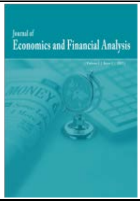
Journal of Economics and Financial Analysis
Type: Double Blind Peer Reviewed Scientific Journal
Printed ISSN: 2521-6627 | Online ISSN: 2521-6619
Publisher: Tripal Publishing House | DOI:10.1991/jefa.v5i1.a38
Received: 11.02.2021 | Accepted: 25.06.2021 | Published: 30.07.2021
Journal homepage: ojs.tripaledu.com/jefa



Comparing Optimal Monetary Policy Rules, Does Wage Inflation Matters?

Wissem BOUKRAINE*, Hella Guerchi MEHRI
Department of Economics, University of Tunis El Manar, Tunisia

Abstract

The aim of this paper is to determine the optimal monetary policy for the Tunisian economy by comparing different targeting rules in terms of welfare loss. Our approach is conducted through simulated scenarios from a small open economy DSGE model, with frictions in the labor market. We are motivated by the fact that the Tunisian economy suffers from inflation, unemployment and a continuous depreciation of its currency which put pressure on production costs. In addition, with underdeveloped financial market attention is given to exchange rate volatility. Recent literature focuses on wage inflation to reduce production costs and unemployment caused by terms of trade fluctuations rather than reacting to the exchange rate. Our main result is the superiority of the wage inflation rule in reducing welfare losses.

Keywords: *Wage Inflation; Unemployment; Optimal Monetary Policy; Rules; DSGE; Tunisia.*

JEL Classification: *E24, E47.*

* Corresponding author.
E-Mail: boukrainewissem@gmail.com (W. Boukraine), hella.guerchi-mehri@fsegt.utm.tn (H.G. Mehri)

1. Introduction

Commitment to a rule is the result of a long line of work whose culmination is the problem of time inconsistency which arises because decision makers always feel the temptation to deviate from a plan that has become incompatible in the light of new circumstances. Under discretion, policymakers are tempted to pursue an expansionary monetary policy that exploits the short-run trade-off between unemployment and inflation (Friedman & Schwartz (1963) and Meltzer (2004, 2014)). However, the absence of a long-run trade-off between unemployment and inflation implies that this discretionary policy can only result in higher inflation without reducing unemployment. In that context, commitment to a rule is becomes necessary. Generally, the economic literature distinguishes two types of rules, those that use the monetary base as a policy instrument and are commonly known as (McCallum, 1988, 1999) type rules and those using the interest rate as a policy instrument and are called (Taylor, 1993, 1999) type rules. Adherence to an optimal policy rule means that every action taken is optimal from a timeless perspective given the central bank's understanding of the monetary transmission mechanism at the time the decision is made. Taylor's original rule is retrospective, but later different types of rules appeared, some are retrospective, other prospective and even hybrid, which means that the central bank considers both past and expected values of the variables when determining the interest rate. Some works incorporate other variables like the exchange rate, in fact, Ball (1999), Svensson (2000), and Taylor (2001) argue that an exchange rate reaction under a Taylor rule appears to be advantageous to the central bank, but the weight given to it should be considerably lower than the weight of inflation and production. Aghion et al. (2009) confirm that countries with relatively less developed financial markets are more likely to experience production losses due to exchange rate volatility. In this case, greater concern over exchange rate volatility may lead emerging market central banks to follow a Taylor rule that targets output, inflation and the real effective exchange rate. Aizenman et al. (2011) estimate the Taylor rule for several emerging economies and confirm significant reactions of central banks at the exchange rate but still smaller than the reaction to inflation. In order to compare the performance of the simulated rules in terms of stabilization and welfare loss, we will refer to a dynamic stochastic general equilibrium model where the central bank pursues an optimal monetary policy. The literature on optimal monetary policy began with the seminal work of Rotemberg & Woodford (1997). In almost all of this literature, the central bank sets the interest rate to maximize welfare, and fiscal policy only intervenes to correct the inefficiency of the equilibrium state, by a lump sum tax. In that context the literature considers that the optimal policy is to set interest rates to control a combination of inflation and output gap (Giannoni & Woodford, 2002) as well as the exchange rate (Corsetti et al. (2010), Adam & Woodford (2013)), asset prices (Gali, 2014) or wage inflation (Rhee & Song, 2014). However the DSGE specification in the new Keynesian framework is far from perfect, its major weakness is the lack of reflection on unemployment. Such a lack of consideration of labor market frictions suggests that central banks should not take into account unemployment and its fluctuations in the design of monetary policy. But recently, more and more studies are considering labor market frictions (Christoffel et al. (2006), Thomas (2008), Faia (2009), Blanchard & Gali (2010) and Galí et al. (2011)), the latter introduced various forms of nominal and real wage rigidity to study the effects of unemployment on the design of monetary policy. But it should be noted that few studies have extended this analysis to an open economy, like Rhee & Song (2014) and Campolmi & Faia (2014). The paper is organized as follows. Section 2 presents the simulated model and rules. Section 3 details the calibration procedure, section 4 the results, while Section 5 contains the concluding remarks.

2. Model and Rules

2.1. Model

We focus on the Tunisian case by calibrating and simulating (Rhee & Song, 2014) model which incorporate unemployment as in Gali (2011a, b) but extend the work to a small open economy. The introduction of unemployment through frictions in the labor market justify the reaction to wage inflation by the central bank, as it is no longer optimal to only react to inflation and output. The optimal targeting rules we simulate are forward looking, backward looking and hybrid. We augment the rules with real effective exchange rate and wage inflation and compare their performances in the model we consider.

2.1.1. Household

The representative household maximizes $E_0 \sum_{t=0}^{\infty} \beta^t \left[logC_t - \mathcal{X}_t \int_0^1 \frac{N_t(i)^{1+\varphi}}{1+\varphi} di \right]$, subject to the following budget constraints: $P_t C_t + E_t\{Q_{t,t+1} B_{t+1}\} \leq B_t + \int_0^1 W_t(i) N_t(i) di + T_t$, where β represents the discount factor, W_t is the nominal wage for type i labor, B_t is the purchased amount of riskless and one-period discount bond paying one monetary unit, Q_t is the price of that bond, and T_t is lump sum component of household income, C_t the aggregate consummation, and P_t the consumer price index (CPI) defined by the domestic price index $P_{H,t}$ and the price index for goods imported from foreign country $P_{F,t}$.

Under the assumption of risk sharing across households, households resetting their wage in any given period choose the same wage to maximize: $E_t\left\{\sum_{k=0}^{\infty}(\beta\theta_w)^k\left[logC_{t+k|t}-\mathcal{X}_{t+k}\frac{N_{t+k|t}^{1+\varphi}}{1+\varphi}\right]\right\}$, where $C_{t+k|t}$ and $N_{t+k|t}$ respectively denote the composite consumption and labor supply in period $t+k$ of a household that last reset its wage in period t. $\bar{W}_t$, denotes the newly set wage.

Maximization of the last equation is subject to the labor demand schedules and budget constraints that are effective while $\bar{W}_t$ remains in place, $N_{t+k|t}=\left(\frac{\bar{W}_t}{W_{t+k}}\right)^{-\epsilon_w}\int_0^1 N_{t+k}(z)dz$ and $P_{t+k}C_{t+k|t}+E_t\{Q_{t,t+k+1}B_{t+k+1|t}\}\leq B_{t+k|t}+\bar{W}_tN_{t+k|t}+T_{t+k}$, for $k=0,1,2,\ldots$ where $X_{t+k|t}$ the value of X in period $t+k$ of a household that last reset its wage in t.

The first-order condition is as follows: $\sum_{k=0}^{\infty}(\beta\theta_w)^k E_t\left\{\frac{N_{t+k|t}}{C_{t+k|t}}\left(\frac{\bar{W}_t}{P_{t+k}}-\frac{\epsilon_w}{\epsilon_w-1}MRS_{t+k|t}\right)\right\}=0$, where $MRS_{t+k|t}\equiv\mathcal{X}_{t+k}C_{t+k}N_{t+k|t}^{\varphi}$ is the marginal rate of substitution between consumption and labor supply in period $t+k$ for the household resetting the wage in t. At each period, the optimal allocation of expenditures between domestic and imported goods is determined by $C_{H,t}$ and $C_{F,t}$. Across two consecutive periods, the household allocate their expenditure in the following way: $\beta\left[\frac{C_t}{C_{t+1}}\frac{P_t}{P_{t+1}}\right]=Q_{t,t+1}$.

The last equation constitutes a standard Euler equation for intertemporal consumption decision and at the same time represents the expectational IS curve and can be written as : $\beta R_tE_t\left[\frac{C_t}{C_{t+1}}\frac{P_t}{P_{t+1}}\right]=1$. An individual that provides type i labor and experiences disutility of work $\mathcal{X}_tj^{\varphi}$ will work in period t if and only if $\frac{W_t(i)}{P_t}\geq\mathcal{X}_tC_tj^{\varphi}$ where the term on the right side represents the labor disutility expressed in marginal utility of consumption. If we let $L_t(i)$ denote type i labor supply or participation, marginal supplier of type i labor observes : $\frac{W_t(i)}{P_t}\geq\mathcal{X}_tC_tL_t(i)^{\varphi}$.

Taking log of the last equation and integrating over i, gives:

$$w_t-p_t=c_t+\varphi l_t+\xi_t \qquad (01)$$

where $w_t \approx \int_0^1 w_t(i)di$ and $l_t \approx \int_0^1 l_t(i)di$ are the first-order approximation of aggregate labor force or participation around its symmetric steady state.

Following Galí (2011a), the unemployment rate u_t is the log difference between the labor force and employment where:

$$u_t \equiv l_t - n_t \tag{02}$$

The average wage markup $\mathcal{M}_t^w$ is $\mathcal{M}_t^w = \frac{W_t/P_t}{MRS_t}$. Its log-linearized form is:

$$\mu_t^w \equiv (w_t - p_t) - (c_t + \varphi n_t + \xi_t) \tag{03}$$

where μ_t^w is a log of the average wage markup $\mathcal{M}_t^w$.

Combining (03) with (01) and (02), gives $\mu_t^w = \varphi u_t$. The last equation shows that unemployment fluctuation is tightly related to variations in the wage markup, which are the result of nominal wage rigidities. The natural rate of unemployment, μ_t^n , that would prevail under fully flexible nominal wage is:

$$u^n = \frac{\mu^w}{\varphi} \tag{04}$$

2.1.2. Firm

The production function for differentiated goods for the firm z takes the following form: $Y_t(z) = A_t N_t(z)^{1-\alpha}$.,where $a_t \equiv logA_t$ follows the $AR(1)$ process, $a_t = \rho_a\ a_{t-1} + \varepsilon_t^a$, and $N_t(z)$ is an index of labor input used by firm i. It is assumed that each firm receives a subsidy of τ percent of its wage bill. As a result, all the firms face the same real marginal cost: $mc_t = -v + w_t - p_{H,t} - a_t + \alpha n_t$, where $\nu \equiv log\,(1-\tau) - log\,(1-\alpha)$.

Following Calvo (1983), the newly reset prices in period t can be approximated by:

$$\bar{p}_{H,t} = \mu^p + (1-\beta\theta_p)\sum_{k=0}^{\infty}(\beta\theta_p)^k\ E_t\left\{\frac{1-\alpha}{1-\alpha+\alpha\epsilon_p}mc_{t+k} + p_{H,t}\right\} \tag{05}$$

where $\bar{p}_{H,t}$ denotes the log of newly set domestic prices, and $\mu^p \equiv log\mathcal{M}^p = log\left(\frac{\epsilon_p}{\epsilon_p - 1}\right)$ is the log of price markup in a flexible price equilibrium or in the steady state.

The foreign country F is large so that $P_{F,t}^* = P_t^*$ and $C_t^* = Y_t^*$, Similarly to the country H , the following first-order conditions hold for the country F :

$\beta\left\{\frac{C_t^*}{C_{t+1}^*}\frac{P_t^*}{P_{t+1}^*}\right\} = Q_{t,t+1}^*$, where $\frac{1}{E_t\{Q_{t,t+1}^*\}} = R_t^*$, is the riskless short-term foreign nominal interest rate. Goods produced in country H are sold in country F. The country F's demand for the country H's output z is $C_{H,t}^*(z) = \alpha\left(\frac{P_{H,t}^*(z)}{P_{H,t}^*}\right)^{-\epsilon_p} C_{H,t}^*$ and the optimal allocation of expenditures for domestic goods is given by $C_{H,t}^* = \alpha\left(\frac{P_{H,t}^*}{P_t^*}\right)^{-\eta} C_t^*$

2.1.3. Equilibrium

Combining goods market clearing condition with the definition of aggregate domestic output index and the international risk sharing condition yields:

$$Y_t = \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t\left[(1-\delta) + \delta Q_t^{\eta}\right] \tag{06}$$

where $Q = \frac{\epsilon_p P_t^*}{P_t}$ is the real exchange rate, ϵ is the nominal exchange rate, which is defined as the price of foreign currency in terms of domestic currency. Combining the first order log linear approximation of the last equation around the steady state with the log-linearization of the standard stochastic Euler equation gives: $y_t = E_t\{y_{t+1}\} - \psi^{-1}[r_t - E_t\{\pi_{t+1}\} + \delta\phi^{-1}(\sigma-1)E_t\{\Delta y_{t+1}^*\} - \rho]$, where $\psi^{-1} \equiv 1 + \delta\phi^{-1}(1-\sigma)$. The optimal price-fixing condition (05) can be combined with the log-linearized equation describing the evolution of domestic prices to give an equation determining domestic inflation as a function of the marginal cost differences of its steady state:

$$\pi_{H,t} = \beta\, E_t\{\pi_{H,t+1}\} - \lambda_{pH}\hat{\mu}_t^{pH} \tag{07}$$

where $\hat{\mu}_t^{pH} \equiv \mu_t^{w} - \mu^{pH} \equiv -\widehat{mc}_t$ and $\lambda_{pH} \equiv \frac{(1-\theta_{pH})(1-\beta\theta_{pH})}{\theta_{pH}(1-\alpha+\epsilon_p)}(1-\alpha)$.

The log-linearizing of the first order condition of the wage setting around the zero inflation steady state can be rewritten as: $w_t = \beta\theta_w E_t\{\bar{w}_{t+1}\} + (1-\beta\theta_w)[w_t - (1-\epsilon_w\varphi)^{-1}\hat{\mu}_t^{w}]$.

Since all households newly setting their wage choose the same wage, the aggregate wage index appears to be: $w_t = \left[\theta_w w_{t-1}^{1-\epsilon_w} + (1-\theta_w)\bar{w}_t^{1-\epsilon_w}\right]^{\frac{1}{1-\epsilon_w}}$. Combining the last two equations leads to:

$$\pi_{W,t} = \beta E_t\{\pi_{W,t+1}\} - \lambda_w\hat{\mu}_t^{w} \tag{08}$$

where $\pi_{W,t} = w_t - w_{t-1}$ and $\lambda_w = \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w(1+\epsilon_w\varphi)}$. The New Keynesian wage Phillips curve which relate wage inflation and unemployment: $\pi_{W,t} = \beta E_t\{\pi_{W,t+1}\} - \lambda_w\varphi(u_t - u^n)$. The real wage gap $\widetilde{\omega}_t^R \equiv \omega_t^R - (\omega_t^R)^n$, where $(\omega_t^R)^n$ is the natural real wage, i.e., the real wage that would prevail in the flexible prices and wages equilibrium. The real marginal cost: $mc_t = v + w_t - p_{H,t} - a_t + \alpha n_t = v + \omega_t^R + \delta s_t + n_t$, where last equality follows: $p_t = p_{H,t} + \delta s_t$ and aggregate production relation. The average price markup $\hat{\mu}_t^{pH}$ is related to the output and real wage gaps: $\hat{\mu}_t^{pH} = [(y_t - y_t^n) - (n_t - n_t^n) - (\omega_t - (\omega_t^R)^n) - \delta(s_t - s_t^n)] = -\widetilde{\omega}_t^R - \delta\tilde{s}_t = -\widetilde{\omega}_t - \frac{\delta}{\phi}\tilde{y}_t$.

Hence, combining the domestic inflation and the last equation yields:

$$\pi_{H,t} = \beta E_t\{\pi_{H,t+1}\} + \lambda_{pH}\widetilde{\omega}_t^R + \kappa_{pH}\tilde{y}_t \qquad (09)$$

where $\kappa_{pH} = \left(\frac{\alpha+\delta\phi^{-1}}{1-\alpha}\right)\lambda_{pH}$. Equation (09) represents equation for domestic price inflation. The authors also relate the average wage markup $\hat{\mu}_t^{w}$ to the output and real wage gaps as:

$$\hat{\mu}_t^{w} = \omega_t^R - [c_t + \varphi n_t + \xi_t] - \mu^{w} = \widetilde{\omega}_t^R - \left[(1-\delta)\sigma^{-1} + \frac{\varphi}{1-\alpha}\right]\tilde{y}_t \qquad (10)$$

Therefore, the following wage inflation equation can be derived:

$$\pi_{W,t} = \beta E_t\{\pi_{W,t+1}\} + \kappa_w\tilde{y}_t - \lambda_w\tilde{w}_t \qquad (11)$$

where $\kappa_w = \lambda_w\left[(1-\delta)\sigma^{-1} + \frac{\varphi}{1-\alpha}\right]$. Combining (04) and (06) , gives the following equation describing relation between the unemployment rate and the output and wage gaps as:

$$\tilde{u}_t = \varphi^{-1}\left\{\widetilde{\omega}_t^R - \left[(1-\delta)\phi^{-1} + \frac{\varphi}{1-\alpha}\right]\tilde{y}_t\right\} \qquad (12)$$

Then, the following identity relating the change in the real wage gap to domestic price inflation, wage inflation, and the natural wage: $\widetilde{\omega}_t^R \equiv \widetilde{\omega}_{t-1}^R + \pi_{W,t} - \pi_{H,t} - \delta\Delta(\omega_t^R)^n$. Meanwhile, the dynamic IS equation for the small open economy can be obtained by rewriting first order log-linear approximation of (08) in terms of output gap as:

$$\tilde{y}_t = E_t\{\tilde{y}_{t+1}\} - \psi^{-1}\left[r_t - E_t\{\pi_{H,t+1}\} - \overline{rr}_t\right] \qquad (13)$$

where $\psi^{-1} = 1 + \delta\phi^{-1}(1-\sigma)$ and $\overline{rr}_t \equiv \rho + \psi E_t\{\Delta y_{t+1}^n\} - \delta(\sigma - 1)\phi^{-1}E_t\{\Delta y_{t+1}^*\}$ is the small open economy's natural rate of interest. In order to close the model, a Taylor-type interest rule is assumed: $r_t = \rho + \phi_\pi\pi_{C,t} +$

$\phi_{\tilde{y}}\tilde{y}_t + v_t$, where $\pi_{C,t} = \pi_{H,t} + \delta\Delta s_t$ is CPI inflation, and v_t is an exogenous monetary policy component, which is assumed to follow an AR(1) process: $AR\ (1)$: $v_t = \rho_v v_{t-1} + \varepsilon_t^v$ where $\rho_v \in [0, 1]$ and ε_t^v is a white noise process.

2.1.4. Optimal Monetary Policy

The second order approximation under the assumption of $\sigma = \eta = 1$ to the representative household's welfare losses due to domestic price and wage rigidities gives the following welfare loss (derivation is detailed in the appendix of (Rhee & Song, 2014)). $\mathbb{W} = \frac{1-\delta}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \left(\frac{1+\varphi}{1-\alpha}\right) \tilde{y}_t^2 + \frac{\epsilon_p}{\lambda_{pH}} \left(\pi_{H,t}\right)^2 + \frac{\epsilon_{w}(1-\alpha)}{\lambda_{w}} \left(\pi_{w,t}\right)^2 \right\} + tip.$, where $t.i.p.$ are terms independent of policy. Thus, the average period welfare loss is: $\mathbb{L} = -\frac{1-\delta}{2} \left[\left(\frac{1+\varphi}{1-\alpha}\right) var(\tilde{y}_t) \frac{\epsilon_p}{\lambda_{pH}} \ var\left(\pi_{H,t}\right) + \frac{\epsilon_p (1-\alpha)}{\lambda_{pH}} var\left(\pi_{w,t}\right) \right]$. The central banks seek to minimize welfare losses subject to the constraints given by(09),(11), and (13).

The resulting first-order conditions are: $(1-\delta)\left(\frac{1+\varphi}{1-\alpha}\right)\tilde{y}_t + \mathcal{L}_{1t}\kappa_{pH} + \mathcal{L}_{2t}\kappa_{w} = 0$, $(1-\delta)\frac{\epsilon_p}{\lambda_{pH}}\pi_{H,t} - \mathcal{L}_{1t} + \mathcal{L}_{1t-1} - \mathcal{L}_{3t} = 0$, $(1-\delta)\frac{\epsilon_{w}(1-\alpha)}{\lambda_{w}}\pi_{w,t} - \mathcal{L}_{2t} + \mathcal{L}_{2t-1} - \mathcal{L}_{3t} = 0$ and $-\mathcal{L}_{3t} + \lambda_{pH} + \pi_{w,t} + \beta E_t\{\mathcal{L}_{3t+1}\} = 0$. Where $\mathcal{L}_{1t}$, $\mathcal{L}_{2t}$ et $\mathcal{L}_{3t}$ are the Lagrange multipliers associated with the three constraints. The dynamical system describing the optimal monetary policy consists of the last four equations together with constraints $(09) - (13)$.

2.2. Monetary Policy Rules

Now we present the optimal targeting policy rules to be simulated and compared. For k horizons, the simple prospective rule with smoothing ρ of the interest rate:$r_t = (1-\rho)\{r_{nat} + \varsigma E_t(\pi_t - \pi^*) + \vartheta((y_t - y_t^*)\} + \rho r_{t-1}$. As the central bank of Tunisia does not express explicit targets for inflation π^*or production y_t^*, we assimilate these targets to their respective natural rates π_{nat} and y_{nat} . $r_t = (1-\rho)\{r_{nat} + \varsigma E_t(\pi_t - \pi_{nat}) + \vartheta((y_t - y_{nat})\} + \rho r_{t-1}$, where ρ is a smoothing parameter, r_{nat} natural interest rate, ς parameter associated with inflation, π_t current inflation, π_{nat}, the natural rate of inflation, $E_t(\pi_t - \pi_{nat})$, the anticipated inflation differential, ϑ parameter associated with output, y_t current production, y_{nat}, natural rate of production and $y_t - y_{nat}$ the production differential.

Below we consider variants of the prospective Taylor rule:

Flexible Inflation Targeting with Smoothing (FITS1):

$$r_t = (1-\rho)\{r_{nat} + \varsigma E_t(\pi_t - \pi_{nat}) + \vartheta((y_t - y_{nat})\} + \rho r_{t-1}$$

Flexible inflation targeting (FIT1):

$$r_t = r_{nat} + \varsigma E_t(\pi_t - \pi_{nat}) + \vartheta((y_t - y_{nat})$$

Flexible inflation targeting with smoothing (FITS2):

$$r_t = (1-\rho)\{r_{nat} + \varsigma E_t(\pi_t - \pi_{nat}) + \vartheta((y_t - y_{nat}) + \varrho(REER_t - REER^*)\} + \rho r_{t-1}$$

Flexible inflation targeting (CFI 2):

$$r_t = r_{nat} + \varsigma E_t(\pi_t - \pi_{nat}) + \vartheta((y_t - y_{nat}) + \varrho(REER_t - REER^*)$$

Where ϱ parameter associated with the exchange rate, $REER_t$the real effective exchange rate,$REER^*$, the real effective exchange rate target and $E_t(REER_t - REER^*)$ the anticipated differential between the real effective exchange rate and its target.

Flexible inflation targeting with smoothing (FITS3):

$$r_t = (1-\rho)\left\{r_{nat} + \varsigma E_t(\pi_t - \pi_{nat}) + \vartheta((y_t - y_{nat}) + \varpi E_t(\pi_{w,t} - \pi^*_{w,t})\right\} + \rho r_{t-1}$$

Flexible inflation targeting (FIT3) :

$$r_t = r_{nat} + \varsigma E_t(\pi_t - \pi_{nat}) + \vartheta((y_t - y_{nat}) + \varpi E_t(\pi_{w,t} - \pi^*_{w,t})$$

Where ϖ is the parameter associated with wage inflation, $\pi_{w,t}$ current wage inflation, $\pi^*_{w,t}$, target wage inflation and $E_t(\pi_{w,t} - \pi^*_{w,t})$, the expected differential between wage inflation and its target.

Flexible inflation targeting with smoothing (FITS4) :

$$r_t = (1-\rho)\left\{r_{nat} + \varsigma E_t(\pi_t - \pi_{nat}) + \vartheta((y_t - y_{nat}) + \varpi E_t\left(\pi_{w,t} - \pi^*_{w,t}\right) + \varrho(REER_t - REER^*)\right\} + \rho r_{t-1}$$

Flexible inflation targeting (FIT4) :

$$r_t = r_{nat} + \varsigma E_t(\pi_t - \pi_{nat}) + \vartheta((y_t - y_{nat}) + \varpi E_t\left(\pi_{w,t} - \pi^*_{w,t}\right) + \varrho(REER_t - REER^*)$$

3. Calibration

The calibration chosen for the parameters follows the prevailing empirical literature on DSGE models of small open economy and the estimated global projection model GPM used by the central bank of Tunisia. We consider a productivity shock on the supply side to compare the rules. The exogenous processes describing the shock are calibrated according to Gali & Monacelli (2005): $a_t = 0.66a_{t-1} + \varepsilon_t^a$ where ε_t^a is a white noise. For the particular case of optimal monetary policy, $\sigma = \eta = 1$, the discount factor β is fixed at 0.99, the degree of openness $\delta = 0.4$, the degree of decreasing labor productivity, is set at $\alpha = 0.25$. The elasticity of substitution among goods $\varepsilon_p = 9$implies that at equilibrium, the price markup is $\mu_p = 12.5\%$ and the share of labor income is equal to$2/3$. The parameters of the contract duration for prices and wages are defined as follows: $\theta_{ph} = \theta_w = 0.75$. The inverse of Frisch's elasticity of labor supply $\varphi = 5$implies that the elasticity of labor supply is $1/5$ and the elasticity of labor substitution $\varepsilon_w = 4.52$. The values of the average wage markup is then $28\ \%$. $\rho = 0.1$the smoothing parameter,$\varpi = 0.1$ the parameter associated with wage inflation, $\varsigma = 1.21$the parameter associated with inflation, $\vartheta = 0.4$the parameter associated with production and $\varrho = 0.1$the parameter associated with the exchange rate.

4. Results

4.1. Forward-Looking Rules

Table 1. Cyclical properties of forward-looking rules following a productivity shock

	FITS1	FIT1	FITS2	FIT2	FITS3	FIT3	FITS4	FIT4
Output gap	0.42	0.43	0.43	0.44	0.30	0.33	0.33	0.35
Inflation	1.02	1.04	1.00	1.02	0.98	1.01	0.97	0.99
Real wage gap	1.69	1.71	1.69	1.71	1.70	1.73	1.70	1.72
Wage inflation	0.15	0.15	0.16	0.16	0.10	0.10	0.11	0.11
Real depreciation rate	1.24	1.28	1.21	1.25	1.21	1.25	1.19	1.22
Unemployment gap	0.83	0.87	0.86	0.89	0.71	0.77	0.75	0.80

The rule (FITS3), which reacts to inflation, output and wage inflation, seems the most appropriate since it best stabilizes better the variables in the face of the productivity shock. The rule (FITS4) that responds to inflation, output, wage inflation and the real effective exchange rate is close to the results of (FITS3). The rule (FIT1) which ignores friction in the labor market and only reacts to inflation and production has the least stabilizing power.

Table 2. Contribution to welfare loss of forward-looking rules following a productivity shock

	Var (Wage inflation)	**Var (Inflation)**	**Var (Output gap)**	**Total**
	inverse Frisch elasticity of labor supply $\varphi = 5$ $\varepsilon_w = 4.52$ wage mark-up $\mu = 1.28$			
FITS1	-0.08	-0.00	-0.24	-0.32
FIT1	-0.08	-0.00	-0.26	-0.33
FITS2	-0.10	-0.00	-0.26	-0.36
FIT2	-0.09	-0.00	-0.27	-0.37
FITS3	-0.05	-0.00	-0.15	-0.20
FIT3	-0.05	-0.00	-0.17	-0.22
FITS4	-0.06	-0.00	-0.17	-0.23
FIT4	-0.06	-0.00	-0.18	-0.24

In the forward looking specification, the rule (FITS3), which reacts to inflation, output and wage inflation, shows the least welfare loss compared to its non-smoothing version and other specifications.

4.2. Backward-Looking Rules

Table 3. Cyclical properties of backward-looking rules following a productivity shock

	FITS1	**FIT1**	**FITS2**	**FIT2**	**FITS3**	**FIT3**	**FITS4**	**FIT4**
Output gap	0.65	0.71	0.69	0.73	0.63	0.69	0.67	0.72
Inflation	0.87	0.89	0.86	0.88	0.85	0.87	0.83	0.85
Real wage gap	1.78	1.81	1.78	1.81	1.76	1.80	1.78	1.80
Wage inflation	0.14	0.14	0.15	0.15	0.09	0.09	0.10	0.10
Real depreciation rate	1.08	1.11	1.06	1.09	1.06	1.10	1.04	1.07
Unemployment gap	1.23	1.32	1.28	1.36	1.19	1.28	1.25	1.32

The rule (FITS3) that reacts to inflation, output and wage inflation still the most appropriate. The rule (FITS2) which reacts to inflation, output and the real effective exchange rate is close to the results of (FITS3). The rule (FIT2), which responds to inflation, output and the real effective exchange rate, has the least stabilizing power.

Table 4. Contribution to welfare loss of backward-looking rules following a productivity shock

	Var (Wage inflation)	Var (Inflation)	Var (Output gap)	Total
	inverse Frisch elasticity of labor supply $\varphi = 5$ $\varepsilon_w = 4.52$	wage mark-up $\mu = 1.28$		
FITS1	-0.08	-0.00	-0.57	-0.64
FIT1	-0.08	-0.00	-0.66	-0.74
FITS2	-0.10	-0.00	-0.64	-0.73
FIT2	-0.09	-0.00	-0.72	-0.81
FITS3	-0.04	-0.00	-0.54	-0.58
FIT3	-0.04	-0.00	-0.63	-0.68
FITS4	-0.05	-0.00	-0.61	-0.66
FIT4	-0.05	-0.00	-0.69	-0.74

In the backward-looking specification, the smoothing rule (FITS3), which reacts to inflation, output and wage inflation, still shows the least loss of welfare.

4.3. Hybrid Rules

Table 5. Cyclical properties of hybrid rules following a productivity shock

	FITS1	FIT1	FITS2	FIT2	FITS3	FIT3	FITS4	FIT4
Output gap	0.43	0.47	0.45	0.48	0.30	0.37	0.33	0.37
Inflation	1.00	1.02	0.98	1.00	0.97	1.00	0.95	0.98
Real wage gap	1.72	1.75	1.72	1.75	1.72	1.75	1.72	1.74
Wage inflation	0.15	0.15	0.16	0.16	0.09	0.09	0.10	0.10
Real depreciation rate	1.22	1.26	1.19	1.23	1.20	1.25	1.18	1.22
Unemployment gap	0.89	0.97	0.92	0.98	0.74	0.84	0.77	0.85

In the hybrid orientation, the rule (FITS3), which reacts to inflation, output and wage inflation, still seems the most appropriate with a stabilizing power higher than its non-smoothing version and other specifications. The rule (FITS4) that responds to inflation, output, wage inflation and the real effective exchange rate is close to the results of (FITS3). The rule (FIT2) that responds to inflation, output and the real effective exchange rate still displays the least stabilizing power.

Table 6. Contribution to welfare loss of hybrid rules following a productivity shock

	Var (Wage inflation)	**Var (Inflation)**	**Var (Output gap)**	**Total**
	inverse Frisch elasticity of labor supply $\varphi = 5$ $\varepsilon_w = 4.52$	wage mark-up $\mu = 1.28$		
FITS1	-0.09	-0.00	-0.28	-0.37
FIT1	-0.09	-0.00	-0.33	-0.41
FITS2	-0.11	-0.00	-0.31	-0.42
FIT2	-0.11	-0.00	-0.34	-0.45
FITS3	-0.05	-0.00	-0.16	-0.21
FIT3	-0.05	-0.00	-0.21	-0.26
FITS4	-0.05	-0.00	-0.18	-0.24
FIT4	-0.05	-0.00	-0.22	-0.28

The rule (FITS3), which responds to inflation, output and wage inflation, still shows the least welfare losses compared to its non-smoothing version and the other specifications.

5. Concluding Remarks

Inflation, unemployment and the depreciation of the national currency are the main problems of the Tunisian's economy; the central bank is mainly focused on inflation since 2006, despite the growing literature on the absence of a divine coincidence, through the introduction of frictions in the DSGE model, as proven by Blanchard & Gali (2007). The introduction of real rigidities, incomplete exchange rate pass-through and labor markets frictions have become common not only in theory but also in central banks models due to the necessity for monetary policy to keep an eye on other variables beside inflation. In this context, we calibrate and simulate for the case of Tunisia, Rhee & Song (2014) model which is based on the work of Gali & Monacelli (2005) and incorporates labor market frictions in open economy. The Phillips curve in the model is forward looking, this specification amplifies the impact of supply shocks, from which the Tunisian economy suffered these years. Our purpose is to compare optimal rules augmented with the effective real exchange rate and wage inflation, while the smoothing is considerate adequate for economies with underdeveloped financial market. Our main finding is that the rules with smoothing have a much better stabilizing power and display lower welfare losses regardless of the orientation of their specifications. The commitment to target inflation, output gap and wage inflation is superior to all other rules especially in the forward specification. Despite the performance of the rule that reacts to the depreciation of the exchange rate, it remains lower than the one that reacts to inflation, output and wage inflation.

References

Adam, K., & Woodford, M. (2013). Housing Prices and Robustly Optimal Monetary Policy. Working Paper (June).

Aghion, P., Bacchetta, P., Ranciere, R., & Rogoff, K. (2009). Exchange rate volatility and productivity growth: The role of financial development. *Journal of Monetary Economics*, 56(4), pp. 494-513.

Aizenman, J., Hutchison, M., & Noy, I. (2011). Inflation Targeting and Real Exchange Rates in Emerging Markets. *World Development*, 39(5), pp. 712-724.

Ball, L. (1999). Policy Rules for Open Economies. In John B. Taylor (ed.), *Monetary Policy Rules*. University of Chicago Press, pp. 127-156.

Blanchard, O., & Galí, J. (2007). Real wage rigidities and the new keynesian model. *Journal of Money, Credit and Banking*, 39, pp. 35–65.

Blanchard, O., & Galí, J. (2010). Labor Markets and Monetary Policy: A New Keynesian Model with Unemployment. *American Economic Journal*, 2(2), pp. 1–30.

Campolmi, A., & Faia, E. (2014). Rethinking Optimal Exchange Regimes with Frictional Labour Market. *Macroeconomic Dynamics*.

Corsetti, G., Dedola, L., & Leduc, S. (2010). Optimal Monetary Policy in Open Economies. In B.M. Friedman and M. Woodford (eds.), *Handbook of*

Monetary Economics, Volume III, pp. 861–933. Amsterdam: Elsevier Science Publishers, B.V.

Christoffel, K., Kuester, K., & Linzert, T. (2006). Identifying the role of labor markets for monetary policy in an estimated DSGE model. Working Paper Series 0635, European Central Bank.

Faia, E. (2009). Ramsey monetary policy with labor market frictions. *Journal of Monetary Economics*, 56, pp. 570-581.

Friedman, M., & Schwartz, A. (1963). *A Monetary History of the United States, 1867–1960*. Princeton, NJ: Princeton University Press.

Gali, J. (2014). Monetary Policy and Rational Asset Price Bubbles. *American Economic Review*, 104 (3), pp. 721–52.

Galí, J., & Monacelli, T. (2005). Monetary Policy and Exchange Rate Volatility in a Small Open Economy. *Review of Economic Studies*, 75 (3), pp. 707-734.

Galí, J., Smets, F., & Wouters, R. (2011). Unemployment in an Estimated New Keynesian Model. Working Papers 541, Barcelona Graduate School of Economics.

Galí, J. (2011a). The Return of Wage Phillips Curve. *Journal of the European Economic Association*, 9 (3), pp. 436-461.

Galí, J. (2011b). *Unemployment Fluctuations and Stabilization Policies: A New Keynesian Perspective.* Cambridge: The MIT Press.

Giannoni, M., & Woodford, M. (2002). Optimal Interest-Rate Rules: I. General Theory. NBER Working Paper No. 9419.

McCallum, B. (1999). *Issues in the design of monetary policy rules, Handbook of Macroeconomics 1*. Elsevier, Amsterdam, pp. 1483-1530.

McCallum, B. (1998). Robustness properties of a rule for monetary policy. *Carnegie-Rochester Conference Series on Public Policy*, 29(1), pp. 53-84.

Meltzer, A. (2004). *A History of the Federal Reserve, Volume 1: 1913-1951*. Chicago, University of Chicago Press.

Meltzer, A. (2014). *A History of the Federal Reserve*, *Volume 2: 1951-1969*. Chicago, University of Chicago Press.

Rhee, H., & Turdaliev, N. (2013). Optimal monetary policy in a small open economy with staggered wage and price contracts. *Journal of International Money and Finance*, 37(C), pp. 306-323.

Rhee, H., & Song, J. (2014). Optimal Monetary Policy and Exchange Rate in a Small Open Economy with Unemployment. *East Asian Economic Review, Korea Institute for International Economic Policy*, 18(3), pp. 301-335.

Rotemberg, J., & Woodford, M. (1997). An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy. In B.S. Bernanke and J.J. Rotemberg (eds.), *NBER Macroeconomics Annual 1997*, pp. 297–361. Cambridge, MA: MIT Press.

Svensson, L. (2000). Open-economy inflation targeting. *Journal of International Economics*, 50(1), pp. 155-183.

Taylor, J. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy*, 39(1), pp. 195-214.

Taylor, J. (1999). *A historical analysis of monetary policy rules.* University of Chicago Press, Chicago, pp. 319-341.

Taylor, J. (2001). The Role of the Exchange Rate in Monetary-Policy Rules. *The American Economic Review*, 91(2), pp. 263-267.

Thomas, C. (2008). Search and matching frictions and optimal monetary policy. *Journal of Monetary Economics*, 55 (5), pp. 936–956.