Journal of Quantitative Economics, Vol. 11 Nos.1&2 (Combined), January-July 2013

THE TAYLOR CURVE AND THE OUTPUT GROWTH-INFLATION TRADE-OFF: EVIDENCE FROM DCC-GARCH MODELS

SAMIRA HADDOU[1]

Abstract

This paper uses the dynamic conditional correlation model developed by Engle (2002) to investigate the synchronous/asynchronous movements of growth rates and inflation as well as their uncertainties in Tunisia. This methodology has the advantage of taking into account the non-constancy of the volatility of macroeconomic aggregates caused by the multiplicity of the exogenous shocks, especially for small open economies. It has been shown, using a bivariate GARCH model over the period 1990:Q1–2009:Q4, that the dynamic correlation exhibits relatively strong negative link, while there is a bidirectional causality in level running from economic growth to inflation in variance. The paper finds also evidence in support of the Taylor (1979) hypothesis that there is a long-run tradeoff between the inflation and the growth.

Keywords: Dynamic Conditional Variance; Tradeoff, Uncertainty, Taylor curve.

JEL classification: E3, E5, C22, C51, C52.

1. Introduction

There is a wide consensus among economists and policymakers that inflation harms economic growth and stability and should therefore be kept under control. They agree also that when attempting to bring down inflation, they face a tradeoff at the expense of other goals – at least in the short run- ; such tradeoff is more or less costly according to the levels and sources of inflation pressures. However, when the economy is hit by shocks, the tradeoff between the levels of inflation and the output leads *ipso facto* to a long-run tradeoff between the corresponding variabilities. The so-called Taylor curve (1979, 1993 & 1994) that defines such linkage between the inflation and output growth variability has become for most modern central banks a rule of thumb in the conduct of the monetary policy.

The importance of uncertainty in the conduct of the monetary policy has been underlined by many economists and central bankers (See among others, Greenspan, 1999; Goodhart, 2003; Poole, 1998; Svensson and Williams, 2008). Indeed, central bankers when designing their policies face many uncertainties. These uncertainties concern the model which they use to understand how the real economy functions. They concern also their lack of knowledge about the monetary transmission mechanisms. Also, central bankers have neither a a precise idea about the dominant channel that propagates the stance of the monetary policy to the real sphere nor a

[1] Department of Quantitative Methods and Information Technologies, High Institute of Management, Sousse University, Tunisia, Email: samhaddou@gmail.com

rough idea about the transmission lags. As said by Pool (1998): “The problems arise from what we do not know; we must deal with the uncertainty from the base of what we do know…”. Put differently, and in the Taylor (1993) monetary rules context, central banks must adjust their policy rate “to sail as safely as they can in the deep-sea of uncertainty”. This implies that the weight assigned to inflation should be smaller than when inflation is more uncertain. Likewise, the weight assigned to the output gap should be smaller than when the output gap is less certain (see among others, Peersman and Smets, 1999; Smets, 1999; Soderstrom, 2000; Rudebusch, 2001; Srour, 2003; Walsh, 2003 and Swanson, 2004).

Since the seminal contribution of Taylor (1993), most empirical studies focusing on the issue of Taylor curve have used unconditional variances proxied by either their moving standard deviations or their root mean squared errors. These criteria have been considered as measures of the predictable variability and not uncertainty. With the development of ARCH models (Engle, 1983), the concept of variance has been intended to include the unpredictable variability, called also the uncertainty (Grier and Perry, 1998).

Various empirical methodologies have been used to examine the inflation-growth uncertainty linkage. This paper aims at examining empirically the general relevance of the Taylor hypothesis by focusing on the dynamic variance–covariance structure for the Tunisian economy. It makes use of the DCC-GARCH approach to generate the conditional variance of the inflation and output growth as proxies for inflation and output growth uncertainties. Furthermore, in order to enhance the usefulness of such estimates and to avoid assigning them more policy implications than they deserve, we shall run Cheung et Ng (1996) test which permits to find out the potential causal relationships between the inflation and the output growth, on the one hand, and the inflation uncertainty (hereafter, nominal uncertainty) and the output growth uncertainty (hereafter, real uncertainty), on the other hand. Indeed, information about nominal and real uncertainties will not be fully useable by policymakers unless causality direction between them is found out. More specifically, unveiling delayed actions or short- and long-run causalities between inflation and output growth permits to the central bank to take preemptive measures to smooth the effects of the business cycle swings on the real economy as much as possible.

The paper is organized as follows. Section 2 contains a review of previous studies on the predicted effects of the relationships between nominal and real uncertainties. Then, section 3 presents the empirical methodology. After that, section 4 presents data sources and reports and discusses the estimation results as well as diagnostic tests for model adequacy. Finally, section 5 summarizes the main findings and draws some policy implications.

2. The Relationship between Output and Inflation Uncertainties

Debates about inflation and its effects on economic growth have raised questions not only about the interactions between these variables but also between their uncertainties (see Taylor, 1993 & 1994). Nonetheless, no consensus regarding the sign of such relationship seems to figure at the horizon; and the empirical studies are still diverging and do not provide a clear-cut conclusion regarding the sign of the relationship between the inflation and the output growth uncertainties. Views are divergent among those who support a positive relationship (Okun, 1971; Logue Sweeney, 1981; Devereux, 1989, Cukierman and Gerlach, 2003) and those who advocate a negative relationship (Taylor, 1979, 1993, 1994; Fisher, 1993, Fuhrer, 1997; Ungar and Zilberfard, 1993; Conrady and Karanasos, 2010).

Okun (1971) argues for a positive relationship seeing that if changes in inflation are brought about by changes in the private demand, countries that tolerate large fluctuations in the inflation rate also tend to be more inclined to tolerate large fluctuations in the activity. Logue and Sweeney (1981) argued that a high inflation uncertainty induces a high relative price variability, which in turn generates a greater variability in the investment and output growth. Furthermore, if inflation increases with output uncertainty as put forward by Devereux (1989) and Cukierman and Gerlash (2003), then the output uncertainty and the inflation uncertainty shall be positively correlated due to the Firedman-Ball hypothesis.

Besides, Briault (1995) points out that an increase in the output growth leads to more inflation at least over the short-run (the so-called short-run Phillips curve effects), which generates a more inflation uncertainty (the Friedman hypothesis). According to Taylor (1993), there is a tradeoff between the inflation uncertainty and the output uncertainty, the above means that output uncertainty will fall. Taylor (1993) stipulates that two conditions should be fulfilled for such a long-run tradeoff to exist. First, there should be shocks that deviate observed inflation from its expected trajectory. Second, these shocks set in motion persistent inflation dynamics. It is this latter inflation persistence characteristic that brings about a situation where the inflation rate variability can be brought down only at the cost of greater variability in the output growth.

Taylor’s theory has important consequences on the conduct of the monetary policy. Central banks cannot focus on their main goals, namely mastering inflation unless they magnify the gap between the real output and its potential level. Therefore, subsequent to an inflationary shock, a conservative central bank that is more leery to inflation variability reacts tightly and aggressively by increasing its policy rate to bring down inflation as quickly as possible. In doing so, it generates less inflation uncertainty while harming the economic growth and increasing its uncertainty. In contrast, a flexible central bank will attempt to contain inflation gradually while seeking to smooth the output uncertainty as much as possible; in such case, inflation will be more volatile. In the same vein, Fuhrer (1997) stresses that the tradeoff between the uncertainties becomes crucial in the particular case when the economy reaches a low inflation level situation, which helps assessing how the monetary policy responds to the exogenous shocks that might disturb the equilibrium. If inflation uncertainty declines with increasing inflation rates as pointed out by Ungar and Zilberfarb (1993) and Conrady and Karanasos (2010), then the inflation uncertainty and the output uncertainty might be negatively correlated.

The empirical studies relative to this issue can be classified into three strands of literature. The first strand makes use of the simultaneous estimation approach of GARCH models (Baillie et al. 1996). The second strand has recourse to univariate GARCH models that allow for simultaneous feedback between the conditional means and variances of inflation and growth (see for instance, Grier and Perry, 1998; Conrad and Karanasos, 2005; Fountas and Karanasos, 2006; Fountas and Karanasos, 2007). Finally, the third strand employs bivariate GARCH formulations (Karanasos and Kim, 2005 and Fountas et al., 2006). It is worth noting that studies belonging to the last strand of the empirical literature use either a Constant Conditional Correlation[3] (CCC) or

[3] See Bollerslev (1990)

a BEKK-GARCH specification. The main drawback of these specifications is that they do impose either no feedback or a positive one. Following Lee (2006), the Dynamic Conditional Correlation (DCC) specification by Engle (2002) is adopted in this paper seeing that it permits to overcome the previously mentioned caveats. Specifically, the DCC is a generalization of the CCC specification since it allows the series to be positively or negatively correlated or uncorrelated. It is worth noting also that these methodologies have been mostly applied to developed economies. This paper attempts to extend their scope of application to emerging economies such as Tunisia.

3. Empirical Methodology

This section starts with presenting the empirical model specification to be estimated, and then it runs dynamic causality tests by making use of the Cross Correlation Function **(CCF)** test.

3.1. The DCC-GARCH model

The basic idea behind using the bivariate GARCH model in this paper is to generate proxies for the inflation and the output growth uncertainties by conditional variances, and to find out the causal relationship between the nominal and the real uncertainties. To illustrate the estimation procedure, let π_t and y_t denote the inflation rate and real output growth, respectively, and define the residual vector as $\varepsilon_t = (\varepsilon_{\pi t}, \varepsilon_{yt})'$. ε_t is assumed to be conditionally a normal stochastic process with a 0 mean vector and a 2×2 time-varying conditional variance-covariance matrix, H_t, measured at the time *t* , where $Vech(H_t) = (h_{\pi_t}, h_{\pi_t y_t}, h_{y_t})'$

The reduced form of the autoregressive process for the two variables is written as:

$$X_t/\mathcal{F}_{t-1} = \varepsilon_t \quad \text{... (1)}$$

where X_t is a 2× 1 column vector such that $X_t = (\pi_t, y_t)'$. $\mathcal{F}_{t-1}$ is the information set available at time t-1. The DCC-GARCH model can be easily apprehended by rewriting the variance-covariance matrix (H) as:

$$H_t = D_t R_t D_t \quad \text{... (2)}$$

2here

$$D_t = \text{diag}\left\{\sqrt{h_{it}}\right\} \quad \text{...(3)}$$

is a (2 ×2) diagonal matrix of standard deviations from the temporally varying estimates of the two previous equations using an univariate GARCH process and $R_t = (Q_t^*)^{-1} Q_t (Q_t^*)^{-1}$ is the time varying correlation matrix. $Q_t^* = \text{diag}(\sqrt{q_{11,t}}, \sqrt{q_{22,t}})$ and $Q_t = \{q_{ijt}\}$ stands for the matrix of conditional variance-covariance of the standardized errors:

$$Q_t = \left(1 - \sum_{m=1}^{M} a_m - \sum_{n=1}^{N} b_n\right)\bar{Q} + \sum_{m=1}^{M} a_m z_{t-m} z'_{t-m} + \sum_{n=1}^{N} b_{t-n} Q_{t-n} \quad \text{... (4)}$$

where $z_t = \frac{\varepsilon_{it}}{\sqrt{h_{it}}}$ is a vector containing standardized errors; a_m and b_n are scalar parameters restricted to be positive and their sum less than one; they are supposed to intercept, respectively, the effects of shocks and delayed dynamic correlations on the level of recent contemporary. $\bar{Q}$ denotes the unconditional covariance matrix of the standardized residuals computing from the first stage estimation. The information contained in D_t are generated by a GARCH (P, Q), which can be formulated as follows:

$$h_{it} = \omega_i + \sum_{p=1}^{Pi} \alpha_{ip}\varepsilon_{it-p}^2 + \sum_{q=1}^{Qi} \beta_{iq} h_{it-q} \qquad \forall\ i = \pi, y \qquad \dots (5)$$

The dynamic conditional correlations $\rho_{12,t} = \frac{q_{12,t}}{\sqrt{q_{11,t}q_{22,t}}}$ are the key elements of the matrix (R_t) whose main diagonal elements consists of 1. These dynamic correlations represent the conditional correlations between output growth and inflation.

The DCC model parameters should be estimated by the method of maximum likelihood in two steps. Given the maximized values of variances obtained from the first step, the dynamic conditional correlations are estimated in the second step. The log-likelihood is written as (see Engle, 2000):

$$L = -\frac{1}{2}\sum_{t=1}^{T}\left(2\log(2\pi) + 2\log|D_t| + \log|R_t| + z_t' R_t^{-1} z_t\right) \qquad \dots (6)$$

In addition to the inference about the DCC parameters, finding out causality among these variables has been proved to be a very important policy-making tool. However, as elegant as it appears, the above procedure remains agnostic about the causality analysis between the key variables (inflation and output growth). To this end, causality regression can be run by Cheung and Ng (1996) test whose behavior does not depend on the assumption of normality. Furthermore, this test is informative about the timing of causation in contrast to that of Granger causality test.

3.2. The CCF test

We follow Cheung and Ng (1996) in briefly describing the CCF test procedure in order to examine the causal relationship between inflation and output growth uncertainties. The test procedure is based on the standardized residuals and their squares estimations from the DCC-GARCH models. Let $\rho_{uv}(k)$ and $\rho_{\varepsilon\xi}(k)$ the cross-correlations of standardized square residuals (η,v) and of the standardized residuals (u,ξ) from GARCH equations to a lag of order k, respectively. Causality in the mean of π_t and y_t can be tested by computing the statistisics $CCF_{u\xi} = \sqrt{T} * \rho_{u\xi}(k)$. As for the causality in variance, it can be tested by computing the $CCF_{\eta v} = \sqrt{T} * \rho_{\eta v}(k)$. Next, these statistics are compared to the critical value of the normal distribution for different significance levels.

4. Data and Empirical Results

4.1. Data Description and Sources

Data used in this article are quarterly and cover the period 1990:Q1 to 2009:Q4. π stands for inflation and it is calculated as the log of the difference in the consumer price index (CPI), π_t=log(CPI_t/CPI_{t-4})*100. Following Sarel (1996), the inflation rate is logged to avoid that extreme observations distort the regression results. Y_t denotes the real output growth which is calculated as the log of the difference in real gross domestic product (RGDP), Y_t=log($RGDP_t$/$RGDP_{t-4}$)*100. RGDP is calculated as the ratio of nominal GDP over CPI. GDP is only available on quarterly frequency since 2004:Q1. Thus, complete quarterly figures have been generated by having recourse to the ECOTRIM package (Barcellan, 1994) by considering the industrial production index, IPI, as a benchmark. The variables GDP (line IFS, 99b) and CPI (IFS, line 64) are sourced from the International Financial Statistics, International Monetary Fund (IMF) while IPI is extracted from the National Statistics Institute database.

4.2. DCC-GARCH Results

Table 1 reports the results from the GARCH model fitting. These results lend support to the hypothesis that inflation and output growth exhibit significant conditional heteroscedasticity. In particular, the sum of α and β in the inflation GARCH equation is fairly close to 1 indicating a rather high persistence in the conditional variances. The Ljung-Box Q-statistics test indicates that the null hypothesis of no serial correlation up to lag 20 is not rejected for the two equations. The normality residual test statistics of Jarque–Bera fails to reject the null of normality of the π and y equation residuals. The corresponding p-values are respectively 0.17 and 0.825. Finally, the White test fails to reject the null of the absence of heteroscedasticiy. In sum, the model passes all the misspecification tests successfully indicating that the GARCH(1,1) model adequately captures both the conditional variance and the joint distribution of the residuals.

Table 1. Estimation results of univariate GARCH(1,1) models

Parameters	π_t	y_t
ϖ	0.002 (0.19)	0.142 (0.35)
α	0.287 (0.05)	0.381 (0.03)
β	0.685 (0.00)	0.305 (0.52)
Ljung-Box Q(20) Ljung-Box Q^2(20)	-0.144 (0.84)	0.020 (0.95)
	-0.065 (0.69)	0.049 (0.93)
ARCH(1) LM	0.42 (0.52)	0.074 (0.79)
Jarque Bera	5.37 (0.28)	0.385 (0.82)

Notes: P-values are reported between parentheses.

Since the DCC-GARCH system will be estimated using the maximum likelihood method, Bollerslev and Wooldridge's (1992) quasi-maximum likelihood procedure is employed to generate consistent standard errors that are robust to non-normality. The inspection of the log-likelihood values corresponding to alternative lag specifications suggests that data are best fitted by a DCC(1,1) specification with each of the conditional variances captured by the univariate GARCH(1,1) model, i.e $M=N=P_i=Q_i=1$. Furthermore, the results of parameters constancy tests, which is developed by Engle and Sheppard (2001) for testing the null that R_t=R, provide strong evidence against the alternative of a constant conditional coefficient. Using the standardized residuals from the first step, the conditional correlations among the inflation and the output growth are then estimated by having recourse to the DCC model (see Table 2).

Table 2. DCC(1,1)-GARCH (1,1) estimation results

a_1	0.095 (0.35)
b_1	0.803 (0.00)
Log-likelihood	-190.44
χ^2-test: R_t =R	35.54 (0.00)

Notes: P-values are reported between parentheses.

While the short-run persistence of shocks on the dynamic conditional correlation is not statistically significant, the largest long-run persistence of shocks to the conditional correlations is 0.897 and it is statistically significant. Figure 1 depicts the dynamic of the conditional correlation between output growth and inflation uncertainties, q_{12}. The trend is marked by negative and rather variable correlations. This would indicate that inflation was countercyclical rather than procyclical and holds consistent with Taylor hypothesis.

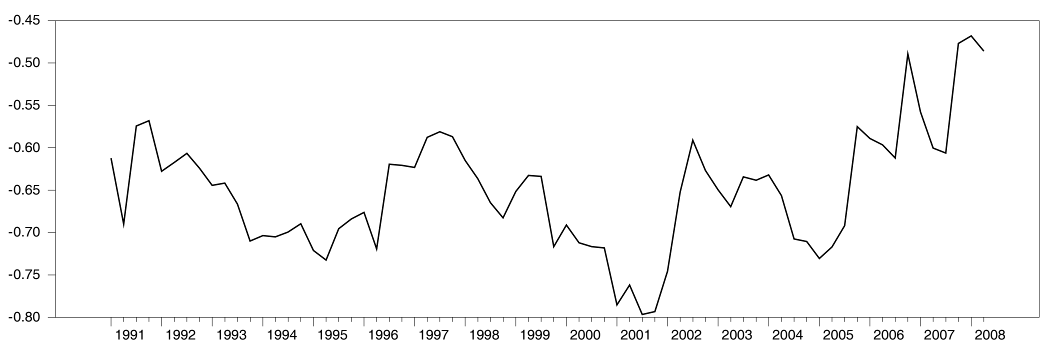

Figure 1. Dynamic correlations

On another front, Figure1 shows also that the co-movements of uncertainties have generally increased after the 2001's as a result of the global shocks, especially commodities prices surge, draught shocks in 2003 and 2005 and the recent financial turmoil of 2007. Furthermore, Fuhrer (1997) shows that the asymmetry of monetary policy reaction to inflation and output affects the nature of possible variability tradeoffs. This finding has been corroborated by Haddou (2010) who points out that the BCT follows a non linear Taylor rule with a speed reaction to the inflation rate deviations from its target than the speed reaction to the output deviations from it potential level.

4.3. Causality Tests Results and Comments

To explore the causal relationships among the inflation, the output, and the nominal and real uncertainty variables, we consider the conditional variances of monthly inflation and output growth as proxies of nominal and real uncertainty by means of the DCC-GARCH(1,1) model. Table 3 reports the Cheung and Ng (1996) test results. The number of lags and leads depicted in the first row of Table 3 refers to the number of quarters where inflation precedes or succeeds to the output growth. It should be stressed that a statistically significant correlation at the period (t=0) stands for a common shock affecting both economic magnitudes. In such case, the inflation coincides with the output growth. The *CCF* test statistic indicates that there is evidence of strong contemporaneous causality in mean at the 1% level. This could be explained by the fact that subsequent to a supply shock triggering in motion a countercyclical movement between output and inflation, which translates to a negative correlation during a span of time less than one quarter.[5]

Furthermore, the output growth is found to cause positively inflation in the mean at the lag four at the 5% level. This finding lends support to the short-run Phillips curve. Indeed, if the unemployment rate was known, then it would have been possible to predict price changes thanks to the Phillips curve as well as determining the potential output according to the Okun law. In such case, the increases in the productivity level growth would be the tradeoff between the inflation and the output growth. Nonetheless, data do fail to reject the feedback effect from the inflation to the output. As it has been widely documented in the economic literature, such reverse causation is likely to appear if monetary authorities pursue an accommodative policy.

Table 3. Sample cross-correlation analysis for the level and squares of standardized residuals

	Short-run		*Long-run*	
K	$\pi_t \leftrightarrow y_t$		$h_{\pi t} \leftrightarrow h_{yt}$	
-4	0.268	2.305***	-0.197	-1.692*
-3	0.064	0.551	0.068	0.584
-2	-0.129	-1.113	0.132	1.134
-1	0.05	0.403	0.060	0.519
0	-0.605	-5.208***	0.137	1.177
1	0.213	1.833*	-0.072	-0.620
2	0.094	0.806	-0.047	-0.403
3	0.035	0.299	-0.029	-0.247
4	0.095	0.818	-0.056	-0.480

Notes: k is the number of quarters where output growth precedes inflation. A lead is given by a negative lag parameter. Significance at 1 the percent, 5 percent and 10 percent level is indicated respectively by * and ** and ***.

Likewise, causality tests results of the variances confirm the presence of shocks propagation from the output growth towards the inflation rate at the lag four at the 10% level. Put

[5] Though demand shocks could give raise to negative correlation between output growth and inflation in a context of price rigidity, the above explanation seems to be the most likely seeing that Tunisia has shown very little demand shocks over the period under investigation.

differently, shocks to the output growth would propagate to inflation thereby intensifying the volatility of monetary sphere. Such result implies that the output uncertainty might generate uncertainty about the potential reactions of the monetary authorities, which eventually would create uncertainty about the future inflation rate. This lends support to the Taylor hypothesis which conjectures that there is a long-run tradeoff between the inflation and the output uncertainties. Indeed, the experience has shown that the BCT has often faced such a tradeoff. For instance, the Tunisian economy has witnessed a poorer performance[7] in 2005, which manifests itself in 2006 by a significant increase in growth uncertainty; in such a circumstance, and in order to contain the inflationary spiral, the BCT decided to increase gradually and cautiously its main policy rate in 2006:Q3 and 2006:Q4, respectively by 1.67 and 27 bases points taking the risk to hamper growth.[9] It is important to note that the results obtained through these two causality tests provide a firm conclusion about the role of growth as an engine of the Tunisian economy.

5. Concluding Remarks and Economic Implications

The inflation-growth nexus has sparked the interest of the economists, the policymakers as well as the central bankers. The paper objective is to find out whether a significant long run connection between the inflation and economic growth exists in Tunisia. Using the DCC-GARCH model over the period 1990–2009, this paper results have shown that the dynamic correlation has exhibited relatively a strong negative link. More specifically, the causality is shown to be bi-directional in level, whereas it runs from the economic growth to the inflation in variance with a time delay of four quarters. Put simply, the output uncertainty is found to affect negatively the inflation uncertainty which does corroborate the Taylor hypothesis. This may indicate that when the growth uncertainty manifests itself (for instance, subsequent to supply shocks inducing an increase in the output variability), the BCT allows them to persist (that is, it does not react) in order to offset the potential real uncertainty effects on inflation (via the inflation uncertainty channel). Thus, the real uncertainty affects negatively the nominal one which in turn does not contribute in increasing inflation.[11]

To sum up, the paper's findings corroborate the short run Phillips curve effects as well as the Taylor hypotheses, which have important policy implications. Firstly, as highlighted by the empirical results which have underscored the role of growth in Tunisia as an economy engine, it seems therefore appropriate for the policymaker to adjust the composition of the portfolio of the economic activities by diversifying more to services and industry away from agriculture[13] to reduce uncertainties to output growth. For instance, the Tunisian economic fabric should be oriented to high value-added activities with substantial potential for growth, such as software

[7] This performance was due to negative growth in, notably, the agriculture and textiles sectors.

[9] It has been shown that when the economy witnesses a high instability, firms' production plans become less efficient; and consequently, the output growth diminishes while its uncertainty increases (see Ramey and Ramey (1991)).

[11] In practice, the experience has shown that the BCT has usually preferred not to react when the economy is hit by supply shocks inducing thereby an increase in the real uncertainty.

[13] It is worth noting that climatic shocks in Tunisia are short-lasting and recurrent, and impact on agriculture as well as other economic sectors and branches (i.e. food industry, water availability…) via a spillover effect.

industry and telecommunication. These sectors are not only less vulnerable to shocks but also needs skilled labor force which is available.

Secondly, even though diversification contributes significantly to smooth the effects of different shocks, its success depends heavily on active accompanying political process aiming at reinforcing both the domestic demand (internal competitiveness) and the exports policy (external competitiveness), which eventually allow the country to take full advantage of domestic as well as the foreign market opportunities. A dynamic and deep domestic market is a major determinant of the development of the competitive potential of an economy. It could be used as an effective instrument to smooth the business cycle effects. The second component of competitiveness is inflation mastering. Indeed, a low and stable inflation enhance competitiveness and assure exchange rate stability. Policies consisting in attempting to bring down inflation by raising the policy rate are likely to affect harmfully the economic growth, at least in the short-run; such policies should be avoided. In the long-run, the output uncertainty might deplete the effective demand, and eventually hamper the aggregate supply. Therefore, policymakers should back up the effective demand by sound fiscal and monetary policies, especially those consisting in controlling budget deficit and money growth. The exchange rate flexibility is also another instrument which could be used since it has turned out to be effective in absorbing the effects of shocks, especially shocks to terms-of-trade.

6. References

Baillie, R. Chung, C. and M. Tieslau (1996) “Analyzing inflation by the fractionally integrated ARFIMA-GARCH model”, *Journal of Applied Econometrics,* 11, 23–40.

Barcellan, R. (1994), “ ECOTRIM: a Program for Temporal Disaggregation of Time Series”, Paper presented at the joint INSEE and Eurostat Quarterly National Accounts Workshop in Paris on December 5th and 6th, 1994.

Bollerslev, T. (1990), “Modelling the Coherence in Short-run Nominal Exchange Rates: A Multivariate Generalized ARCH Model”, *The Review of Economics and Statistics,* 72(3), 498-505.

Bollerslev, T. and J.M. Wooldridge (1992), “Quasi maximum likelihood estimation of dynamic models with time varying covariance”, *Econometric Reviews,* 11, 143–172.

Briault, C. (1995), “The Costs of Inflation”, *Bank of England Quarterly Bulletin*, 33-45.

Cheung, Y.W. and L.K. Ng (1996), “A causality-in-variance test and its application to financial market prices”, *Journal of Econometrics,* 72, 33–48.

Conrad, C. and M. Karanasos (2005), “On the inflation-uncertainty hypothesis in the USA, Japan and the UK: a dual long memory approach”, *Japan and the World Economy,* 17, 327-343.

__________ (2010), “Negative volatility spillovers in the unrestricted ECCC-GARCH model”, *Econometric Theory,* 26 (3), 838-862.

Cukierman, A. and S. Gerlach (2003), “The inflation bias revisited: theory and some international evidence”, *The Manchester School*,71, 541-565.

Devereux, M. (1989), “A positive theory of inflation and inflation variance”, *Economic Inquiry,* 27, 105-116.

Engle, R.F. (2000), “Dynamic Conditional Correlation - A Simple Class of Multivariate GARCH Models”, Economics Working Paper Series 544151, Department of Economics, University of California at San Diego, UC San Diego.

__________ (2002), “Dynamic Conditional Correlation-A Simple Class of Multivariate GARCH Models”, *Journal of Business and Economic Statistics*, 20, 339-350.

Engle, R.F. and K. Sheppard (2001), “Theoretical and empirical properties of dynamic conditional correlation multivariate GARCH”, University of California, San Diego, Department of Economics, Discussion paper 2001-15.

Fisher, S. (1993), “The Role of Macroeconomic Factors in Growth”, *Journal of Monetary Economics*, 32, 485–512.

Fountas, S. Karanasos, M. and J. Kim (2006), “Inflation Uncertainty and Output Growth Uncertainty and Macroeconomic Performance”, *Oxford Bulletin of Economics and Statistics*, 68(3), 319-343.

Fountas, S. and M.Karanasos (2007),. “Inflation, Output Growth, and Nominal and Real Uncertainty: Empirical Evidence for the G7”, *Journal of International Money and Finance,* 26(2), 229-250.

Friedman.M., (1977), “Nobel lecture: Inflation and Unemployment”, *Journal of Political Economy*, 85, 451-472.

Fuhrer. J., (1997), “Inflation/Output Variance Trade-offs and Optimal Monetary Policy”. *Journal of Money, Credit, and Banking*, 29(2): 214–234.

Goodhart, C. (1999), “Central Bankers and Uncertainty”, *Bank of England Quarterly Review*, February, 102-121.

Greenspan, A. (2003), *Remarks, in Monetary Policy and Uncertainty: Adapting to a Changing Economy*, Federal Reserve Bank of Kansas City.

Grier.K and M.Perry (1998), “On Inflation and Inflation Uncertainty in the G7 Countries”. *Journal of International Money and Finance,* 17(4), 671–689.

____________ (2000), “The Effects of Real and Nominal Uncertainty on Inflation and Output Growth: Some GARCH-M Evidence”, *Journal of Applied Econometrics,* 15(1), 45–58.

Guerrero, F. (2006), “Does inflation cause poor long-term growth performance?”, *Japan and the World Economy*, 18, 72–89.

Karanasos, M. and J. Kim (2005), “The Inflation-Output Variability Relationship in the G3: A Bivariate GARCH (BEKK) Approach”, *Risk Letters,* 1(2), 17-22.

Haddou, S. (2010), “Non linéarité de la fonction de réaction des autorités monétaires tunisiennes”, *Economie et prévision*, N°195-196.

Lee, J. (2006), “The co-movement between output and prices: Evidence from a dynamic conditional correlation GARCH model”, *Economics Letters,* 91, 110-116

Logue, D. and R.Sweeney (1981), “Inflation and real growth: some empirical results”, *Journal of Money, Credit, and Banking,* 13, 497-501.

Okun, A.M. (1971), "The Mirage of Steady Inflation", *Brookings Papers on Economic Activity,* 2, 485–98.

Peersman, G. and F. Smets (1999), "The Taylor Rule: A Useful Monetary Policy Benchmark for the Euro Area?", *International Finance,* 2(1), 85-116.

Poole, W. (1998), "A Policymaker Confronts Uncertainty", *Federal Reserve Bank of St. Louis Review*, *80*(5), 3-8.

Ramey, G and V. Ramey (1991), "Technology commitment and the cost of economic fluctuation", NBER Working Paper 3755.

Rudebusch, G. (2001), "Is the Fed too timid? Monetary policy in an uncertain world", *Review of Economics and Statistics*, 88, 203-17

Sarel, M. (1996), "Non-linear Effects of Inflation on Economic Growth", *IMF Working Staff Papers*, 43(1), 199–215.

Smets, F. (1999), "Output gap uncertainty: does it matter for the Taylor Rule?" In B. B. Hunt and A. Orr (eds), *Monetary policy under uncertainty*, Reserve Bank of New Zealand.

Soderstrom, U. (2000), "Monetary policy with uncertain parameters", European Central Bank Working Paper 13.

Srour. G., (2003), "Some notes on monetary policy rules with uncertainty". Bank of Canada Working Paper 2003-16.

Svensson, L.E.O. and N. Williams (2008), "Optimal Monetary Policy under Uncertainty in DSGE Models: A Markov Jump-Linear-Quadratic Approach", NBER Working Papers 13892, National Bureau of Economic Research, Inc.

Swanson, E. (2004), "On signal extraction and non-certainty-equivalence in optimal monetary policy rules", *Macroeconomic Dynamics*, 8, 27-50.

Taylor, J. (1979), "Estimation and control of a macroeconomic model with rational expectations", *Econometrica*, 47, 1267-1286.

_______ (1993), "Discretion versus policy rules in practice", *Carnegie-Rochester Conference Series on Public Policy*, 39, 195-214.

________ (1994), "The Inflation / Output Variability Trade-off Revisited", in Jeffrey C. Fuhrer, ed., *Goals, Guidelines, and Constraints Facing Monetary Policymakers*. Boston: Federal Reserve Bank of Boston.

Ungar, M. and B. Zilberfarb (1993), "Inflation and its unpredictability: theory and empirical evidence", *Journal of Money, Credit, and Banking,* 25, 709-720.

Walsh, C.E. (2003), "Implications of a changing economic structure for the strategy of monetary policy, in Monetary Policy and Uncertainty- Adapting to a Changing Economy", Federal Reserve Bank of Kansas City, 297-348.

♦♦♦