0
Dec. 2003 (P)	Oct. 2003(P)	-2
May. 2004 (P)	Jun. 2004(P)	+1
Mar. 2005 (T)	M	M
Feb. 2006 (T)	Feb. 2006(T)	0
May. 2006 (P)	May. 2006(P)	0
Mean Lead (-) or Lag (+)		-0.5
Standard Deviation		0.7

[a] M denotes that the turning point is missing.

5.2.2 Granger causality tests and impulse response analysis

A more formal way of evaluating the forecasting performance of our CLI than by graphical inspection or analysis of correlation coefficients is to measure how well they perform in estimating inflation equations. In this sub-section, the quality of the constructed CLI is assessed using causality tests and impulse response analysis. It is important to mention that we are not using the causality test to make a choice of variables involved, rather we are using it merely to confirm it in a weak way. Thus we shall be quite satisfied if the hypothesis of no causality from the composite indicator to inflation is rejected.

For this purpose, we first investigated the times series properties of the series for inflation rate and the CLI by applying the DF-GLS unit root test developed by Elliot, Rothenberg, and Stock (1996) in conjunction with the Schwartz Bayesian criterion (SIC) for selecting lag length. The DF-GLS test is an asymptotically more powerful variant of the well known augmented Dickey–Fuller (ADF) test that is obtained from generalized least squares detrending. The results of tests reported in table 5, indicate that both series are stationary (Integrated of order zero). In light of this finding, the empirical analyses are performed in the framework of a VAR in levels with an optimal lag length of 2 which was selected on the basis of the Akaike information (AIC) and the final prediction error (FPE) criteria. The specification of the estimated VAR is given by:

$$IR_t = a_{11}IR_{t-1} + a_{12}CLI_{t-1} + b_{11}IR_{t-2} + b_{12}CLI_{t-2} + c_1 + e_{1t}$$
$$CLI_t = a_{21}IR_{t-1} + a_{22}CLI_{t-1} + b_{21}IR_{t-2} + b_{22}CLI_{t-2} + c_2 + e_{2t}$$

Where IR is the inflation rate, CLI is the composite leading indicator, and a_{ij}, b_{ij}, and c_i are the parameters to be estimated.

Table 5: Unit Root tests

Series	Lag length	$t_{DF\text{-}GLS}$	1% Critical Values
Inflation rate	1	-4.370	-3.515
CLI	0	-4.319	-3.542

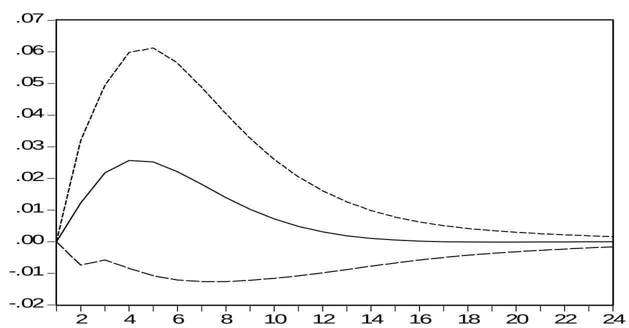
Unit root tests include a trend and an intercept.

The bivariate VAR given above can be used to test for causality between inflation rate and CLI. We use the Granger causality test to investigate the relationship between the two variables. Granger's definition of causality is the most widely used concept of causality. According to Granger (1969), CLI is said to "Granger-cause" IR if and only if IR is better predicted by using the past values of CLI than by not doing so with the past values of IR being used in either case. Essentially, Granger's definition of causality is framed in terms of predictability. In other words, this technique helps to determine whether certain time series is useful in forecasting another one.

In our specification, the standard Granger causality test entails testing to see if the coefficients associated with the variable CLI are jointly and significantly different from zero in the equation for inflation rate. Under the assumption of stationarity of variables and the null hypothesis of no Granger causality, the relevant Wald test statistic follows a χ^2 distribution with m degrees of freedom in large samples, m being the number of zero restrictions imposed. On performing the Granger test, we found that the null hypothesis of non-causality from the composite indicator to inflation can be rejected at the 1% significance level (χ^2 =2.61, p-value = 0.005). In other words, causality is detected from the composite index to the inflation rate.

The second use to which we put the VAR model is the derivation of impulse response functions, which represent a useful way of arriving at judgments about the time dimension of the CLI. The impulse response function, which traces out the time path of inflation to one standard deviation shock to the CLI, is depicted in figure 3. We bootstrapped 1000 replications of the VAR residuals to obtain robust standard errors for the impulse responses and used these to construct the 90% confidence bands shown in the figure. The time horizon over which the dynamic adjustment path of inflation is plotted following a one standard deviation innovation in the LCI extends to 24 months. The graph demonstrates the hump-shaped feature so often observed in the impulse response functions reported in business cycle studies. In our context, this characteristic demonstrates the leading quality of the CLI. More specifically, the estimated impulse response from the VAR reveals that the peak effect for the CLI occurs at 4 months. This can be taken as an indication that that movement in the CLI contains information on inflation approximately 4 months ahead.

Figure 3: Impulse response of Inflation to CLI



6. Summary and conclusion

In this paper, a composite leading indicator is constructed for predicting future path of inflation rate in Tunisia. For doing so, we applied a methodology which has been widely used for predicting turning points in the business cycle but which has been applied less widely to inflation. More specifically, leading qualities and partial information contents of a number of basic series including monetary aggregates, interest rates, exchange rates and several measures of demand pressure were assessed by correlation analysis and a few important basic series were chosen for combination. The composite leading indicator was constructed by using principle component analysis. The performance of the leading composite indicator was also assessed by using several methodologies including turning point analysis, Granger causality tests and impulse response functions. Empirical evidence suggests that this leading inflation index is indeed useful for monitoring and forecasting inflation developments in Tunisia. Whilst the procedure for choosing the components of the CLI was theoretically based, the manner by which they have been combined and the assignment of weights to the variables in order to construct the CLI were rather arbitrary. It could be possible that a more meticulous search for the optimal weighting could generate a better CLI than the one produced by this study.

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Appendix A

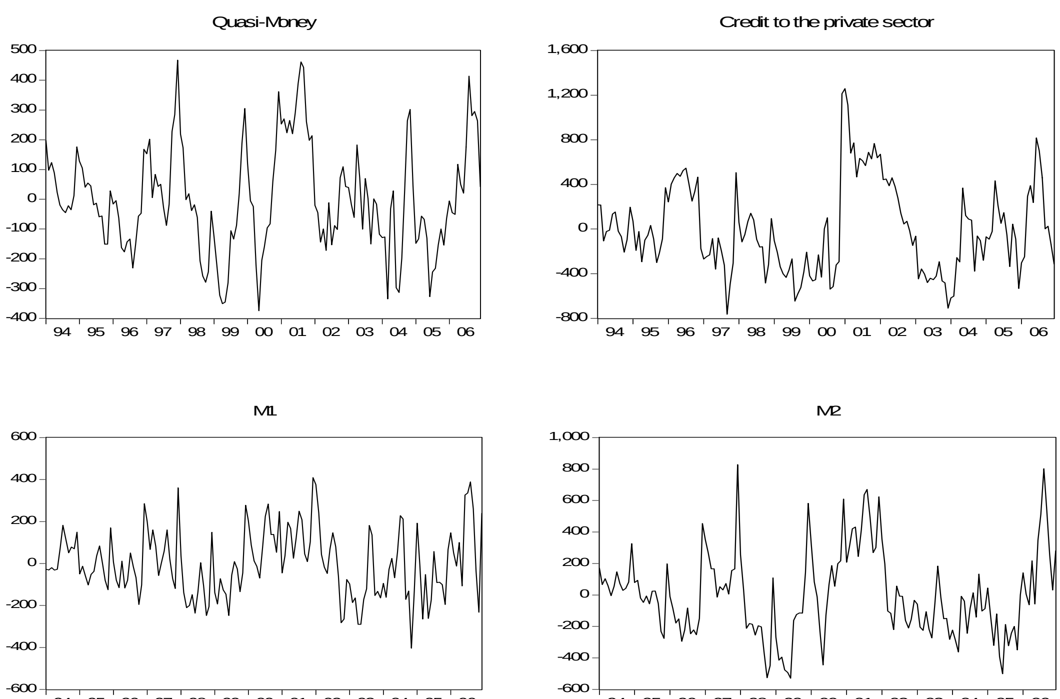
Table A.1: data definitions and sources

Indicator name	Description	Source
QM	Quasi-money = companies deposits + certificates of deposits +special saving accounts	BCT
M1	Fiduciary money + Bank money + companies and individual deposits + deposits at the CCP	BCT
M2	M1+ Quasi-money	BCT
M3	M2 + Home savings + Debenture loans	BCT
M4	M3 + commercial papers	BCT
CREDIT	Domestic Credit	BCT
TMM	Money Market Rate	BCT
ERSDR	Tunisian dinars per unit SDR	IFS
ERDOLL	Tunisian dinars per unit US dollar	IFS
NEER	Nominal Effective Exchange Rate	IFS
REER	Reel Effective Exchange Rate	IFS
IP	Index of Industrial production (Base 2000 = 100)	IFS
MP	Mining Production (Base 2000 = 100)	IFS
CPP	Crude Petroleum Production (Base 2000 = 100)	IFS

Notes: CCP: Centre des Chèques Postaux
BCT : Banque Centrale de Tunisie
IFS : IMF international Financial Statistics.

Appendix B

Figure B.1: Monetary/credit aggregates, Interest rates



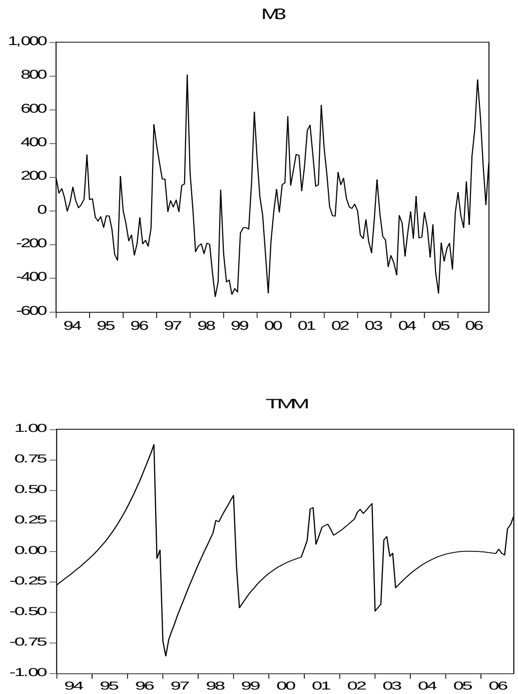


Figure B.2 : Exchange rates

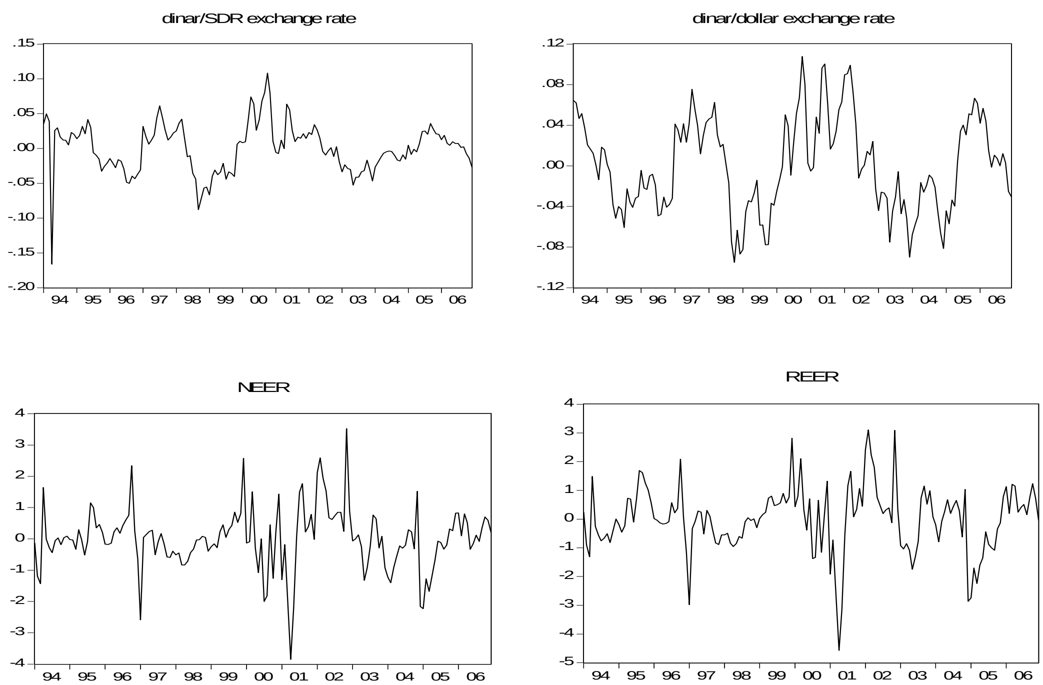
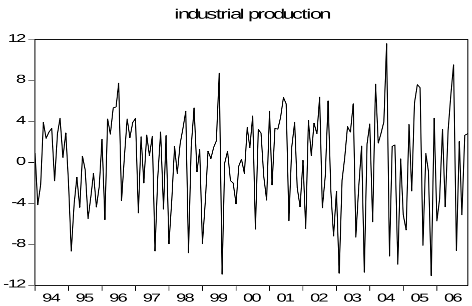
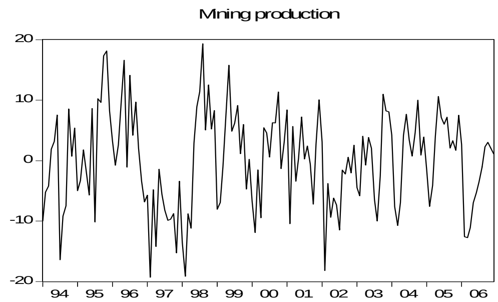
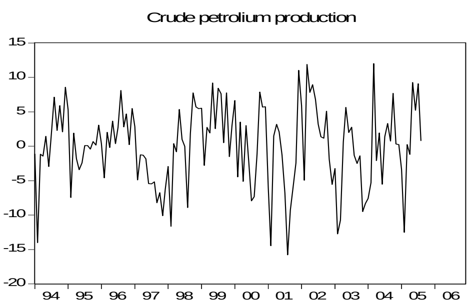


Figure B.3: Industrial performance







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