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Exchange Rate Pass-Through and Inflation Dynamics in Tunisia: A Markov-Switching Approach

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Abstract This paper studies the effect of exchange rate pass-through on inflation in Tunisia over the period 2001–2009. The authors' objective is to track inflation regimes for the Tunisian economy and to forecast its determinants. Using a Markov-switching approach, the authors identified two main regimes for inflation in Tunisia over this period: a low and stable inflation regime associated with a low pass-through level, and a high inflation regime associated with a high pass-through level.
In order to highlight the mechanisms underlying shifts in inflation regimes, the authors used a time-varying probabilities approach and identified a set of variables to assess their effect on inflation in Tunisia. The results show that the price level decreases in response to an increase in interest rates. Along with this, the empirical results provide strong evidence that industrial production indices have a negative and significant effect in increasing the probability to stay in an inflationary regime and a high pass-through level. In addition, the results show robust supports to suggest that the imports increase the probability to stay in a high inflation regime and a high pass-through level. However, exports increase the probability to stay in a low inflation regime and a low pass-through level.

JEL G15, F3, F4
Keywords Pass-through; inflation; Markov switching; economic fundamentals

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1. INTRODUCTION

Inflation and its determinants have been among the important issues of concern to economists. Given the fact that it is one of the major macroeconomic problems faced by emerging economies in recent decades. Along with this, there is a growing consensus about the deleterious impact on economic performance and social welfare of high inflation.

The liberalization and modernization of financial markets as well as changes in stabilization policies have caused changes in the inflation process. After a long period of relative price stability both in developed and developing countries, inflation has re-emerged around the world as a global challenge with serious socio-economic implications.

Tunisia is particularly concerned with this challenge as the process of economic and financial liberalization, since the establishment of the convertibility of its current account in January 1993, is pursued. Tunisia has already begun the process of opening its domestic market to international capital flows. She has also adopted more market-based monetary policy tools and is currently planning to progressively opt for greater exchange rate flexibility (Ben Ali, 2007). Policy-makers in Tunisia should then consider controlling and targeting inflation, a necessary condition for successful capital account liberalization. Thus, to be able to react on time, the BCT will need to base its monetary policy decisions not on past inflation outcomes but on inflation forecasts (Senhadji, Saadi and Kpodar, 2007).

The main objective of this paper is to investigate the process governing the inflation dynamics in Tunisia. Empirical results should reveal the significant factors driving inflation, which should be controlled or monitored by monetary authorities to make inflation-targeting in Tunisia effective. In particular, an important issue in controlling for inflation is to assess the pass-through. This issue is of particular importance as it affects the whole monetary policy in Tunisia, where exchange rate is sensitive to capital flows and where shocks in an open economy are often the main reasons for missing inflation targets. An important goal of the present study is to assess and track exchange rate pass-through. If pass-through is systematically related to monetary policy, as suggested by Taylor (2000), this would have significant implications for the appropriate way to conduct monetary policy in Tunisia. It is thus of utmost importance to understand and quantify the exchange rate pass-through for any monetary authority with an explicit or implicit goal of price stability. To what extent can a low inflation environment in Tunisia contribute to a pass-through decline is an important question that still needs to be addressed. Hence, the objective of this paper is to present new empirical evidence on Exchange Rate Pass-Through in Tunisia, focusing on its possible role in influencing the inflation environment.

As defined by Goldberg and Knetter (1997) exchange rate pass-through is the percentage change in local currency import prices resulting from a one percent change in the exchange rate between the exporting and importing countries. Changes in import prices are, nevertheless, to some extent passed on to producer and consumer prices. We are, therefore, in this paper using a broader definition of exchange rate pass-through, which is seen as the change in domestic prices that can be attributed to a prior change in the nominal exchange rate.

The pass-through issue has been widely debated in the economic literature since one of the main challenges for the inflation targeting facing emerging economies is to assess the impact of exchange rate shocks on domestic price measures and to forecast its determinants (Taylor,

2000; Bailliu and Fujii, 2004; and Gagnon and Ihrig, 2004 for developed economies, Choudhri and Hakura, 2006 and Ca'Zorzi et al., 2007 for emerging markets).

Following Hamilton (1989), the Markov-switching regime model has become extensively used to study nonlinearities in economic indicators such as inflation process (Blix, 1999).

Our purpose in this paper is to assess the effects of Tunisia's monetary policy on both inflation and exchange rate using Markov approach. To our Knowledge, this is the first paper that allows Markov Regime Changes in the inflation as well as in the Pass-Through in Tunisia. In this study, nonlinearities are important since the inflation, in Tunisia, responds to a shock in a very different way depending on which state the economy is in; i.e. a low and stable inflation or a high and volatile inflation. The transition from one state to another is modelled as a regime switch, and the probability of changing regime is inferred from the data. The idea that we have explored here, is that inflation in a Tunisia does not definitely correspond to one or other regime but may rather shift alternatively from one regime to the other, using a Markov-switching approach. This intuition can be strengthened by a preliminary econometric study. In fact, we have compared a single-regime linear model for inflation in Tunisia with the two-state-Markov-switching model. We carried out the likelihood ratio test introduced by GARCIA (1992) and we found that the statistics test largely exceed the empirical values, which allows as to retain a specification of two regimes for inflation.[1]

In the Hamilton's original model, the transition probabilities were constants. However, constant or fixed transition probabilities are too restrictive to explain the behaviour of inflation since economic variables are not allowed to affect transitional probabilities. Hence, an extension of Hamilton (1989) allows time-varying transition probabilities. As explained by Filardo (1994) and Diebold et al. (1999), the Markov-switching model with time-varying transition probability (TVTP) has the advantage over the fixed transition probabilities (FTP) in terms of flexibility. It can recognize systematic changes in the transition probabilities before and after turning points, capture more complex temporal persistence and allow expected duration to vary across time. In this context, economic fundamentals and policy shocks can influence the regime transition probabilities. Moreover, the challenge in the changes in the pass-through of exchange rate shocks behind the changes in inflation rate is that as economic factors change over time, the general pricing as well as the pass-through might change. For that reason, we consider the hidden regime switching methodology by Hamilton (1990), and its later extension by Filardo (1994) as the econometric framework to build inferences about the underlying fundamentals that determine the choice of the pricing policy, and to simultaneously estimate the Pass-through influence on inflation. That is why we suggest in this study a general form of the pass-through relation that can be implemented empirically, taking into account that the response of Pass-through to changes in inflation may be less than abrupt. In this case, the parameter of the underlying process may evolve continuously, with a probabilistic transition between the high and low inflation regimes. For that, we use a Markov-switching model in this paper. This model allows us to consider possible shifts in the evolution of the inflation process, which may better represent the actual behaviour of inflation in Tunisia, which is subject for a shift from one state to another and back again, following a probabilistic approach (Hamilton 1989-1990).

The main interest of the study is to investigate the pass-through effect on inflation in Tunisia.

[1] This result has not been reported in the manuscript to avoid encumbering the empirical part but it is available upon request.

Specifically, we apply the general framework of Markov-switching models where inflation, as well as its potential explicative variables can, alternatively, follow two regimes. Two main objectives arise from our study.

First, assess the impact of pass-through on inflation by distinguishing two different regimes for the nominal effective exchange rate and for inflation. Using the Markov regime-switching framework, we assess the extent to which Pass-through affects inflation, when it is subject to regime-switching.

Second, identify macroeconomic and policy-related determinants that may have contributed to a switch in inflation process in Tunisia over the last decade and in particular during liberalization phases. In fact, in this second step, our aim is to check if this set of macroeconomic variables is significant in underlying inflation dynamic in Tunisia and how it affects the probability of switching between the first regime of low inflation and low Pass-through level and the second regime of high inflation and Pass-Through level.

By applying a Markov-switching model, where the transition from one inflation regime to another depends on variables selected as sources of inflation's proxies, this study attempts then to shed light on sources of inflation, the effect of pass-through on inflation and to track factors that could be efficient to control for inflation. To our knowledge, this is the first paper to address such issue in assessing the dynamic of inflation in Tunisia and to forecast its determinants. This question is all the more important insofar as Tunisia will issue in the immediate future the total convertibility of the Tunisian Dinar and the liberalization of its capital account.

This paper is organized by discussing the exchange and monetary policies in Tunisia in the following section. Section 3 briefly reviews and highlights aspects of the literature on pass-through. A methodology section follows in Section 4. Section 5 briefly discusses empirical results. Section 6 concludes.

2. EXCHANGE RATE AND MONETARY POLICIES IN TUNISIA: AN OVERVIEW

Following the demise of the Bretton Woods system in 1973, major industrial countries moved to floating exchange rates. Until the end of the Bretton woods system, Tunisia had pegged its currency to the French Franc, given the importance of France as its main trading partner. Until the early 1980s, Tunisia then officially maintained its nominal exchange rate within a stable band relative to the French franc.

In 1986, with the support of the International Monetary Fund, Tunisia embarked on structural adjustment program aimed to establish a market based and private driven economy. As a result, Tunisia initially devaluates its currency by about 40 % over the next few years, before adopting a stable real effective exchange rate policy relative to a basket of currencies. The real effective exchange rate targeting policy, combined with sound monetary and fiscal policies, helped Tunisia to preserve external competitiveness and bring some discipline in macroeconomic policies. To accompany Tunisia's increased international integration, Tunisian authorities announced the current convertibility of the Tunisian dinar in January 1993 (Ben Ali, 2007).[2]

[2] It should be noted that Tunisia had issued the current convertibility of the Tunisian Dinar in December 1992. Tunisia intends to issue the total convertibility of the Tunisian Dinar in the near future. For further details on exchange rate policy, you can refer to Ben Ali (2007).

Regarding the monetary policy, money targeting has been its main objective. In 2003, Central Bank of Tunisia switched to targeting M3 money supply growth instead of M2 but without any changes in its monetary policy design and formulation. This helped Tunisia declining inflation rates from double digit rates in the early 1980s to sustainable levels in 2000s as described in table 1. A light rise in inflation rate on the contrary was seen since 2008, due to an increase in the price level of fuel and building materials, but also to imported inflation, arising from the depreciation of the national currency against the dollar and the euro.

Table 1. The Evolution of the Annual Inflation Rates in Tunisia (2001-2009)[3]

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Inflation (%)	2.700	2.706	2.725	3.622	2.014	4.504	3.147	5.046	3.5

Source: International Monetary Fund (2009).

It should be noted that without a nominal anchor for inflation, Tunisia has judiciously used discretionary (fiscal and monetary) and indirect (incomes) policies to maintain price stability facilitated by the absence of major terms of trade shocks and capital controls for non-residents. However, this overall policy strategy is likely to become less effective as its economy become more vulnerable to external shocks. Indeed, the Tunisian dinar's total convertibility remains a top priority in the immediate future. In particular, real exchange rate targeting will become more complex with volatile capital flows make it more difficult to estimate the exchange rate equilibrium, and more risky since targeting errors can lead to greater output volatility in a more open financial environment (Dropsy and Grand, 2008). To curtail the risks of increased international financial integration in an open capital account framework, the central bank of Tunisia has adopted more market-based monetary policy tools, such as open-market operations, and is gradually moving to greater exchange rate flexibility.

For a small open economy, such as Tunisia, adopting a flexible exchange rate regime, we expect a close relationship between exchange rates changes and changes in the level of inflation.[4] In the absence of exchange rate targets as nominal anchors for inflation expectations, Central Bank of Tunisia should consider a different approach to control inflation, a necessary condition for a successful floating exchange regime. Compared to discretionary policies, most economists agree that rule-based policies (via money-growth rules or interest rules) are more effective and more capable of building credibility. Also, inflation targeting appears to be another interesting solution to control inflation, as long as certain macroeconomic, institutional and operational conditions are fulfilled (Carare et alii, 2002; Khan, 2003).

From an economic point of view and as far as Tunisia is concerned with inflation targeting, our objective in this paper is to forecast inflation determinants in Tunisia in an open trade and financial framework.

[4] Edwards (2006) states that in many countries, the nominal exchange rate was often used as a way of bringing down inflation.

3. LITERATURE REVIEW

A broad stand of the monetary macroeconomics literature stresses the importance to assess the degree of pass-through, since it is a key issue in the conception and the control of the monetary policy (Gagnon and Ihrig, 2004, Edwards, 2006 and Mishkin, 2008). Indeed, a small degree of pass-through would mean that the variations of foreign exchange rate have less effects on the consumer prices and, consequently, on short-term inflation. That could adjust the forecasts of the central banks concerning the future behavior of inflation, forecasts which are determining in the control of the monetary policy. Moreover, exchange rate pass-through plays a crucial role in choosing the exchange regime and monetary policy frameworks.

In its broad meaning, the expression "exchange rate pass-through" is used to refer to the effects of exchange rate changes on one variable. Generally four variables are considered when dealing with pass-through: import and export prices, consumer prices, investments and trade volumes (Campa and Goldberg, 1999).

According to Law of one price, in a perfect competition framework, international arbitrage behavior would ensure that the domestic price of any traded good is equal to the foreign price of an identical good multiplied by the nominal exchange rate. In this framework, a change in the foreign prices or in the nominal exchange rate should be reflected on the domestic prices one-to-one. Such situation is called complete pass-through. However, in practice, this is almost never observed. There may be several factors for the pass-through to be incomplete.

Frankel et al. (2005) give a brief summary of the factors affecting pass-through of the changes in import prices or exchange rates via devaluations on the inflationary framework for the developed and developing countries. Authors' findings suggest that pass-through effects have historically been much higher in poor countries than in rich ones and are significantly higher in an environment of high inflation. They document also that pass-through effects have declined significantly in the 1990s, attributing this decline mainly to barriers to arbitrage between different countries. This result is consistent with the previous study of Mihaljek and Klau (2001) who document a general decline in pass-through from exchange rate changes into domestic inflation in emerging market economies since the mid-1990s.

Studies on the pass-through are diverse. Using a model of firm behavior based on staggered price setting and monopolistic competition, Taylor (2000) examines the relation between exchange rate variation and inflation. He reports that low inflation environment in many industrialized countries, which was brought about by more credible monetary policies, has successfully reduced the degree of the Exchange Rate Pass-Through (ERPT) to domestic prices. He document that ERPT is primarily a function of the persistence of exchange rate and price shocks, which tend to be reduced in an environment where inflation is low and monetary policy is credible. This result was later on claimed by Gagnon and Ihrig (2004) asserting that there has been a secular decline in pass-through from exchange rates to consumer prices in industrial countries over the past 35 years linking this decline to monetary policy credibility.

Choudhri and Hakura (2001) examine this hypothesis. They derive a pass-through relation based on new open economy macroeconomic models with a large database covering 71 countries over the period 1979-2000. They argue that estimated ERPT tends to vary systematically with the mean inflation rate. They show a strong evidence of a positive and significant relationship between the pass-through and the average inflation rate across countries and periods. Later on, Choudhri and Hakura (2006) assess the importance of price

inertia and expectations for the exchange rate pass-through. They asserts that since prices are set by firms, the pass-through will include the expected effect of changes in the exchange rate on future costs and prices, and this depends on the inflationary environment. They also reports that for high inflation regimes, the effect of monetary shocks would be more persistent and likely to be reflected in exchange rates concluding that the exchange rate pass-through would be larger in high inflation regimes.

For countries with very high inflation rates, Devereux and Yetman (2002) find, as in Choudhri and Hakura (2001), that aggregate pass-through is very high. They report a non-linear relationship between estimated pass-through coefficient and average inflation rates. Indeed, as inflation rises, pass-through rises, but at a declining rate.

Using data from 20 industrialized countries, Gagnon and Ihrig (2004) test whether the change in pass-through is explained by change in inflation regime. Relating the estimated pass-through pre- and post-inflation regime change for each country with the corresponding inflation regimes, they find that the decline in pass-through is explained by the fall in inflation variability. Their findings also support the view that countries with low and stable inflation rates tend to have low estimated rates of pass-through from exchange rates into consumer prices. This result is not consistent with the documented evidence in Barhoumi (2006). Using data from a large set of developing countries, the author finds a little difference in the long-run exchange rate pass-through in countries with widely divergent inflation regimes. Their empirical findings suggest also that homogeneity of pass-through rates across countries can be rejected and that countries with fixed exchange rate and lower tariff barriers exhibit a higher long-run exchange rate pass-through of import prices into domestic prices than countries with higher tariff barriers and floating rates.

Likewise, Bailliu and Fujii (2004) report this result for 11 industrialised countries. Their results provide evidence suggesting that pass-through declines with a shift to a low-inflation environment. In a recent paper, Barhoumi and Jouini (2008) investigate this issue. Their study provides evidence that pass-through declines are associated with inflation decreases on the period stretching from the 1980s to the 1990s. Their finding show that the change in the monetary policy regimes of these countries caused a shift to a low inflation environment, and hence an ERPT decline.

Ihrig, Marazzi and Rothenberg (2006) examine the effect of exchange-rate pass-through to both consumer and import prices to determine the extent to which they have fallen in the G-7 countries since the late 1970s and 1980s. They documented numerical decline of all countries in the responsiveness of import prices to exchange-rate movements. They also argue that while 10 percent depreciation in the local currency would have increased import prices by nearly 7 percent on average across these countries in the late 1970s and 1980s, and it would have only increased import prices by 4 percent in the last 15 years. Their study also indicates evidence of responsiveness of consumer prices to exchange-rate movements' declines for nearly every country. Finally, the study shows that while 10 percent depreciation in the local currency would have increased consumer prices by almost 2 percent on average in the late 1970s and 1980s, it would have had a neutral effect on consumer prices in the last 15 years.

In a recent paper, Júnior and León-Ledesma (2010) perform regression analyses to test the hypothesis arguing that exchange rate pass-through (ERPT) into domestic inflation has been declining in many countries following a dramatic change in inflation environment during the 1990s. Using a state-space model that allows ERPT to be time-varying and dependent on the

inflation environment, the authors estimate the model for 12 developed and emerging economies and test whether inflation contains significant information about the future evolution of the ERPT. Their paper reports supporting evidence of a smooth decline in the impact of exchange rates on domestic inflation, but do not support the hypothesis that lower inflation precedes ERPT decline.

To assess the effect of exchange regimes on the pass-through, Kara and Öğünç (2005) explored two subsamples to distinguish between the pre-float and the float behavior of exchange rate pass-through in Turkey. Their findings also indicate that pass-through has weakened and slowed down after the adoption of the floating exchange rate regime. Authors' findings suggest that most of the pass-through is completed within four to five months during the pre-float period, whereas it takes approximately one year under float. They highlighted a diminished magnitude of pass-through, in addition to the slowdown in its pace. In a two-year horizon, the total pass-through was estimated as approximately 60 percent for the pre-float period, while it has fallen down to 30 percent under the floating regime.

Following McCarthy's (1999) VAR framework, Leigh and Rossi (2002) have explored the exchange rate pass through as an additional source of information to assess underlying inflationary pressure in Turkey. They highlighted the fact that the pass through to wholesale prices is more pronounced than Consumer Price index and that the impact of the exchange rate on prices is mostly felt in the first four months and is over after about a year. Hyder and Shah (2004) followed McCarthy and Leigh and Rossi in assessing exchange rate pass through in Pakistan. They documented similar results as Leigh and Rossi. Their results show also that pass-through to domestic prices are much stronger in higher inflationary environment relative to lower inflationary environment. Similarly, and a in a single country setting, Garcia and Restrepo (2001) argued that the exchange rate pass-through has been low for Chile and concluding that exchange rate pass-through depends on economic activity. They also assert that declines in economic activity reduce the output gap and compensate for the inflationary impact of exchange rate depreciations.

4. METHODOLOGY

In this section, we discuss the Markov-switching approach used in our empirical study. Then, we present the data and variables.

The Markov-Switching Approach

There has been a large debate on the correct characterisation behaviour of economic time series in general and inflation one in particular that often seems to be non-stationary. Specifically, this debate emphasis the integrated nature of inflation behaviour dynamics that often seems to go through distinct phases and having various behaviours over time. This study makes use of an alternative time-series characterisation for inflation that allows for distinct and differing periods of inflationary behaviour, each characterised by its own time-series properties depending on a probabilistic process.

This paper builds on an approach introduced in Hamilton (1989) paper for analyzing such discrete qualities of inflation. The parameters of the autoregression vector can be subject to occasional discrete shifts. The probability law governing these shifts is also stated explicitly and presumed to exhibit dynamic behavior of its own. The econometrician's task is then to

determine when the shifts occurred and to estimate parameters characterizing the different regimes and the probability law for the transition between regimes.

This approach is appealing for three reasons. First, its fits in with the fact that inflation can perform differently in different sub-periods. It is a switching process where sudden changes can occur. Second, the Markov-switching modelling approach we apply in this study imposes a simpler-than-conventional structure on the inflation process within any given regime, but gains power to fit the historical data by allowing regimes to change. The distinctive feature of this approach is the use of simple equations for inflation, within a framework that allows for discrete regime shifts. Specifically, Markov-switching models allow for two or more processes to exist with a series of shifts between the states occurring in a probabilistic manner, so that shifts occur endogenously rather than being imposed. Third, This Markov-switching methodology has also been motivated by the patterns of inflation for Tunisia that have historically, switched in response to many oil shocks.

Compared to other switching approaches such as the structural switching method that can only give us the different switching dates of inflation, Markov-switching approach let us through the smoothed probabilities graph, to have a probabilistic approach of appurtenance of each regime, while explaining inflation by macroeconomic factors, conditionally with all the information of the sample. Markov-switching models are an alternative to take into account market changes that can potentially cause changes in parameter estimates of models and, ultimately, improve forecasting accuracy. Now it is well established in the literature that Markov approach presents more sophisticated methods and original results compared to other structural break tests such as the Chow test (Hamilton, 1989 and 1990).

Its worth noting that we compared a single-regime linear model with the two-state –Markov-switching model. For that, we carried out the likelihood ratio test introduced by GARCIA (1992) and we found that the statistics test largely exceed the empirical values, which allows as to retain a specification of two regimes. [5]

Two main methods for estimating transition probabilities can be distinguished when dealing with Markov-switching process: Fixed Transition Probability (FTP) and Time Varying transition probability (TVTP) that will be discussed below.

FTP Approach

The Fixed Transition Probability (FTP) approach is the Markov-switching model in its standard form. Its main feature is that it does not allow the transition probabilities to vary. The basic idea of Markov-switching model is to describe the stochastic process that determines the switch from one regime to another using a Markov Chain. The Markov Chain is used to model the behaviour of a non observed state variable that determines which regime is current. As first introduced by Hamilton (1989, 1990), a Markov Chain can be represented as follows: Suppose that the probability of a variable s_t assuming some particular j value, depending only on the previous value s_{t-1}, is given by the following equation:

$$P\{s_t = j \setminus s_{t-1} = i, s_{t-2} = k...\} = P\{s_t = j \setminus s_{t-1} = i\} = P_{ij} \qquad (1)$$

[5] This result has not been reported in the manuscript but it is available upon request.

This process is described as a Markov Chain with M-states, where probability P_{ij} indicates the probability of state i being followed by state j. We can, thus, build the Markov transition matrix of first order, where probability of transition to the next regime relies only on the current regime. As presented in the seminal paper of Hamilton (1989), two transition probabilities can be distinguished:

$p = Pr(s_t = 1 \setminus s_{t-1} = 1)$ is the probability of staying in a low inflation regime.

$q = Pr(s_t = 2 \setminus s_{t-1} = 2)$ is the probability of staying in a high inflation regime.

We will estimate the Markov-switching model by maximum-likelihood using the Kittagawa-Hamilton filter (see Hamilton 1990 or 1994 for this filter). Hamilton's filter consists of two stages. First, initial values of the vector of parameters Θ are initialized using the ordinary least square method. Then, the series are sorted, split in M parts on which initial conditional regressions are computed to launch the Maximum likelihood descent. Second, the model is recursively estimated through the EM algorithm[6], starting from the unconditional density of the explained variable y_t calculated by summing conditional densities over possible values for S_t, as follows:

$$f(y_t \setminus \Theta)_{t-1} = \sum_{j=1}^{M} P(S_t = j, y_t \setminus I_{t-1}, \Theta)_{t-1} \quad (2)$$

$$\text{Or, } f(y_t \setminus \Theta)_{t-1} = \sum_{j=1}^{M} P(S_t = j \setminus I_{t-1}, \Theta)_{t-1} f(y_t \setminus S_t = j, I_{t-1}, \Theta)_{t-1} \quad (3)$$

The maximum likelihood estimate of Θ is obtained by maximizing the log-likelihood as follows:

$$L(\Theta) = \sum_{t=1}^{T} \ln(f(y_t \setminus I_{t-1}, \Theta)) \quad (4)$$

Where: Θ is the vectorized matrix of parameters. We define $S_t = \{1,\ldots,M\}$ as a M-state unobserved variable, following a first order Markov Chain and representing the number of regimes. St = 1 (resp. St = M), means that the time series are said to be in the "lowest" (resp. the "highest") regime. $I_{t-1}= (y_{t-1},\ldots, y_1)$ is the information set available in t-1, that is the lagged values of the endogenous variable will provide information relevant for the estimation of the Markov-switching model. P_t is the conditional probability related to the state j.

Within the framework of this paper, the Markov-switching approach describes the inflation process as being governed by two different regimes where switches between them are based on a probabilistic process. Estimates of parameters for the two most likely regimes are generated using maximum likelihood techniques. With the parameters previously identified namely the interest rate (TMM), the industrial production index (IPI), the exports (X) and the imports (M) unit values, it is then possible to estimate the probability that our variable of interest (inflation) is following one of the alternative regimes. This involves identifying where in the probability distribution of each regime the observation falls at each point in time. That is, the likelihood is calculated for each possible state.

TVTP Approach

[6] For a detailed description of the EM algorithm, see Hamilton (1990, 1994).

Time Varying transition probability (TVTP) is a Filardo (1994) extended version of the Fixed Transition Probability approach (*FTP*) that allows the transition probabilities to be time-varying. Following Filardo (1994), we allow the transition probabilities to be time-varying and dependent on macroeconomic and monetary policy-related variables. The logistic function for the transition probabilities specification was first introduced by Filardo (1994) and Diebold et al. (1994), then generalized by Filardo (1998), Gray (1996), Beine, Laurent and Lecourt (2003), Isogai, Kanoh and Tokunaga (2004) :

$$p_{i,j,t} = \Pr\left[S_t = j \setminus S_{t-1} = i,\ Z_{t-1}\right] = \frac{\exp(\lambda_{i,j,0} + Z'_{t-1}\lambda_{i,j,1})}{1 + \exp(\lambda_{i,j,0} + Z'_{t-1}\lambda_{i,j,1})}, \quad (5)$$

Where,

$i = 1, 2, \ldots, M;\ j = 1, 2, \ldots, M - 1;$ and

$$p_{i,M,t} = \Pr\left[S_t = M \setminus S_{t-1} = i,\ Z_{t-1}\right] = 1 - \sum_{j=1}^{M-1} p_{i,j,t}, i = 1, 2, \ldots, M. \quad (6)$$

M is the number of regimes and s_t is a first order Markov variable. Z_t is a vector of economic variables explaining the transition from one regime to the other. Following Filardo (1994), the time varying probabilities for two regimes can be described as below:

$$\Pr(s_t = 1 \setminus s_{t-1} = 1) = \frac{\exp(\lambda_{10} + \sum_{j=1}^{n} Z'_{t-1}\lambda_{1j})}{1 + \exp(\lambda_{10} + \sum_{j=1}^{n} Z'_{t-1}\lambda_{1j})} \quad (7)$$

$$\Pr(s_t = 2 \setminus s_{t-1} = 2) = \frac{\exp(\lambda_{20} + \sum_{j=1}^{n} Z'_{t-1}\lambda_{2j})}{1 + \exp(\lambda_{20} + \sum_{j=1}^{n} Z'_{t-1}\lambda_{2j})}. \quad (8)$$

Where,

$\Pr(s_t = 1 \setminus s_{t-1} = 1)$ is the probability of remaining in a low inflation regime, given that the previous regime is characterized by a low and stable inflation, and $\Pr(s_t = 2 \setminus s_{t-1} = 2)$ represents the probability of a high inflation regime, preceded by a high and volatile inflation.

Zt is a vector of **j** macroeconomic and policy-related variables considered to predict the future course of inflation as described in the following subsection. By allowing transition probabilities to vary over time, we can analyze the mechanisms underlying shifts from a low inflation regime (St=1) to a high inflation regime (St=2) and vice versa. In particular, we will

use this econometric framework to determine the effect of macroeconomic and policy-related variables on inflation's shift from one regime to another.

The key parameters affecting the probabilities of transition from one regime to the other are the coefficients λ. In particular, it is important to examine the sign of these coefficients. For example, if the coefficient λ_{11} is positive, this means that the corresponding economic fundamental Z is a significant factor in increasing the probability to stay in a disinflationary regime (regime 1). However, if the coefficient is negative, this means that the corresponding macroeconomic variable Z lowers the probability of remaining in a low inflation regime and increases the probability to overbalance towards a high and volatile inflation (regime 2). Similarly, the coefficient λ_{21} measures how the exogenous variable Z affects the probability of staying in a high inflation regime (regime 2) and eventually the probability of switching to a low inflation regime (regime 1), depending on whether this coefficient is respectively positive or negative.

Data and Variables Description

The main interest of the study is to examine the inflation dynamics and track its determinants. Inflation is tracked as a function of a set of macroeconomic and policy-related determinants. The study is conducted in a Markov-switching analysis. It uses monthly observations over the period running from January 2001 to December 2009. The frequency of the data (from 2001 to 2009) lets us to have 108 observations, which is very satisfactory from an econometric point of view. Up to our knowledge, our data correspond to the largest sample used in the literature in order to track the inflation determinants in Tunisia. Moreover, the robustness of our empirical findings are evidenced by two significant inflation regimes in mean and variance for both FTP and TVTP approaches as discussed in details in the results section.

Given the importance of the European union as Tunisia main trading partner (with more than 85 % of Tunisia's trade) and given that Tunisia's major international trade and financial transactions are carried in euro, we consider the Euro/Dinar nominal average daily exchange rate (T) as published in the financial statistics of the central bank of Tunisia.

The consumer price index (CPI) measures changes through time in the price level of consumer goods and services purchased by households. It is a statistical estimate constructed using the prices of a sample of representative items whose prices are collected periodically. The monthly growth rate of the CPI is used to compute the inflation rate.

The Industrial Production Index (IPI) is an economic indicator that measures real production output. Following the literature, industrial production index (IPI) is taken as a proxy of economic activity (Senhadji, Saadi and Kpodar, 2007; Hassan, 2005).

TMM is the monthly money market average interest rate. This reference rate was kept for long time in fixed level to keep of the attractiveness of the Tunisian economy. Since the financial liberalization program was launched in the mid 80's, and then in the 90's this rate was relatively liberalized. TMM now serves as the reference rate for the Tunisian economy by which banks, financial institutions and companies officially acquire liquidities on the Tunisian monetary market. Studies on inflation determinants that include monetary market rate as determinants of inflation are abundant and mostly confined to a country setting cases such as Blix (1999) for Swedish inflation, Bleaney and Fielding (1999) for developing countries. We

introduced it to take account of the effects of Tunisia's monetary policy on both inflation and exchange rate (Dropsy and Grand, 2008; Khan, 2003, Deme and Fayissa, 1995). The monthly TMM series are provided by the Central Bank of Tunisia.

Since the imported inflation is necessary to describe the pass-through, we take account for the relationship between exchange rate and inflation. Two channels could be evidenced through the link with imports and exports. The role of exports (X) in explaining inflation was previously evidenced by Hassan (2005), arguing that since the mid-1980's, Tunisia's exports have been successfully diversified moving from oil-dominated and volatile to more stable and diversified economy with lower inflation. Moreover, exchange rate depreciation lower export prices and increases import prices leading to an increase in domestic demand and therefore in domestic prices. It is worthy noting that in less developed countries (and in Tunisia in particular) where import goods are different from those for the home market, this impact depends on the relative substitutability between home and export goods. Following Deme and Fayissa (1995), we then consider the imports unit values (M) in our variables set. Data regarding exports and imports are extracted from the International Financial Statistics-IMF and the annual reports of the Central Bank of Tunisia.

5. RESULTS AND DISCUSSION

A natural starting point for any time series analysis before estimating our model is to test for the stationarity of the time series data to be used. This is particularly essential as the stationarity of macroeconomic series are limited in general (Pedroni, 1996; Froot and Rogoff, 1994; Chinn and Johnston, 1996), particularly in the developing countries. For this purpose we used the (Kwiatkowski-Phillips-Schmidt-Shin (1992)-KPSS stationarity test. Having a null hypothesis of stationarity, this test may be conducted under the null of either trend stationarity (TAU Test) or level stationarity (Nau test). Applying this test requires the choice of the number of lags to take into account in the long-term variance for the residuals autocorrelation. We have shown here for three lag values: 0, 4 and 8. All the tests and the subsequent estimations were carried out using GAUSS software, version 3.2.32.

The summary results of the KPSS test, reported in tables 2-a and 2-b., show that all variables are not stationary except for inflation. In fact, the first column of table 2-a shows that the KPSS statistic for the inflation variable with a minimum residual lag of 0 and a maximum of lag 8, is respectively equal to 0.359 and 0.239, for level stationarity (NAU Test) , which is lower than the 5% critical value (0.463). Concerning the trend stationarity, this statistic is respectively equal to 0.046 and 0.035, which is similarly lower than the 5% critical value (0.146). Therefore, we can accept the null hypothesis of both level and trend stationarity for inflation. In contrast, we can observe from the table 2-a, that the all the remaining variables are not trend, nor level stationary. Indeed, the values of the KPSS statistic far exceed the empirical values. For example, the KPSS test statistic for the TMM, corresponding to a residual lag of 8 and trend stationarity (TAU test) is equal to 0.151, which exceeds the 5% critical value (0.146), suggesting the rejection of the null of stationarity. This analysis is then generalized to the rest of the macroeconomic variables.
Non-stationary variables have then to be differentiated. Table 2-b shows that The KPSS statistics do not reject the stationarity hypothesis for the first differences of the series at 5% significance level. For example, the KPSS statistic for the IPI variable, corresponding to a lag of 4 and level stationarity (NAU test) is equal to 0.055, which is lower than the critical value (0.146), suggesting that we can accept the null of stationarity for the differentiated series. To conclude, the KPSS test fails to reject the stationary null for inflation. This result provides

strong evidence in favor of a level and trend stationary specification for the inflation data. In contrast, the KPSS test supports a strong evidence of a difference stationary for the rest of the macroeconomic fundamentals.

Table 2-a. Outcomes of the KPSS Stationarity Test (before Differentiation)

	inflation		T		TMM		IPI		X		M	
Lag	NU Test	TAU Test	NU Test	TAU Test	NU Test	TAU Test	NU Test	TAU Test	NU Test	TAU Test	NU Test	TAU Test
0	0.359	0.046	10.369	0.912	6.008	1.108	7.012	0.36	8.998	0.572	8.775	0.675
4	0.23	0.031	2.182	0.255	1.314	0.243	1.821	0.164	1.965	0.166	1.988	0.225
8	0.239	0.035	1.27	1.179	0.803	0.151	1.095	0.13	1.141	0.116	1.155	0.154
Critical value	0.463	0.146	0.463	0.146	0.463	0.146	0.463	0.146	0.463	0.146	0.463	0.146

Table 2-b. Outcomes of the KPSS Stationarity Test (after Differentiation)

	inflation		ΔT		ΔTMM		ΔIPI		ΔX		ΔM	
Lag	NU Test	TAU Test	NU Test	TAU Test	NU Test	TAU Test	NU Test	TAU Test	NU Test	TAU Test	NU Test	TAU Test
0	0.359	0.046	0.155	0.022	0.183	0.159	0.007	0.007	0.013	0.011	0.02	0.009
4	0.23	0.031	0.205	0.030	0.126	0.110	0.024	0.024	0.039	0.034	0.073	0.034
8	0.239	0.035	0.287	0.045	0.120	0.106	0.055	0.055	0.062	0.054	0.085	0.040
Critical value	0.463	0.146	0.463	0.146	0.463	0.146	0.463	0.146	0.463	0.146	0.463	0.146

Consequent upon the results of stationarity, we proceed by estimating our model.
For this purpose, we proceed in two steps: in a first step, we use the FTP approach, using the Kittagawa-Hamilton Filter, in order to investigate the relationship between the exchange rate Pass-through and the inflation rate, during the different inflation states. In a second step, we use the TVTP approach in order to assess the role played by a set of macroeconomic variables to explain the transition from one inflation regime to the other.

FTP

As presented in the Methodology section, we conduct an estimation procedure based on the equations 2, 3 and 4. In fact, the endogenous variable y_t corresponds in this case to the inflation rate Π_t. The information set (I_{t-1}) corresponds to the lagged value of the inflation rate Π_{t-1}. We use the exchange rate pass-through ΔT as the vectorized matrix of parameters Θ. s_t is a two states Markov variable.
In fact, a major contribution of our approach consists on introducing the Exchange rate Pass-through as an explicative factor of the different inflation states. As mentioned in the section 3, the expression “exchange rate pass-through” is used to refer to the effects of exchange rate changes on prices. The exchange rate pass through in this paper is derived using the variation of the nominal average exchange rate Euro/Dinar. Our objective is to assess the effect of this exchange rate pass-through on the level of inflation in Tunisia.

Hence, we can then estimate a Markov-switching autoregressive model with exogenous variable as an MS-ARX model (Hamilton, 1990), specified in the following equations:

First, inflation is assumed to follow the following process (Hamilton, 1990):

$$\Pi_t = \beta_0(s_t) + \beta_1(s_t)\Pi_{t-1} + \beta_2(s_t)\,\Delta T + u_t \quad , \qquad (9)$$

Where Π the inflation rate and ΔT is the Exchange Rate Pass-Through.

This model allows β_0 and all the coefficients β_i, (i=1,2) to vary between two states, s=1,2. The error term u_t, featured by $u_t \sim NID(0, \sigma^2[s_t])$ is i.i.d sequence of normally distributed variable with zero mean and a variance $\sigma^2[s_t] = \begin{vmatrix} \sigma_1^2, \text{if } s_t = 1 \\ \sigma_2^2, \text{if } s_t = 2 \end{vmatrix}$.

Table 3-a reports the results from an FTP model (equation 9), which serves as a benchmark model for our study. In contrast to the previous literature using a Markov-switching model to estimate inflation (Berg and Lundkvist, 1997; Blix, 1999; and Dropsy and Grand, 2008), we use monthly data over a longer sample period. This table presents significant evidence to support the assumption that two distinct phases characterize inflation in Tunisia. This argument find support in the inflationary dynamic that occurred in Tunisia with the impact of the first oil shock that caused a peak in inflation in 1974 before it came back down quickly until the second oil shock which caused a second transitory peak in inflation. Since the mid-1980s, and following the Structural Adjustment Program, Tunisia successfully managed to gradually reduce its inflation rates to less than 4 percent in 2004.

Our results show also that the point estimate of the state dependant means, β_0 are statistically different and significant. Moreover, there is an economic and significant difference between their magnitudes. Thus, the first state is characterized by a low inflation, with an monthly inflation rate intercept of 0.174 percent and a high inflation regime with a monthly inflation rate intercept of 0.275 percent, with T-statistics respectively equal to 3.642 and 4.288, which far exceeds the 5% critical value (1.96). Furthermore, we test for price stability allowing thus the variance of the inflation to be state-dependant since major changes in monetary policy could cause shifts in the mean and/or the variance of inflation. Hence, an important finding of this study is that it gives evidence to support the existence of two regimes for volatility: low inflation volatility with an average inflation's variance of 0.033, associated with the low inflation regime, and high inflation volatility with an average inflation variance of 0.111, associated with the high inflation regime. This result is consistent with the documented evidence in Loungani and Swagel (2001) and in Dropsy and Grand (2008). This provides further support to the argument asserting the existence of two regimes for inflation levels (low and high inflation rates) but also between two regimes of inflationary trends (accelerating and decelerating inflation).

In fact, the pass-through coefficient β_2 is respectively highly significant and equal to (-0.132) in the first regime; insignificant and equal to (-0.005) in the second regime. From an economic point of view, this can be interpreted by the fact that an appreciation of the dinar relative to the euro leads to a decrease in domestic prices. Furthermore, a low pass-through level leads to a low inflation level and a high pass-through level leads to a high inflation level. Taylor (2000) was the first to demonstrate this link who documented that the more the

environment is traditionally marked by inflation, the more the price changes are influenced by exchange rate variations. Studies supporting this evidence is also provided by Campa and Goldberg (2005) and Gagnon and Ihrig (2004) for developed economies, and by Choudhri and Hakura (2006) and Ca'Zorzi, Hahn and Sanchez (2006) for emerging markets

Although β_2 in regime 1 is significant while that in regime 2 is not, but what we mean by high and low pass-through is its level or value (Taylor, 2000 and Gagnon and Ihrig, 2004). Note that β_2 in regime 1 is equal to -0.132 which is lower than its level in regime 2 (-0.005), Hence, it is related to low inflation (an intercept of 0.174 percent). Although the Pass-through level in regime 2 is not significant, the regime still corresponds to a high significant inflation level and a high volatility.

Table 3. Results of FTP-Markov-Switching Approach

	β_0	β_1	β_2	σ^2
Regime 1				
coefficient	0.174	0.457	-0.132	0.033
Std. Error	0.048	0.147	0.037	0.012
t-Statistic	3.642	3.115	-3.623	2.791
Regime 2				
coefficient	0.275	0.214	-0.005	0.111
Std. Error	0.064	0.125	0.039	0.020
t-Statistic	4.288	1.704	-0.136	5.603
Jarque Bera	8.490 (0.014)			
Ljung-Box(11)	24.48 (0.000)			
ARCH (2)	1.209 (0.546)			
log-likelihood	*-19.548*			

Note: Figure in the parenthesis indicates *P-values.*

Table 3-b. The Transition Matrix

	Regime 1	Regime 2
Regime 1	0.942	0.034
Regime 2	0.058	0.966

In addition, table 3-b shows that the probability of staying in a low and stable inflation regime at time (t), given that the economy was in the same state at time $(t-1)$, is p=0.942. The probability of being in a high and volatile inflation regime in time (t), given that the economy was in the same regime at time $(t-1)$ is large, q=0.966 greater than p. These high probabilities indicate that if the economy is in either low or high inflation, it is likely to remain in such regime.

The figure 1 plots the probability of being in a low inflation regime at each date in the sample;

i.e, it depicts the evolution of the smoothed probabilities of state 1. The inference is based on the full sample and the estimated maximum likelihood parameters (table 3-a). The switching between regimes is sudden, deep and sporadic.

Although the peaks in figure 1 are much lower than one, this is not problematic, since there are a lot of smoothed probabilities that are equal to zero, so we find in figure 2 corresponding to a high and volatile inflation (regime 2), that there is a high number of peaks equal to one.

The economy stays in a low inflation regime most of the time. This confirms the shorter duration of high inflation episodes in Tunisia. One of the explanations for that increased resistance to inflation is the stronger commitment to sound monetary and fiscal policies that helped Tunisia to bring some discipline in macroeconomic policies and to the smaller exposure to exogenous shocks.

An important finding of this study is the existence of four major changes from a high inflation to a low inflation in the sample as showing in figure 1. The first occurred between 2001 and 2002, the period marked by recent external economic shocks that followed September 11 and the second, between 2004 and 2005. In fact, in 2004, a new Tunisian fiscal law provides for further capital account liberalization and exchange rate policy flexibility. After that, the economy experienced two low inflation phases: between 2007 and 2008 and during the end of 2009. This period corresponds to the international financial crisis. Indeed, according to the latest African Development Bank (2009), "The only good news (of this crisis) is the easing of inflationary pressures."

In fact, the figure 3 plots the variation of the nominal average exchange rate Euro/Dinar. An important result consists in the consistency of the data on the evolution of the variation of the Exchange Rate Euro/Dinar as well as the regime data. In fact, the variations of this exchange rate are also deep and sporadic.
Moreover, we observe that any variation of the Exchange rate leads to a rapid reaction of inflation in Tunisia. For example, there is a first peak of the variation of the exchange rate in Tunisia in 2004, which simultaneously leads to an increase in the probability of staying in a high and volatile inflation regime as shows the figure 2. In addition, at the beginning of 2009, the variation of the exchange rate highly increases and reaches a second peak, which is consistent with a high inflation rate (the probability of staying in a high inflation rate is close to 1 in figure 2), which can be explained by the international financial crisis as mentionned above.

TVTP

Consequent upon the results of the inflation regime identification, our actual research focuses on identifying the macroeconomic and policy-related variables to highlight the mechanisms underlying the dynamics of inflation in Tunisia over the period of study. For this purpose, we consider a set of four explanatory variables to explain shifts in inflation regimes. Studies on inflation dynamic use several set of economic fundamentals such as money supply, gross domestic product, effective exchange rate (Deme and Fayissa,1995), past inflation, money growth, oil prices and exchange rates (Loungani and Swagel, 2001), the monetary market interest rate, nominal effective exchange rate, consumer price index and industrial production index, external shocks such as Oil and food price shocks, French inflation, the nominal exchange rate flexibility index, the government budget balance to Growth Domestic Product ratio and the growth of money supply M2 (Dropsy and Grand, 2008).

In our study, we use the interest rate (TMM), the industrial production index (IPI), the exports unit values (X) and the imports unit values (M) as economic fundamentals.[7] The regression results of the TVTP-Markov-switching approach based on different variables, providing the empirical effects of theses variables on inflation dynamics, are reported in Table 4.
The following statistical specification of the transition probabilities have been presented in the previous subsection.

$$\Pr(s_t = 1 \setminus s_{t-1} = 1) = \frac{\exp(\lambda_{10} + \lambda_{11} TMM_{t-1} + \lambda_{12} \mathrm{IPI}_{t-1} + \lambda_{13} \mathrm{X}_{t-1} + \lambda_{14} M_{t-1})}{1 + \exp(\lambda_{10} + \lambda_{11} TMM_{t-1} + \lambda_{12} \mathrm{IPI}_{t-1} + \lambda_{13} \mathrm{X}_{t-1} + \lambda_{14} M_{t-1})} \qquad (10)$$

$$\Pr(s_t = 2 \setminus s_{t-1} = 2) = \frac{\exp(\lambda_{20} + \lambda_{21} TMM_{t-1} + \lambda_{22} \mathrm{IPI}_{t-1} + \lambda_{23} \mathrm{X}_{t-1} + \lambda_{24} M_{t-1})}{1 + \exp(\lambda_{20} + \lambda_{21} TMM_{t-1} + \lambda_{22} \mathrm{IPI}_{t-1} + \lambda_{23} \mathrm{X}_{t-1} + \lambda_{24} M_{t-1})}. \qquad (11)$$

Table 4. Outcomes of TVTP-Markov-Switching Model

	Regime 1				Regime 2		
	coefficient	std.error	T-Student		coefficient	Std.error	T-Student
β_0	0.156	0.0249	6.274	β_0	0.226	0.044	5.087
β_1	-0.446	0.0753	-5.921	β_1	0.344	0.096	3.570
β_2	-0.092	0.016	-5.879	β_2	-0.0373	0.0314	-1.190
σ^2	0.004	0.002	2.158	σ^2	0.091	0.013	6.916
λ_{10}	-6.586	313.036	-0.021	λ_{20}	7.450	2.949	2.525
λ_{11}	0.679	0.116	5.853	λ_{21}	0.251	0.399	0.628
λ_{12}	10.583	177.122	0.059	λ_{22}	-0.706	0.359	-1.965
λ_{13}	1.607	0.763	2.106	λ_{23}	0.035	0.076	0.457
λ_{14}	3.917	155.157	0.025	λ_{24}	0.313	0.135	2.314

It is important to note at this stage that some variables that we hope to be significant are unfortunately non significant. We report these results, but the interpretation is more relevant for the significant coefficients at conventional level.

First, we can observe from this table that the data for all specifications can be split into two main regimes: a low inflation state with a low volatility and a low Pass-through level, and a high inflation state with a high Pass-through level and a high volatility. For example, Table 4 shows that the monthly inflation rate estimated with a TVTP based inference switches between two different regimes: β_0=0.156 percent for the first regime and 0.226% for the second regime. The corresponding T-student statistics are respectively 6.274 and 5.087 which far exceed the 5% critical value (1.96). Moreover, the pass-through level coefficient (β_2) is low, negative and highly significant for the first regime (β_2= -0.092), high but non significant for the second regime. Result can be generalized for the other specifications. They are mostly highly significant and close to these FTP benchmark estimates. This provides further support to the robustness of the methodology used in this paper.
In addition, TVTP can provide valuable additional information about whether a particular phase has occurred and whether a turning point is imminent by incorporating economic inflation time series that can help identify the phase that the economy is in and that can forecast when the economy may switch phases.

Second, recall, for example, that from the equations (10) and (11), and as we developed in the section corresponding to the Markov-switching approach (TVTP), the coefficient λ_{11} measures the impact of the economic variable in explaining the probability of remaining in the first, low inflation regime $\Pr(s_t = 1 \setminus s_{t-1} = 1)$. Similarly, the coefficient λ_{21} represents the economic impact of the macroeconomic fundamentals on the probability of staying in the second, high inflation regime $\Pr(s_t = 2 \setminus s_{t-1} = 2)$. The sign of this λ coefficient is important since it allows us to comment the effect of the variables on staying in the first or second regime (positive sign), or to overbalance to the other regime (negative sign). For the sake of conciseness, only the most significant variables λ are interpreted.

Our results show that the price level decreases in response to an increase in interest rates TMM. In fact, we can observe from the table 4, that the respective coefficient indexed by the state 1, λ_{11} is positive and equal to 0.679. This coefficient is significant, since the corresponding T-statistic (5.853) far exceeds the 5 percent critical value (1.96). This means, as explained below, that the higher the TMM, the higher the probability to stay in a low inflation regime and the lower the inflation and the Pass-through level. Thus, we can conclude that the TMM variable is a significant factor in increasing the probability to stay in a disinflationary regime (regime 1) and, as indicated above, a low significant pass-through level (β_2= -0.092). This emphasises the idea that interest rate is one of the main instruments used by the central bank of Tunisia to control for inflation. Any increase in interest rates causes a decline in the credit demand, and therefore a reduction in the domestic demand leading to downward movements in the domestic prices. It's worth noting that in Tunisia, all lending rates are indexed on the TMM and this reference rate was kept for long time in fixed level to boost investment and to promote a policy of economic growth by exports.

As regards IPI variable, we find that it has a negative and significant effect in increasing the probability to stay in an inflationary regime (regime 2) .In fact, their respective λ_{22} coefficient indexed by the state 2 is negative and equal to -0.706. Furthermore, it is significant at the 5% level (T-statistic=-1.965).). In this case, the sign of λ_{22} is negative, this means that the IPI unit value have a negative impact on the probability of staying in the second regime and then a positive impact to switch to the first regime.

This allows us to conclude that when the IPI increases, the inflation decreases. This allows us to conclude that when the IPI increases, the inflation decreases. Generally, IPI is a harbinger for upcoming inflation when it begins to fall. Meanwhile, increases in the IPI can show a growing efficiency of production, hence a burgeoning economy leading to lower inflation expectations. As a result, one should be worry about the potential inflationary impact of inflation expectations in the Tunisian context. This result provides further support to the documented evidence in Omay, Karadagli and Aluftekin (2010) stating that Turkish inflation is affected by the Industrial Production Index via the nominal uncertainty channel. In this regard, a declining industrial production index leads to slowdown in economic growth and then to high levels of inflation.

As regards estimation outcomes of the TVTP model based on exports unit values, we find a positive sign for the coefficient λ_{13} (=1.607). This coefficient is statistically significant at conventional levels (T-statistic = (2.106)). In this case, the sign of λ_{13} is positive, this means that the exports unit value have a positive impact on the probability of staying in the first disinflationary regime.

This suggests that exports increase the probability to stay in a low inflation regime and a low pass-through level. This finding supports the argument that exchange rate depreciation boost exports and therefore economic growth. Meanwhile, a depreciation of the dinar against the euro makes imported inputs more expensive relative to the dinar leading to a decrease in imports. Concerning the imports, we find a positive sign for the λ_{24} coefficient in Table 4 (λ_{24} = 0.313 significant at the 5% level). This suggests that the imports increase the probability to stay in a high inflation regime and a high pass-through level.

As explained by Filardo (1994) and Diebold et al. (1999), the Markov-switching model with time-varying transition probability (TVTP) has the advantage over the fixed transition probabilities (FTP) in terms of flexibility. In this context, and as we can observe from the empirical results, economic fundamentals and policy shocks can influence the regime transition probabilities.

To conclude, our empirical result finds evidence to support that the transition probabilities present, in almost all cases, the sign suggested by economic intuition. Indeed, the probability of remaining in a low and stable inflation regime increases with arise in the monetary market interest rate (TMM), the industrial production index (IPI) and the exports unit value (X) and decreases with the imports unit value (M). Indeed, for most specifications, the low inflation regime is associated by a low pass-through level, either for FTP or TVTP approach. Our results suggest that generally and for significant values of inflation rate and pass-through, these variables move in the same direction: First, the lower this inflation, the lower the Pass-through level and the price volatility. Second, while this result is in contradiction with Dropsy and Grand (2008), it is in line with most empirical studies such as Choudhri and Hakura (2001), Taylor (2000) who concluded that this low degree of pass-through observed in developing countries is associated with a decreasing inflation trend from the 1990s, and Gagnon and Ihrig (2004) who found that countries with low and stable inflation experience low degrees of pass-through and a decrease in the level and variability of inflation.

Finally, we found that the TVTP model gives more information than the FTP model because the probabilities have changed significantly during the period under analysis and the explanatory variables are very informative in dating the evolution of the state of the economy.

6. CONCLUDING COMMENTS

This paper examined theoretically and empirically the impact of exchange rate changes on inflation and described the nature, degree and direction of the relationship between the nominal exchange rate and inflation for the Tunisian economy, mainly, the dynamic governing the transmission mechanism of exchange rate changes on consumer prices. Using Fixed Transition Probability and Time varying transmission probability-Markov-switching approaches, we investigated the existence of a relationship between pass-through and inflation. Our results reveal a robust significant relationship between local inflation and the pass-through level. The empirical findings of this study suggest also that for the Tunisian economy, variables such as the industrial production index, the imports and exports unit values seem to be particularly important for the transmission mechanism of upward or downward movements in the exchange to inflation.

Drawing on our empirical research, Tunisia is ought to control for exchange rate movements to conduct a credible exchange rate policy, especially with the transition of Tunisia to a more flexible exchange rate regime since greater flexibility inward and outward capital flows could lead to much more sensitivity of prices to upward or downward movements of exchange rate. This also heavily relies on the credibility of the Central Bank of Tunisia (CBT) in designing a stable monetary policy. Central Bank credibility is a key issue for monetary policy because it helps in keeping inflation at low levels. To build credibility, it is necessary that the central bank achieves a reputation in order to make agents believe in their announced policy (De Mendonça, 2007). Building reputation by clearly communicating a record of actions and the rationale for its policy, a central bank can achieve more credibility for monetary policy influencing expectations and maintaining optimal inflation levels (Mishkin, 2008). In this regard, CBT should enjoy a real mandate in pursing the inflation objective, a sufficient discretion and accountability in determining the adequate instruments.

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Figures

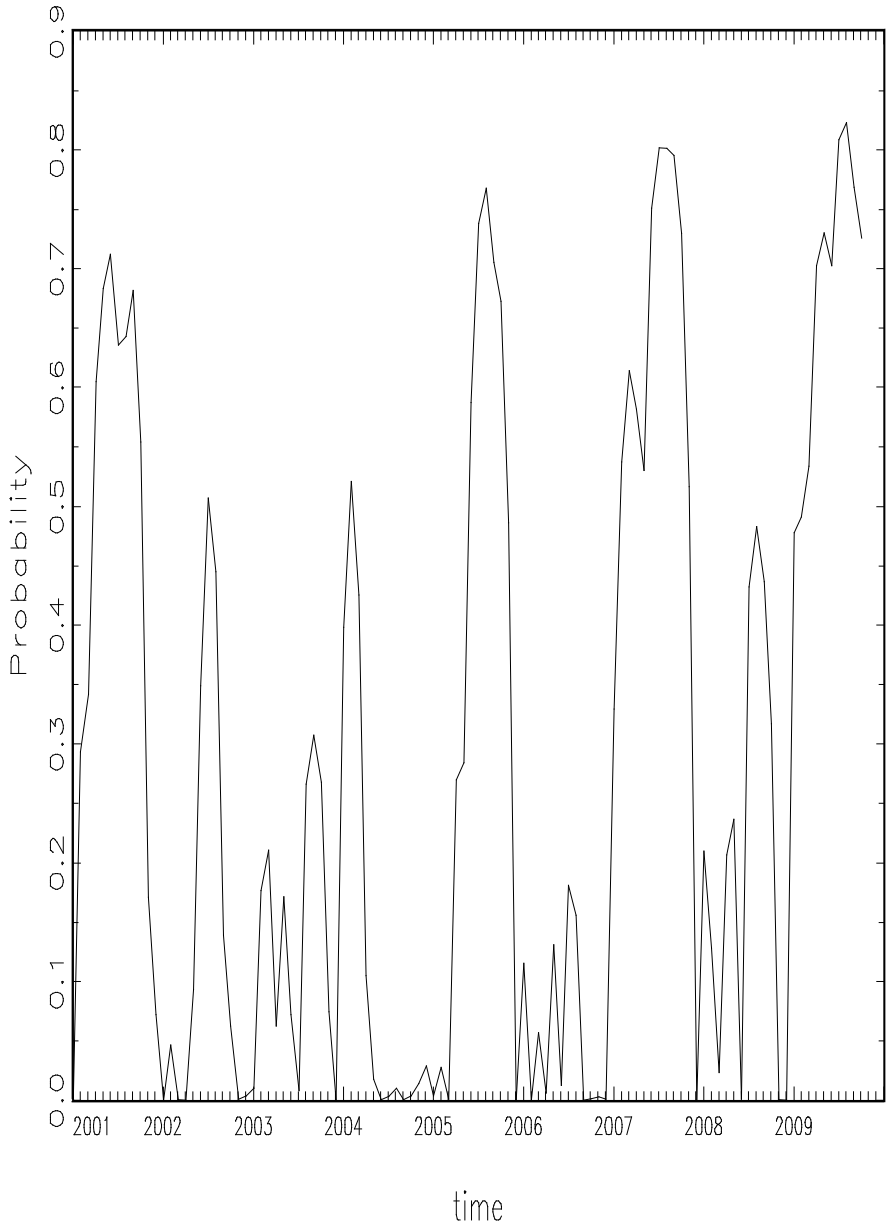

Figure 1. Smoothed probability in regime 1 (low and stable inflation)

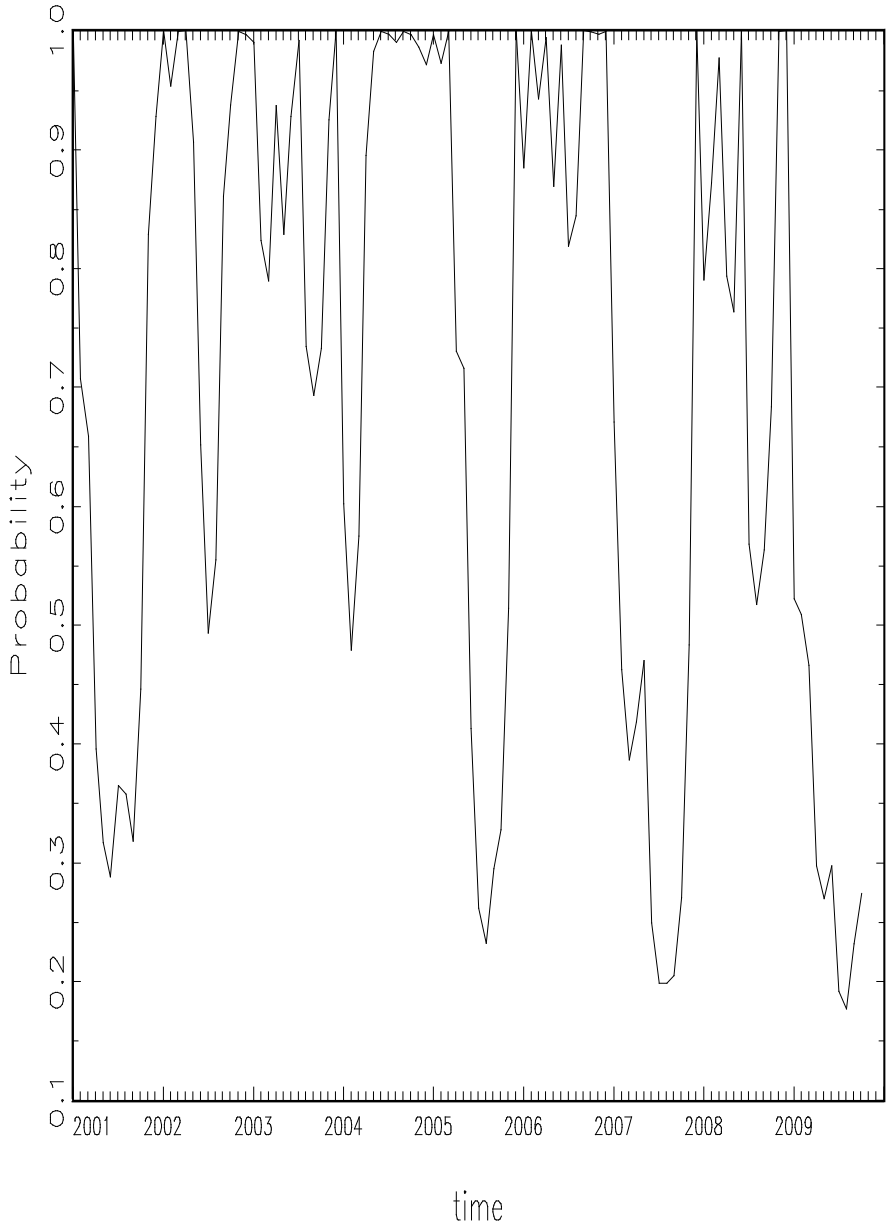

Figure 2. Smoothed probability in regime 2 (high and volatile inflation)

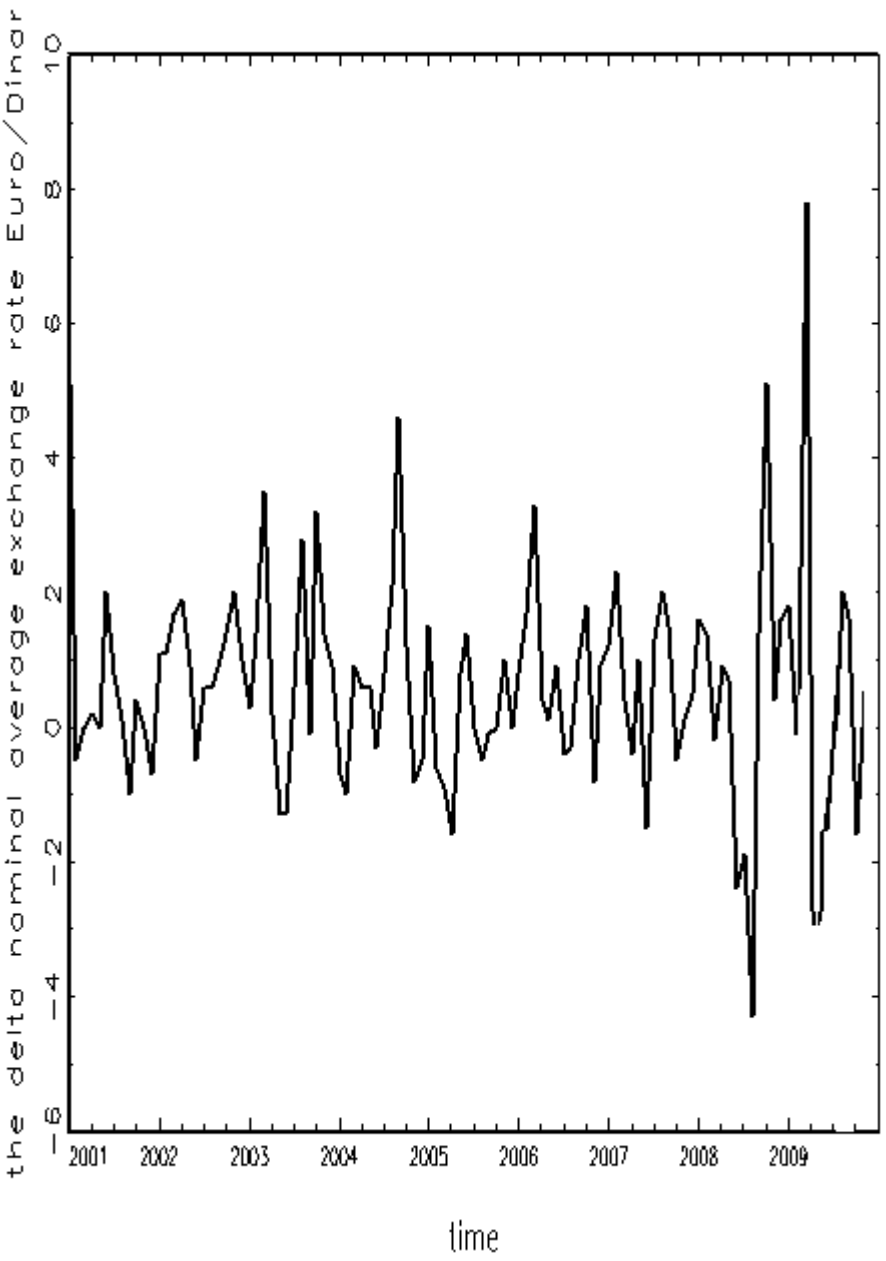

Figure 3. The variation of the nominal average exchange rate Euro/Dinar