A New Assessment of the Non-Accelerating Inflation Rate of Unemployment and Capacity Utilization in Tunisia

Kamel Helali[1]

Abstract

The empirical developments made by Phillips are at the origin of theoretical orientations highlighting the capacity utilization rate in relation to inflation. It is in this innovative framework that our research whose focus seems to be varied but we tried to concentrate on the comparison between inflation-unemployment relationships through the NAIRU on the one hand, and the inflation-capacity utilization relationship through the NAIRCU on the other hand. Therefore, the degree of asymmetry between NAIRU and NAIRCU becomes particularly important when the economy operates at an unemployment rate far away from the NAIRU or a capacity utilization rate much higher than the NAIRCU.

Keywords: *Capacity utilization, Phillips curve, NAIRU, NAIRCU, Tunisian economy.*

JEL Classification: *C51, D24, E31, E52.*

Introduction

Since the pioneering work of A. W. Phillips (1958) on the wages-inflation relationship in the UK, the impact of the capacity utilization rate (CU) on the inflation rate has emerged as an important study topic in macroeconomics.

It was in the late 1960s that the Phillips curve theory was first criticised when Friedman (1968) and Phelps (1968) suggested that the nominal variables cannot have an impact on the real ones in the long run. This means that a lower unemployment rate cannot be achieved at the expense of a higher inflation in the long run; however inflation expectations would change the wages and prices are set over the long run. The finding of Friedman and Phelps implied that the inflation-unemployment trade-off exists only in the short-run. In the long run, however, the unemployment converges to his "natural level", and then is

[1] Faculty of Economics and Management of Sfax, University of Sfax. E-mail address: kamel.helali@fsegs.usf.tn. Phone: +216 98667705

transformed into the Non-Accelerating Inflation Rate of Unemployment (NAIRU).

However, the sharp economic acceleration in the US at the end of 1960s led to an extremely rapid rise in tensions exerted on the productive apparatus, which appeared essential to the conjunctural analysis (Gordon, 1975). So, to remedy the shortcomings of the Inflation-Unemployment theory, McElhattan (1978) proposed an alternative measure of aggregate-demand pressures on the inflation rate and estimated the Non-Accelerating Inflation Rate of Capacity Utilization (NAIRCU) for the US, using a reduced-form model and assuming a constant NAIRCU. Thus, we can detect a long-run steady and permanent relation between inflation and CU. A fundamental question was raised: on what non-accelerating inflation capacity utilization rate do we have to operate?

Therefore, our main objective was to find a production capacity level that is consistent with a long-run inflation stability. In this study, the unemployment and CU rates were considered as indicators that characterise the overall inflation in the economy. While estimating the NAIRU and NAIRCU, it relied on two assumptions: 1) constant NAIRU and NAIRCU; 2) time-varying NAIRU and NAIRCU.

The remaining of this paper is structured as follows: section 2 presents the literature review followed by the Inflation-Capacity utilization relationship theoretical development in section 3 to give an overview of the NAIRU and NAIRCU global assessment. The Capacity Utilization estimation and interpretation are the focus of section 4. The constant and the time-varying NAIRU and NAIRCU are estimated in section 5 using the ARDL approach. The concluding section 6 presents the basic inferences deduced from this work.

2. Literature of review

Since the CU has become a leading indicator of consumer price inflation and reflects global growth and demand, several researchers have discussed the relationship Inflation-CU. Among these researchers, we can state Gittings (1989), Nahuis (2003), Oomes and Dynnikova (2006), Meļihovs and Zasova (2009) and Alves and Arnildo (2013). In fact, Gittings (1989) follows McElhattan's (1978) approach, but he accepts two reasons for the existence of inflationary pressures when the CU is high. First, when capacity constraints are achieved, firms are able to increase their prices further to deal with a high demand. Second, the aggregate demand growth increases demand, the prices of new capital, and the costs of financing such equipment. Thus, through the real cycle, the capital price increases relative to the labor one.

On his part, Nahuis (2003) undertook the study of this indicator for the European countries. He claimed that the European countries' NAIRCU is a better indicator of capacity utilization, given the weak labour market elasticity and hysteretic typical for the unemployment rate. As for Oomes and Dynnikova (2006), they estimated the NAIRCU for Russia, assuming it is constant over time. Their results suggest that the output gap in Russia was negative between 1999 and 2003, but may have become positive, thus contributing to inflationary pressures.

Meļihovs and Zasova (2009) tried to walk in the same steps aiming to evaluate the capacity utilisation rate and inflation short-run relationships. These researchers had as objectives: (i) the determination of the CU rate at which no pressure is exerted upon inflation and (ii) showing whether the Latvian economy CU rate was an underlying factor that enhanced an inflationary trend after accessing the EU.

Alves and Arnildo (2013) have estimated the NAIRU, NAIRCU and output gap with Kalman filter relying on quarterly data for 1999Q2-2012Q4 in Brazil. Their findings reveal that the unemployment gap is the important demand variable to explain non-tradable goods inflation, whereas the capacity utilization gap is relevant for tradable goods inflation.

Based on the above analyses, we presented the main models for estimating the NAIRU and NAIRCU in the following section.

3. NAIRU and NAIRCU modelling

3.1 The NAIRU model

Referring to Sekhon (2001) and Ball and Mankiw (2002), a simple model was developed to estimate the NAIRU. It is important to note that it is only significant if it plays a key role in the economic policy determination (see Farzana et al., 2011; Engelbert, 2011; Anoop et al., 2013). The NAIRU model is a standard inflation model based on the anticipation of the augmented Phillips curve:

$$\pi_t - \pi_t^e = \beta\left(u_t - u_t^*\right) + \gamma X_t + \zeta_t \qquad (1)$$

where π_t is the current inflation rate, π_t^e is the expected inflation rate, u_t is the unemployment rate, u_t^* is the NAIRU, X_t is to contain additional explanatory variables to control supply shocks such us money growth or import price, and ζ_t is an error term.

In order to model the expected inflation, authors like Gordon (1995), Tootell (1994), Weiner (1993) and Gagnon (2009) chose a random effect process presented by $\pi_t^e = \pi_{t-1}$, representing the naive inflation. So $\pi_t - \pi_t^e = \Delta\pi_t$. Hence, equation (1) would be written as follows:

$$\Delta\pi_t = \beta(u_t - u_t^*) + \gamma X_t + \zeta_t \qquad (2)$$

This equation neglects the possibility of a serial correlation in terms of errors. Therefore, an autoregressive specification could be conventionally estimated:

$$\Delta\pi_t = \mu + \beta(L)u_t + \delta(L)\Delta\pi_{t-1} + \gamma(L)X_t + \varepsilon_t \qquad (3)$$

where L is a lag operator, $\beta(L)$, $\delta(L)$, and $\gamma(L)$ are polynomial lags, ε_t is an uncorrelated error term and $\mu = -\beta(L)u_t^*$. The NAIRU (u_t^*) estimator is then:

$$\hat{u}^* = -\hat{\mu}/\hat{\beta}(1) \qquad (4)$$

where $\beta(1) = \sum_{i=1}^{p} \beta_i$, with p number of lags of the polynomial $\beta(L)$. It should be noted that the NAIRU is a nonlinear function of the coefficients μ and $\beta(1)$.

The estimated approach in equations (3) and (4) may change if the NAIRU varies over time. In order to achieve this work, we have to replace the $\hat{\mu}$ with $\sum_{j=1}^{l} \alpha_j H^{j-1}(t)$, where H^j is a Hermite polynomial of order j and t is the time centred around 0. Therefore, we have:

$$\Delta\pi_t = \sum_{j=1}^{l} \alpha_j H^{j-1}(t) + \beta(L)u_t + \delta(L)\Delta\pi_{t-1} + \gamma(L)X_t + \varepsilon_t \qquad (5)$$

And the time varying NAIRU estimate is:

$$\hat{u}^* = -\sum_{j=1}^{l} \alpha_j H^{j-1}(t) \Big/ \hat{\beta}(1) \qquad (6)$$

3.2 The NAIRCU model

To obtain a certain relationship between the inflation and CU rates, an assumption has to be made about the expected inflation formation. Specifically, the NAIRU and the NAIRCU are special cases of natural rates where the above described anticipated supposition is invoked. If this assumption is not taken into account, then on average, this relation will be unstable. To examine the Inflation-CU relationship in a more precise way, we start with a series of regressions of the following form:

$$\Delta\pi_t = \pi_t - \pi_{t-1} = b_0 + b_1 CU_t + \sum_{i=1}^{n} b_{2i}\pi_{t-i} + \varepsilon_t \qquad (7)$$

where $\Delta\pi_t$ is the inflation variation between t and t-1 and b_0, b_1 and b_{2i} are the parameters to be estimated. Empirically, it is necessary to show that the CU is significant and positive to indicate that a high CU leads to an inflation increase. Thus, the extent of the CU varies with the data used.

The estimated optimal CU rate is defined by $\text{NAIRCU} = -\hat{b}_0 / \hat{b}_1$, which is the rate of full utilization associated with the inflation rate stability. Thus, any change in the inflation rate will be zero. Similarly, lags can be introduced in the CU and inflation and their effect on the relationship can be evaluated for their significance at the 5% level. It is interesting, as well, to estimate the confidence interval of the equilibrium rate at a 95% confidence level. This will allow politicians to profit from the knowledge about the average capacity utilization rate that leads to higher inflation if there is a large uncertainty interval associated with this estimate. The used formula to calculate the confidence interval was provided by McElhattan (1978) and defined as follows:

$$\left(A \pm \sqrt{A^2 - BC}\right) / C \qquad (8)$$

where $A = b_0.b_1 - t_{(n-2)}^{\alpha/2} S_{b_0 b_1}$, $B = b_0^2 - \left(t_{(n-2)}^{\alpha/2}\right)^2 S_{b_0}^2$, $C = b_1^2 - \left(t_{(n-2)}^{\alpha/2}\right)^2 S_{b_1}{}^2$, $S_{b_0}^2$ is the constant estimated variance, $S_{b_1}^2$ is the CU coefficient estimated variance, $S_{b_0 b_1}$ is the covariance between b_0 and b_1 and $t_{(n-2)}^{\alpha/2}$ is the student statistic at *n-2* degrees of freedom.

4. Capacity Utilization estimation and interpretation

In general, the short run production decisions may not be optimal and thus the produced quantities may not correspond to the minimum of the average total cost (Berndt and Morrison, 1981; Helali et al., 2016). This sub-optimality can be attributed either to the firms' poor management or to the institutional framework in which these firms operate.

4.1 Capacity utilization model and measures

According to the Marshallian tradition, to estimate the short-run production capacity (PC), we develop the variable cost function with a quasi-fixed capital variable at constant return to scale (CRS). In fact, this function is specified as $VC = VC(p_j; Y, K; t)$ where *VC* is the variable cost, p_j is a vector of *j* prices of the variable factors (Labor (*L*) and Energy (*E*)), *Y* is the production level, *K* is the fixed capital stock and *t* represents the technological state. The total short-run cost is represented by:

$$TC_{SR} = VC + FC \qquad (9)$$

where *FC* is the fixed cost equal to $p_K K$ with p_K is the capital price. By dividing this equation by the output *Y*, we obtain the short-run average total cost function

(ATC_{SR}). The PC short-run measure is determined by the level that minimizes the ATC_{SR} (Cassels, 1937).

This measure was theoretically and empirically generalized by Morrison (1985) to incorporate non-constant returns to scale (NCRS) and monopolistic behaviour. Based on the fictive cost function notion, a formulation which develops the PC notion as the output that corresponds to the steady state is used to give values to all exogenous variables including the fixed inputs stock. More specifically, the short-run fictive total cost function at NCRS can be characterized by:

$$TCf_{SR} = VC - Z_K K \qquad (\mathbf{10})$$

where Z_K is the capital shadow price which represents the capital marginal efficiency in a dynamic model to explain the fixed input cyclical phenomena and movements. If Y_m is the output that minimizes the fictive average total cost function ($ATCf_{SR}$), then we have $\partial ATCf_{SR}/\partial Y_m = 0$. The resolution of this equation makes it possible to estimate the value of Y_m. Thus, the CU estimate is defined by $CU_m = Y/Y_m$.

The PC alternative measure proposed by Klein (1960) and Friedman (1963) in the long run corresponds to the short-run average total cost curves tangency (ATC_{SR}) with the long-run one (ATC_{LR}). All the factors are variable over the long-run, a firm generally opts to employ a plan that minimizes the ATC_{SR} for a given level of production. By imposing the equilibrium condition in terms of equality of the fictive cost function with the total cost function, the CU measurement may be equivalent to the tangency specification involving NCRS. The curves of total marginal cost at short- (MTC_{SR}) and long-, runs (MTC_{LR}) must meet at the value representing the tangency point of the ATC_{SR} and ATC_{LR} curves.

By equalizing MTC_{SR} and MTC_{LR}, we obtain a measure of the tangency point, noted by Y_t. Thereafter, the CU is estimated at NCRS by $CU_t = Y/Y_t$.

Relying on the variable returns to scale assumption, we develop the Translog flexible cost function. Since the variable cost is written in the form $VC = p_L.L + P_E.E$, the short-run Translog variable cost function with quasi-fixed capital factor and NCRS can be written as follows:

$$LnVC = \alpha_0 + \alpha_t t + \tfrac{1}{2}\gamma_{tt} + \sum_{i=L,E}\alpha_i Ln\, p_i + \tfrac{1}{2}\sum_{i=L,E}\sum_{j=L,E}\gamma_{ij}\, Ln\, p_i\, Lnp_j + \beta_Y\, LnY + \beta_K\, LnK + \tfrac{1}{2}\gamma_{YY}(LnY)^2 + \tfrac{1}{2}\gamma_{KK}(Ln K)^2$$
$$+ \sum_{i=L,E}\rho_{Yi}\, LnY\; Ln\, p_i + \sum_{i=L,E}\rho_{Ki}\, LnK\; Ln\, p_i + \rho_{YK}\, LnY\; LnK + \rho_{tY}\, t\, LnY + \rho_{tK}\, t\, LnK + \sum_{i=L,E}\rho_{ti}\, t\, Ln\, p_i \qquad (\mathbf{11})$$

From Shephard lemma, we determine the optimal variable inputs shares by a logarithmic differentiation of the variable cost function as *K*, *Y* and *t* are already known. Indeed,

$$S_i = \alpha_i + \gamma_{ii} Ln\, p_i + \gamma_{ij} Ln\, p_j + \rho_{Yi} LnY + \rho_{Ki} LnK + \rho_{ti}\, t \qquad (12)$$

For the quasi-fixed input, let S_K be its fictive part in the variable cost relative to the shadow value Z_K. Indeed,

$$S_K = \beta_K + \gamma_{KK} LnK + \rho_{YK} LnY + \rho_{KL} Ln\, p_L + \rho_{KE} Ln\, p_E + \rho_{tK}\, t \qquad (13)$$

If long-run prices are specified at a marginal cost, the differentiation of the cost function with respect to the change of *Y*, noted S_Y, gives us:

$$S_Y = \beta_Y + \rho_{YK} LnK + \gamma_{YY} LnY + \rho_{YL} Ln\, p_L + \rho_{YE} Ln\, p_E + \rho_{tY}\, t \qquad (14)$$

By imposing the homogeneity compared with 1 degree of price, the average cost function as well as the equations shares at NCRS were defined a system composed by (*AVC*, S_L, S_E, S_K, S_Y). To solve the singularity problem, it is necessary to eliminate the labor share equation of our analysis as $S_L + S_E = 1$. The system is estimated by the constrained iterative SURE method of Zellner (1962). Similarly, it is worth noting that with NCRS there is a difference between the expressions of Y_m and Y_t.

4.2 Capacity utilization estimation and interpretation

The study used data cover the overall Tunisian economy observed during the period 1975Q1-2014Q4. Quarterly data were obtained from the National Institute of Statistics (NIS), the Tunisian Institute of Competitiveness and Quantitative Studies (TICQS) and the Tunisian Company of Electricity and Gas (TCEG). The used data include production (*Y*), labor (*L*), capital stock (*K*), energy cost (*E*), average annual wage (p_L), payroll (*MS*), capital price (p_K) and energy price (p_E).

The final iterative constrained SURE iterative model, after the serial correlation correction is summarized in Table 1. The estimates of the Translog cost function with NCRS showed economic evidence. In fact, the convexity with respect to *K* and the concavity with respect to the inputs prices are verified. The estimated coefficients are of expected signs particularly for $\hat{\gamma}_{KK} = 0.0014$. In addition, the energy factor has no significant effect on capital. Economically, these results are not surprising, due to the variables' nature and construction that are generally aggregations.

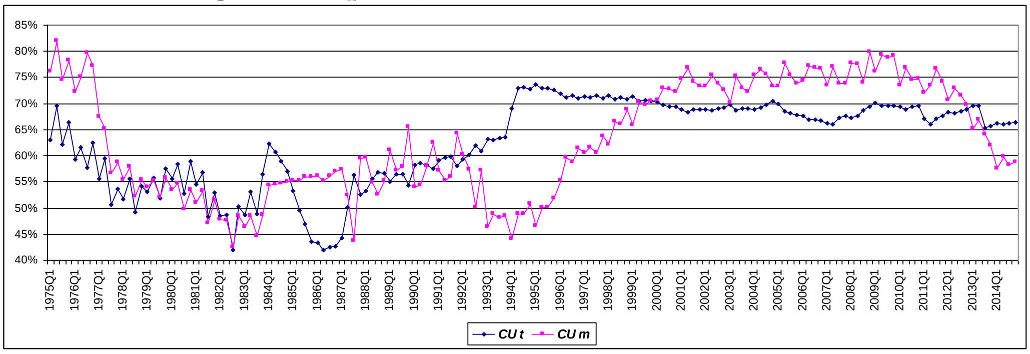
Table 1: Translog cost function estimation at NCRS

Variables	Coefficients	t-Statistics	p-values
α_0	-1.704	-55.72	0.00
α_L	0.434	100.66	0.00
α_E	0.566	100.66	0.00
β_Y	0.089	31.09	0.00
β_K	1.006	253.41	0.00
γ_{LL}	0.139	21.99	0.00
γ_{EE}	0.139	21.99	0.00
γ_{LE}	-0.139	-21.99	0.00
γ_{YY}	0.008	24.22	0.00
γ_{KK}	0.001	3.20	0.00
ϱ_{YK}	-0.011	-39.28	0.00
ϱ_{YL}	-0.0003	1.04	0.30
ϱ_{YE}	0.0003	-1.04	0.30
ϱ_{KL}	0.007	23.80	0.00
ϱ_{KE}	-0.007	-23.80	0.00
α_t	-0.006	-12.70	0.00
α_{tt}	$-0.4\ e^{-4}$	-8.50	0.00
ϱ_{tK}	$0.2\ e^{-3}$	46.52	0.00
ϱ_{tY}	$0.7\ e^{-4}$	14.30	0.00
ϱ_{tE}	-0.003	-48.14	0.00

It should be noted that we tested both: a constant return to scale (CRS) cost function and a NCRS function. Thus, the chi-square test shows a much greater value of 1967.8 to the tabulated value at 5%. So the null hypothesis of the CRS was rejected and the NCRS was adopted.

Based on the above estimates, we can present the evolutions of the two capacity utilizations (CU_t and CU_m) at NCRS as in Figure 1. We can remark a strong correlation between the two results with a small increase for CU_m with respect to CU_t. This shows that the Tunisian economy is characterized by an under-utilization of the production capacity, on the one hand, and, mainly, the appearance of decreasing returns to scale in most periods, on the other. Besides, this presentation shows weak CU rates during the 1980s and 1990s caused by the investments effect after the structural adjustment plan (SAP) of the 1980s. In fact, these rates reached their maximum levels of 80%. In addition, it is clearly noticeable that the economy is represented by an inefficient technology policy leading to decreasing returns to scale throughout the study period 1975Q1-2014Q4. This industrial inefficiency proved by this CU performance indicator is logical when considering the available resources and the country adopted economic policy. Therefore, we can conclude that there is a lack of productive performance at the global and even sectoral level. So we can observe these problems in analyzing certain CU points in terms of the exogenous variables price change. In fact, the 1980-1987 periods should be allowed great importance and interpretation as it corresponds to the decline of the trend of the CU. After that, the CU continued to grow until 2010, reaching a record level of over 79.5%. However, a downward trend is remarked since 2010 to reach a rate of 57% in 2014.

Figure 1: Capacity utilization evolution at NCRS



The objective of the above procedure was to understand the origins and consequences of the production capacities under-utilization in the context of an endogenous growth model different from the disequilibrium models often developed to deal with this type of question. It is, therefore, necessary to know whether the existence of capacities under-utilization modifies the response of an economy to an aggregate shock. But at this point, some other problems arise consisting in whether the performance is to achieve a CU close to or equal to 100% and what the consequences of the production capacity under-utilization on long-run growth are.

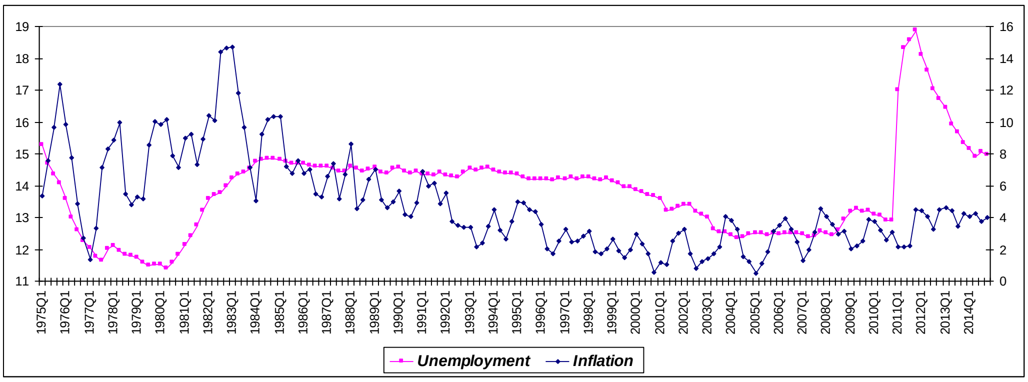
5. Estimation and interpretation of NAIRU and NAIRCU

5.1 Data presentation and integration analysis

The study of the relationship between inflation and unemployment, on the one hand, and the relationship between inflation and CU, on the other hand, is based on the following macroeconomic variables: CU, capacity utilization rate estimated from the Translog cost function with non constant returns to scale; $\pi_t = Log(CPI_t / CPI_{t-4})$, inflation rate as measured by quarterly changes in the Consumer Price Index (CPI) and *u*, unemployment rate. By observing the temporal evolution of the model different variables, we find that all the series display stability problems over time either at the level of the mean or the variance.

From Figure 2, we can see that it shows upward and downward trends with considerable shocks during the 1980s. Despite its stability at around 5%, from the year 2000, this series remains non stationary. The unemployment rate in Tunisia is not stable, either and shows strong disruptions during periods of crisis like that of 2011 when it reached a maximum value of 18.9%. There are, therefore, considerable shocks which make this series non-stationary.

Figure 2: Unemployment and Inflation rates evolution



In this section, we took into account the evolution of the CU, which was already developed in section 4. Indeed, and according to Figure 1, the CU series also exhibits unstable movements and upward and downward trends relative to the country economic situation. The CU series evolved between 42.4% and 82.0% with a low standard deviation of 10%. All of its observations make the CU series non-stationary.

In the beginning of the empirical study of this section, each variable has to be examined for stationarity. The models used are based on the assumption of the stationarity of all variables in the regression. In fact, from Figures 1 and 2, the evolution of the variables is characterized by the presence of breaks. In our study, in order to effectively study the statistical properties of the variables, we will use the Zivot and Andrews (1992) test, which gives greater flexibility to the modelling of the deterministic component of the data generating process.

Table 2: Zivot and Andrew (1992) unit root test in level and first difference

Model	Designation	*CU*	*CPI*	*u*	*ΔCU*	*ΔCPI*	*Δu*
A	**Break date**	1996Q1	1997Q4	1999Q1	1982Q4	1991Q4	1988Q2
	t-statistic	-2.81	-2.92	-3.42*	-4.87***	-4.73**	-3.91***
B	**Break date**	2009Q1	1987Q1	1984Q1	1984Q2	2004Q4	2001Q4
	t-statistic	-2.52	-2.31	-3.27	-5.29***	-5.47***	-4.63**
C	**Break date**	2008Q1	2004	2000Q1	1982Q4	1987Q4	1984Q2
	t-statistic	-2.57	-2.63	-3.19	-5.25***	-4.47**	-3.88**
Decision		**NS**	**NS**	**NS**	**S**	**S**	**S**

Note: Δ represents the first difference. *, ** and *** represent significance at 10%, 5% and 1%, respectively. S and NS mean stationary and not stationary.

As shown in Table 2, all the variables are integrated in order 1. Non-stationarity is both deterministic and stochastic for all the variables. All variables exhibited significant breaks. The first difference of each of these variables, on the other hand, is stationary.

5.2 NAIRU estimation and interpretation

The stationarity tests of the variables of the inflation model (3) show that the inflation and unemployment are non-stationary in level. To solve this problem of integration order, the ARDL approach of cointegration was used. This approach is developed by Pesaran et al. (2001) to estimate the short- and the long-run relationship between the variables. This approach tests the cointegration relationship without requiring the same order of integration of all variables.

The ARDL approach is probably the most widely used model for estimating relationships in the time series context. In this work we wonder whether inflation and unemployment are cointegrated using the new Bounds tests procedure to analyze the level of relationship with the ARDL structure. The general form of the ARDL model is:

$$\Delta y_t = \alpha_0 + \delta_1 y_{t-1} + \delta_2 x_{t-1} + \sum_{i=1}^{p} \lambda_i \Delta y_{t-i} + \sum_{j=0}^{q} \beta_j \ \Delta x_{t-j} + v_t \qquad (15)$$

where $y_t = CPI_t$, $x_t = u_t$ and v_t an error term checking the properties of Gauss-Markov.

Before testing the model, we present a brief discussion of the ARDL approach of cointegration. As mentioned in Pesaran and Shin (1999), there are two steps to achieve the ARDL approach to the cointegration procedure.

Firstly, we test the existence of a long-run relationship between the variables in the system. In particular, the null hypothesis of having no integration or a long-run relationship between the system variables $H_0 : \delta_1 = \delta_2 = 0$ is tested against the alternative hypothesis $H_1 : \delta_1 \neq 0 ; \delta_2 \neq 0$. The Bounds tests procedure is based on Fisher's F-statistic. This statistic used for this procedure has a non-standard distribution because the variables in the system are either I(0) or I(1). Thus, two sets of critical values are computed by Pesaran et al. (2001) for a given level of significance. For example, if the calculated F-statistic exceeds the upper limit of the critical values, then the null hypothesis (H_0) is rejected.

Secondly, once the long-run relationship is established, then the long-run estimates and the error correction model (ECM) of the ARDL model can be obtained from equation (15). The estimation of an ARDL model requires determining the number of lags to be introduced in a first step. The Akaike information criterion (AIC) and the Schwarz criterion (SBC) are often used. In general, the SBC is preferred to the AIC as the latter tends to retain too many lags. In the second step of the ARDL cointegration method, we can perform a parameter stability test for the appropriately selected ARDL representation of the error correction model. However, it is also possible to overcome the shortcomings of the prior methods (Hansen and Johansen, 1993) using the Brown's et al. (1975) procedure if we follow Pesaran et al. (2001). The stability test technique of Brown et al. is based on the residuals of the recursive regression. A general representation of the ECM of equation (15) is formulated as follows:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p} \lambda_i \Delta y_{t-i} + \sum_{j=0}^{q} \beta_j \, \Delta x_{t-j} + \delta \, EC_{t-1} + \xi_t \qquad (16)$$

where δ is the adjustment parameter speed and EC are the residuals obtained from the cointegration model estimate of equation (15). The long run conditional model for $y_t = \Delta CPI_t$, can be obtained from the solution of the reduced form of (15), when $\Delta y_{t-i} = \Delta x_{t-i} = 0$:

$$\Delta CPI_t = \Theta_0 + \Theta_1 \, u_t + v_t \qquad (17)$$

where $\Theta_0 = -\alpha_0 / \delta_1$, $\Theta_1 = -\delta_2 / \delta_1$, and v_t are the random errors. These long-term coefficients are estimated by the ARDL approach of cointegration of Pesaran and Shin (1999). This implies the estimation of the conditional ECM in (16) by OLS and the use of different criteria to determine the optimal structure for the ARDL specification of the short-run dynamics. The estimation results of this short-run dynamics are presented in Table 3.

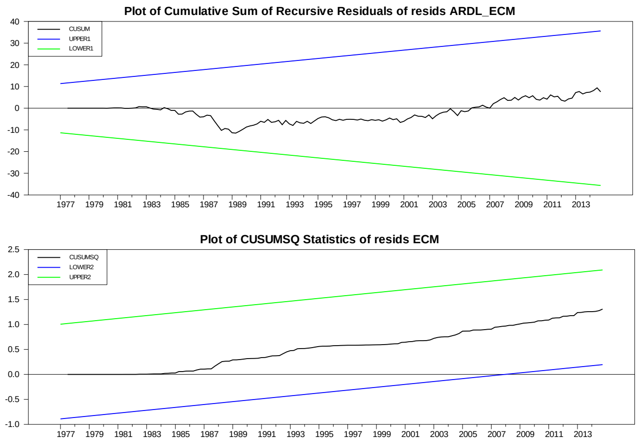
Table 3: Short-run Phillips Curve estimation: Constant NAIRU

Maximum lag order		5
F-Statistic		18.77***
SBC		-1.400
ARDL Model		(5; 2)
Inflation: ΔCPI	**Variables**	**p-values**
CPI_{t-1}	-0.049	0.000
u_{t-1}	-0.204	0.000
ΔCPI_{t-1}	1.401	0.000
ΔCPI_{t-2}	-0.617	0.000
ΔCPI_{t-3}	0.139	0.340
ΔCPI_{t-4}	-0.394	0.004
ΔCPI_{t-5}	0.414	0.000
Δu_t	-0.037	0.605
Δu_{t-1}	-0.052	0.635
Δu_{t-2}	-0.059	0.042
trend	0.046	0.000
Constant	-3.043	0.000
EC_{t-1}	-0.387	0.030
$\bar{R}^2$		0.97
DW		1.87

Note: *** means that the F statistic is above the upper bound of 99% for $k = 2$.

Table 3 shows the negative effect of the unemployment rate on the CPI quarterly change. The inflation equation finds its effectiveness in 5 inflation lags and more precisely for an ARDL (5; 2). The long-run estimate makes it possible to deduce a point estimate of the NAIRU for the Tunisian case. In order to perform the stability test on the preferred representation of the ARDL error correction model, the ECM-ARDL representation, given by the error correction term EC_{t-1}, is estimated in Table 3.

Figure 3: CUSUM and CUSUMQ representations: Constant NAIRU



The results indicate that the error correction term, EC_{t-1}, is statistically significant. This evidences the cointegration relationship between the model variables. In particular, the estimated value of EC_{t-1} is -0.387, implying that the long-run equilibrium adjustment speed in response to the imbalance caused by the short-run shocks of the previous period is 38.7%. To test the model stability, we applied the CUSUM and CUSUMQ tests. These tests are useful for determining the CUSUM and CUSUMQ statistics and their limit values. Figure 3 shows the model stability at a 95% confidence level.

Table 4: Long-run Phillips curve estimation: Constant NAIRU

Designation	CPI	
	Variables	**p-values**
Constant	-61.012	0.000
u	-4.086	0.000
NAIRU	14.93%	
Standard Deviation	0.72	
Confidence interval at 95%	13.52% – 16.35%	

Table 4 shows the long run result of the relationship between variables. It shows that the unemployment rate is very significant and has the good negative sign as expected. This indicates that there is a negative relationship between inflation and unemployment for the case of the Tunisian economy in the long run. The unemployment equilibrium rate which does not allow the inflation acceleration is evaluated by the NAIRU at a rate of 14.93% at a 95% confidence interval of a significance equal to [13.52 - 16.35]%.

The estimated approach may vary if the NAIRU changes over time. Referring to equations (5) and (6), we add the Hermite polynomials to the above estimate; three important remarks can be noted: First, the choice of the three polynomials (H^0, H^1 and H^2) was because the polynomials of order greater than 2 have too weak and insignificant effects. Second, the number of lags remained equal to 5 for the CPI. Third, for the unemployment rate, the number of lags was set to 0 to choose an ARDL(5; 0) model.

Table 5: Short-run Phillips Curve Estimation: Time-varying NAIRU

Maximum lag order		5
F-Statistic		15.72^{***}
SBC		-1.388
ARDL Model		(5; 0)
Inflation: ΔCPI	**Variables**	**p-values**
CPI_{t-1}	-0.044	0.000
u_{t-1}	-0.138	0.000
ΔCPI_{t-1}	1.387	0.000
ΔCPI_{t-2}	-0.607	0.000
ΔCPI_{t-3}	0.128	0.384
ΔCPI_{t-4}	-0.360	0.009
ΔCPI_{t-5}	0.386	0.000
Δu_t	-0.091	0.026
$\boldsymbol{H^0}$	-1.929	0.000
$\boldsymbol{H^1}$	0.024	0.014
$\boldsymbol{H^2}$	$-0.5e^{-4}$	0.356
EC_{t-1}	-0.307	0.088
	$\bar{R}^2$	***0.97***
	DW	***1.87***

Note: *** means that the F statistic is above the upper bound of 99% for $k = 2$.
Table 5 estimates without the unemployment rate trend did not show a strong divergence. A delay in the unemployment rate was more significant than the variable in level and shows its effect on inflation. The time-varying NAIRU would be estimated from the long-run estimates.

The long-run results (Table 6) show the negative and significant effect of the unemployment rate on inflation. This can be clearly seen from Figure 4 which shows the evolution of the time-varying NAIRU with the unemployment rate.

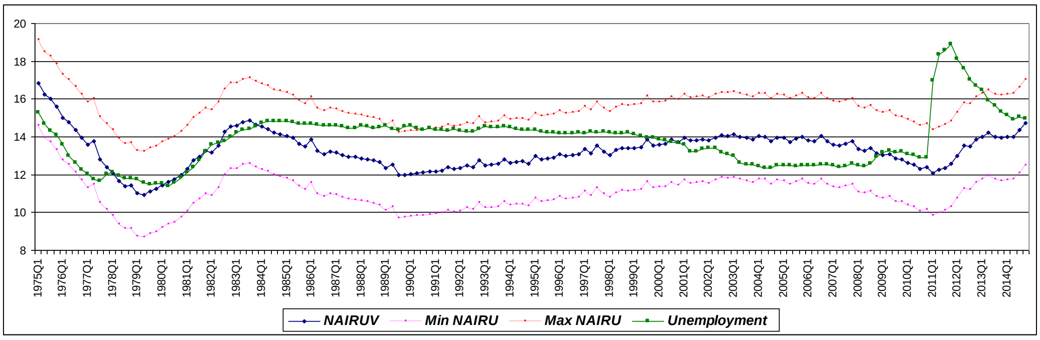
Table 6: Long-run Phillips Curve Estimation: Time-varying NAIRU

Designation	CPI	
	Variables	p-values
Constant [d]	-44.365	0.000
u	-3.169	0.000
NAIRU	13.99%	
Standard Deviation	2.889	
Confidence interval at 95%	8.33% – 19.66%	

Note: d is an average value of the Hermite polynomials series.

The estimated NAIRU points, displayed in the below figure, show little growth around 2.5% between 1975 and 2014. In fact, if u < NAIRU for a small period, the inflationary pressures increase, and inflation tends to accelerate. This was what characterized the 1975-1982 phase, when there was a sharp increase in inflation (14%) accompanied by a financial crisis explaining the 1983-1985 difficulties. At the same time, a CU sharp drop was recorded reaching a minimum of 43%.

Figure 4: Time-varying NAIRU evolution



On the other hand, if we have u > NAIRU, inflationary pressures fall, and the inflation rate tends to slow down (a deflation phenomenon appears). This phase characterized the years when the Tunisian economy recovered. The structural adjustment program of 1987-1988 was able to liberate most of the prices of the financial sector, which made it possible to regain the competitive environment. Thus, the economy recorded a moderate inflation rate allowing a satisfactory macroeconomic policy to continue. This might be justified by the return to using the production capacity. Nevertheless, the Tunisian economy was not able to reduce the unemployment rate.

Finally, if u = NAIRU, the inflation rate tends to remain stable, unless exogenous shocks occur. These shocks include the second Gulf War of 1991, which increased the inflation rate to 8.2% and lowered the CU to 50%, while the unemployment rate is framed by the NAIRU confidence interval.

5.3 NAIRCU estimation and interpretation

Similarly, to examine the robustness of the relationship between inflation and unemployment rate more accurately, we studied the relationship between Inflation and CU in which we applied the ARDL approach where y_t and x_t represent CPI and CU, respectively.

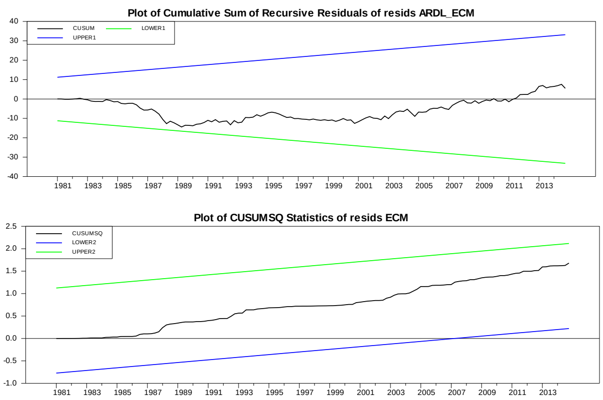
Table 7: Choice of the maximum number of lags: Constant NAIRCU

Without trend			With trend		
Lags Order	**F statistic**	**p-values**	**Lags Order**	**F statistic**	**p-values**
4	F(2, 140) = 0.155	0.856	4	$F(2, 28) = 5.560^{**}$	0.004
5	F(2, 137) = 0.021	0.979	5	$F(2, 25) = 12.265^{***}$	0.000
6	F(2, 134) = 0.064	0.938	6	$F(2, 22) = 8.068^{**}$	0.000

Note: The critical values are obtained from Table III (unrestricted intercept and no trend with an explanatory variable k = 2) in Pesaran et al. (2001, p.300). There are 4.04-4.78 at the 90% level, 4.94-5.73 at the 95% level, and 5.77-6.68 at the 99% level. ** and *** mean that the F statistic is above the upper bound at 95% and 99%, respectively.

The Fisher statistics are shown in Table 7 and indicate that all F-statistics are at least 99% significant for a model with trend. These results prove that the null hypothesis of the absence of a long-run relationship can be strongly rejected. The long-run relationship between CU and inflation is, therefore, obvious and we can then proceed to the next step of the analysis. A maximum number of lags equal to 5 was chosen due to the high value of the F-statistic.

Figure 5: CUSUM and CUSUMQ representations: Constant NAIRCU



As far as the diagnosis of the different ARDL models is concerned, the results show that the most appropriate model is represented by an ARDL (5; 5). Table 8 provides the results of the short-run estimate of the ARDL (5; 5) model. These show that, in the short-run, at least one of the lags of the system variables is statistically significant at 5%. The adjusted coefficient of determination ($\overline{R}^2 = 0.97$) shows a good fit and therefore the model is well specified.

Table 8: Autoregressive Distributed Lag estimate: Constant NAIRCU

Maximum lag order		5
F-Statistic		12.265***
SBC		-1.228
ARDL Model		(5; 5)
Inflation: ΔCPI	**Variables**	**p-values**
CPI_{t-1}	-0.037	0.000
CU_{t-1}	1.805	0.009
ΔCPI_{t-1}	1.419	0.000
ΔCPI_{t-2}	-0.594	0.000
ΔCPI_{t-3}	0.169	0.273
ΔCPI_{t-4}	-0.462	0.002
ΔCPI_{t-5}	0.454	0.000
ΔCU_{t}	-2.699	0.025
ΔCU_{t-1}	2.492	0.071
ΔCU_{t-2}	0.645	0.591
ΔCU_{t-3}	-0.242	0.835
ΔCU_{t-4}	-1.753	0.162
ΔCU_{t-5}	1.471	0.019
trend	0.038	0.000
Constant	1.193	0.013
EC_{t-1}	-0.093	0.014
	$\overline{R}^2$	0.97
	DW	1.92

In order to perform the stability test on the preferred representation of the ARDL method error correction model, the ECM_ARDL representation shown by equation (17) was estimated by the error correction term in Table 8. The results indicate that the error correction term, EC_{t-1}, is statistically significant evidencing the cointegration relationship between the model variables. In particular, the EC_{t-1} estimated value is -0.093, implying that the adjustment speed of the long-run equilibrium in response to the imbalance caused by the short-run shocks of the

previous period is 9.3%. To test the model stability, the CUSUM and CUSUMQ tests were used. Figure 5 shows the model stability for a 95% confidence level.
Table 9 shows the result of the long-run relationship between the variables. It shows that the CU is largely significant and has a positive sign. This indicates that there is a positive relationship between inflation and CU for the case of the Tunisian economy in the long-run.

Table 9: Long-run results: Constant NAIRCU

Designation	CPI	
	Variables	**p-values**
Constant	32.438	0.014
CU	49.081	0.005
NAIRCU	65.24%	
Standard Deviation	0.233	
Confidence interval at 95%	60.68% - 69.80%	

Referring to the long-run estimation, a stable inflation rate is consistent with the equilibrium CU. In fact, the equilibrium CU was estimated without taking into account the effects of oil shocks or contemporary economic phenomena. The NAIRCU value was estimated at 65.2%. This estimate clearly shows the underutilization of the production factors and the inefficiency of the production system in Tunisia. When using the CU as an indicator of inflationary pressures it is important to consider the accuracy of the NAIRCU assessments.

Accuracy is distributed here with a 95% significance level confidence interval. The estimate for the entire period shows an interval of [60.68 - 69.80]%. This gap appears too narrow to provide a significant signal of potential inflationary pressures.

Over the long run, the CU positive effect can be clearly observed. In fact, the CU does check the theoretical concepts of a positive effect on inflation. On the other hand, an inflation increase is also observed which indicates that the CU is a source of inflationary pressures in Tunisia. The inflation due to consumption is too much influenced by the import of non-energy goods because the oil crisis of the 1970s did not affect inflation growth. The unemployment rate, also, can be a serious source of inflationary pressures.

Using the same procedure to estimate the time-varying NAIRU, we estimated the time-varying NAIRCU through another ARDL model (5; 5). In fact, the variable NAIRCU has to be estimated from the long-run relationship presented in Table 10. The long-run results enable us to detect a positive and significant effect of the

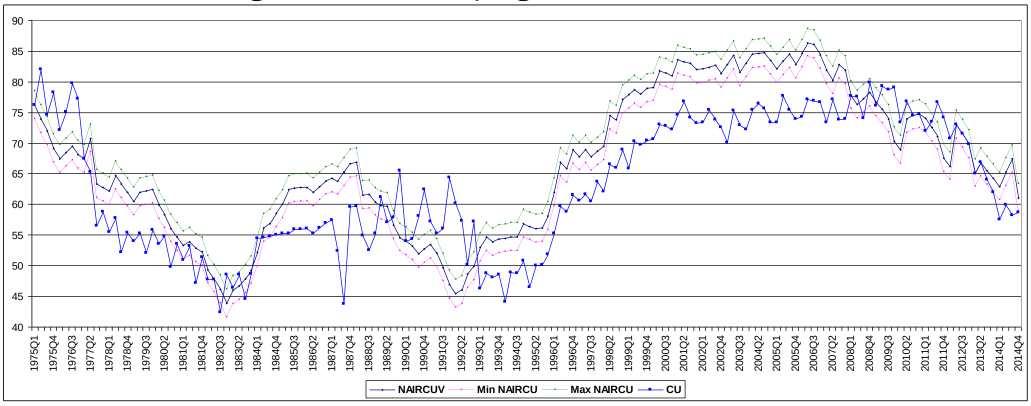
CU on inflation. This can be clearly seen in figure 6 which shows the strong correlation of CU with the time-varying NAIRCU.

Table 10: Long-run results: Time-varying NAIRCU

Designation	CPI	
	Variables	p-values
Constant	35.67	0.000
CU	53.53	0.000
NAIRCU	66.64%	
Standard Deviation	11.47%	
Confidence interval at 95%	64.37% – 68.90%	

In fact, if CU > NAIRCU for a short period, the inflationary pressures increase, and inflation tends to accelerate (a rampant inflation phenomenon appears). This was the case of 1975-1977 and 1988-1992 phases, when there was a sharp increase in inflation (14%) accompanied by a financial crisis explaining the 1982-1986 difficulties. In fact, Tunisia is too dependent on oil revenues and is penalized by its external indebtedness, burdening the public finances which have hitherto provided for the subsidization of prices. Moreover, it does not have a sufficient productive base to be able to absorb the surplus of workers and export a diversified and competitive range of products. The lack of state investment in infrastructure still hampers growth and deters private investors (Morrison and Talbi, 1996).

Figure 6: Time-varying NAIRCU evolution



It can be deduced from this work that the CU in Tunisia can be an effective inflationary pressures indicator for various reasons. First, the Tunisian economy has witnessed inflation rate stability over the recent years, which does not allow us to distinguish between the various fluctuations in the inflation trajectory measured by the consumer price index. Second, the oil shocks or financial crises experienced during the study period were solved either by an economic growth (the 1970s) or by a structural adjustment plan (1987-88). The problems of the Tunisian economy are the result of a poor management in the use of production resources without greatly influencing the financial evolution of the economy.

5. Conclusion

The comparison of the CU estimates offers several interesting results. Considering the model with a single quasi-fixed factor "capital" leads to the result of an inefficiency of the Tunisian economy (CU < 100%). This indicates an investment optimization leading to a shortage of capacity in terms of investment of the present value, although the current observation at the NCRS indicates an excess of capacity. The growth rates difference over the years decreased along with this adaptation. It is worth reminding that this adjustment of scale recognizes the difference between the decreases in costs due to pure technical progress, on the one hand, and those caused by the economies of scale, on the other.

In addition, this study highlighted the similarity between the analyses using the NAIRU concept and those using the NAIRCU. It seems that the best way to show this similarity is through replacing the unemployment rate by the capacity utilization in a simple model of an augmented Phillips curve.

The arbitrage analysis between inflation and production capacity was generally based on the assumption that arbitrage is symmetrical, that is, it is possible to reduce a thrusting in inflation due to inflation access to demand without any net loss of production or employment. However, our analysis shows that an excess of demand is more inflationary than an excess of supply which is rather deflationary (asymmetric). Thus, any increase in output or employment (decrease in unemployment) accompanying an increase in inflation due to a demand excess will be more offset by the downsizing which will be necessary to neutralize this increase. Therefore, the asymmetry degree between NAIRU and NAIRCU is extremely important in case of an overheating economy, thus, generating quite significant costs.

Another key point to retain is that caution in conducting an economic policy is all the more necessary as current and future inflationary pressures are inevitably surrounded by uncertainty. The NAIRCU and the NAIRU, as the conditions of demand excess at any given moment, are known only imprecisely. Also, it is necessary to be vigilant when the economic activity is close to or at its potential rate.

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