USING ASyMmERTy FOR COMPUTING NAIRU AND OUTPUT GAP. EMPIRICAL STUDY FOR ROMANIA

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Abstract. *In this paper we present an algorithm for NAIRU approximation based on an asymmetric Phillips curve with adaptive inflationary expectations. Furthermore, we use asymmetry in Okun's law and asymmetric NAIRU to approximate output gap depending on economic cycles. In order to compute asymmetric output gap, we develop a two- phase methodology. We apply the new methodology to obtain empirical evidences for Romania. We use quarterly data covering 1996Q- 2018Q4 and we prove an asymmetric negative relationship both for inflation - unemployment and unemployment-output deviations. The numerical results support the approach by asymmetry of the relationship inflation-unemployment and unemployment-output deviations.*

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1. Introduction

Asymmetry in Okun's law, which is strongly connected to asymmetry in Phillips curve, as the later is a combination of Okun's relationship and aggregate supply curve, represents an important subject in macroeconomics dynamics.

Asymmetry in Phillips curve refers to the convexity of the curve and means that high unemployment has relatively limited effects in pulling inflation down, while low unemployment can be much more effective. It is well-known that the shape of Phillips curve is a historical controversy mainly proved by empirical evidence for US data. Turner [16] and Debelle and Laxton [5] proved its convexity, while Eisner [7] and Stiglitz [15] proved the concavity of the Phillips curve and Gordon [9] considered its linearity.

More recently, Blanchard et al. [4] used a time-varying approach in order to provide empirical estimations of Phillips curves over the past 50 years (including the Great Recession). The empirical study from [4] regarding 122 recessions in more than 20 countries, including 13 EU members leads to the conclusion that high proportion of the recessions has been followed by lower output or lower growth. They also estimated the slope of Phillips curves and concluded that for given expected inflation, the effect of unemployment on inflation decreased until the early 1990s but has remained roughly stable since then. In [4] they didn't consider the EU countries as a whole, like in Andrle et all. [2].

Okun's law [12] is usually referred to by economists to forecast and provide macroeconomic policy. It is considered in [2] as an empirical relationship that measures the correlation between the deviation of the unemployment rate from its natural rate and the deviation of output growth from its potential. The relationship between output and unemployment has been a widely discussed topic since the Great Recession. In [10] Guisinger et al. estimated Okun's coefficients separately for each U.S. state using an unobserved components framework and found variation of the coefficients across the states. In [8] Grant proved that there is substantial time variation in the Okun's coefficient in the US and that since the Great Recession, a given unemployment gap has been associated with a smaller output gap. Regional evidence on Okun's law in Czech Republic and Slovakia are presented in [6].

Asymmetry in Okun's law means that the response of unemployment to output growth is different when the economy is expanding from that when the economy is contracting. That type of relationship which is different from the conventional one encompassing symmetry has implications for macroeconomic policy. The interest in the asymmetric Okun's law is given by asymmetry in business cycles and can be traced back to Keynes (1936) who suggested that downturns may be sharper than upturns. Recently, Zwick designed in [17] a Markov-switching model with time-varying variances which allows displaying both asymmetric and switching behavior within and across different regimes. Her empirical estimations for Eurozone countries confirmed the asymmetric behavior of the Okun's coefficient in recession and in expansion. Her conclusions do not include any remarks on Romanian case.

In this paper we present a two-phase methodology for asymmetric output gap approximation based on an asymmetric Phillips curve and on the asymmetry in Okun's law.

This paper is organized in four sections including the introduction. Section 2 presents a two-phase methodology to estimate asymmetric output gaps. Two algorithms corresponding to each phase are proposed in this section. The empirical results are presented in Section 3, while Section 4 concludes the paper. To best of our knowledge both the two-phase methodology and the empirical study for Romania are new and not previously reported.

2. Two-phase Methodology for Asymmetric Output Gap Approximation

In the following we present a two-phase methodology for asymmetric output gap approximation.

The first phase is dedicated to the asymmetric NAIRU computation (Andrei et al [1]) by using asymmetric Phillips curve proposed by Debelle and Laxton in [5] and Laxton et al. in [11].

The second phase deals with the computation of the asymmetric output gaps which depend on the economic cycle phases.

2.1 Phase 1 of the Two-phase Methodology

We consider asymmetric Phillips curve proposed by Debelle and Laxton in [5] and Laxton et al. in [11] which is given by the following equation

$$\pi_t = \lambda \pi_t^e + \gamma \left(u_t^N - u_t\right) / \left(u_t - \phi_t\right) + \varepsilon_t^\pi \tag{1}$$

where π_t is actual inflation rate, π_t^e is expected inflation rate, u_t^N is the time-varying NAIRU), u_t is unemployment actual rate and ϕ_t is defined as a lower bound of NAIRU. One can allow ϕ to be time-varying

$$\phi_t = max(0, u_t^N - \bar{u}) \tag{2}$$

where $\bar{u}$ is the threshold of the NAIRU as we considered the constant NAIRU given by the Ball- Mankiw method in [3]. We rewrite (1) as

$$\pi_t = \lambda\pi_t^e + \gamma\widetilde{U}_t + \varepsilon_t \text{ , where } \widetilde{U}_t = (u_t^N - u_t)/(u_t - \phi_t) \tag{3}$$

The first phase algorithm to compute time-varying NAIRU is presented below.

Algorithm 1.

***Step1.1* (The first approximation of the NAIRU u_t^{NHP}).**

Use Hodrick-Prescott filter to approximate the unobservable variable NAIRU u_t^{NHP}.

***Step1. 2*(The lower limit of the unemployment ϕ_t computation).**

- Compute $\bar{u}$ the threshold NAIRU approximated as the constant NAIRU given by the Ball-Mankiw method.
- Consider the Philips curve given by
  $$\pi_t = \pi_t^e - a(u_t^{NHP} - \bar{u}) + \varepsilon_t \tag{4}$$
- Rewrite (4) as $\Delta\pi_t = \pi_t - \pi_t^e = A - au_t^{NHP} + \varepsilon_t$ (5)
  where $\Delta\pi_t$is the difference between actual and expected inflation rate.
- Estimate (5) and compute the Ball-Mankiw constant NAIRU $\bar{u} = \frac{A}{a}$
- Use (2) to compute ϕ_t

***Step1. 3* (The unemployment deviation index $\widetilde{U}_t$ computation).**

- Use the previous calculated NAIRU u_t^{NHP}(step 1.1.) and the lower bound ϕ_t (step1.2.) to compute the unemployment index $\widetilde{U}_t = (u_t^N - u_t)/(u_t - \phi_t)$
- Note that more than one approximation stages are recommended for the unobservable variable u_t^N .

***Step 1.4* (The expected inflation computation by using an adaptive mechanism).**

Compute $\pi_t^e = \theta\pi_{t-1} + (1-\theta)\pi_{t-1}^e$, where $0 < \theta < 1$

***Step 1.5.* (The asymmetric Phillips curve estimation)**

Estimate equation (3)

***Step1.6.* (Errors Estimation)**

Estimate the errors given by the equation $\varepsilon_t = \pi_t - \pi_t^e - \gamma\widetilde{U}_t$

***Step1.7.* (Computation of the time-varying NAIRU)**

Use (1) to compute asymmetric NAIRU $u_t^N = (\pi_t - \lambda\pi_t^e - \varepsilon_t)\left(\frac{u_t - \phi_t}{\gamma}\right) + u_t$

One may note that the computed u_t^N presents asymmetric deviations according to the inflation-unemployment correlation pattern.

2.2 Phase 2 of the Two-phase Methodology

In the second phase we determine asymmetric output gap depending on economic cycles.The extended asymmetric model by using the dynamic Okun's law as in Silvapulle et al.[14] is given by the equation below.

$$u_t^c = \sum_{j=1}^{p} \alpha_j u_{t-j}^c + \sum_{j=1}^{q} \left\{ \theta_j y_{t-j}^{c+} + \eta_j y_{t-j}^{c-} \right\} + \varepsilon_t \tag{6}$$

where $u_t^c = u_t - u_t^N$, $y_t^{c+} = y_t^c \delta_j$ with $\delta_j = \begin{cases} 1, y_t^c > 0 \\ 0, y_t^c < 0 \end{cases}$ and $y_t^{c-} = y_t^c \gamma_j$ with $\gamma_j = \begin{cases} 1, y_t^c < 0 \\ 0, y_t^c > 0 \end{cases}$. We denoted by y_t^c the log cyclic output defined as $y_t^c = y_t - y_t^{POT}$ where y_t is the log real GDP and y_t^{POT} is the log potential output.

The asymmetric Okun's coefficients are given by

$$\varphi^+ = \left\{\sum_{j=1}^{q} \theta_j \,/ (1 - \sum_{j=1}^{p} \alpha_j)\right\}, \text{ in expansion} \tag{7}$$

$$\varphi^- = \left\{\sum_{j=1}^{q} \eta_j \,/ (1 - \sum_{j=1}^{p} \alpha_j)\right\}, \text{ in recession} \tag{8}$$

and they are expected to be negative. The resulted asymmetric output deviations are given by

$$\frac{1}{\varphi^+}(u_t - u_t^N) = (y_t - y_t^{POT}) \tag{9}$$

for output deviations in expansion (inflationary gaps), i.e. $u_t - u_t^N < 0$ and

$$\frac{1}{\varphi^-}(u_t - u_t^N) = (y_t - y_t^{POT}) \tag{10}$$

for output deviations in recession (recessionary gaps), i.e. $u_t - u_t^N > 0$

In the ***second phase*** of the methodology we propose the following algorithm.

Algorithm 2.

Step2.1.Compute the unemployment deviations $u_t^c = u_t - u_t^N$ by using asymmetric NAIRU computed in Phase 1.

Step 2.2. Compute the potential output y_t^{POT} in logarithms by applying HP filter to log real GDP.

Step2.3. Compute the output gaps in logarithms y_t^{c+} for expansions and y_t^{c-} for recessions.

Step 2.4. Find the optimum delay order by applying Akaike-Schwarz [13] information criterion to the variables contained in equation (6) in order to deduce the dynamic Okun's law.

Step 2.5. Estimate the parametres α_j, θ_j and η_j from (6)

Step 2.6. Use the estemated parameters to compute the Okun's coefficients given by (7) and (8) respectively.

Step 2.7. Determine the asymmetric output gap series by using (9) and (10) respectively.

3. Empirical Study for Romania

The empirical study uses the two-phase methodology described in Section 2. In our analysis, we use data from the official website of the National Institute of Statistics, quarterly data for the BIM unemployment rate, inflation rate, nominal GDP, and GDP deflator.

Following step1.1, the first approximation of the NAIRU is obtained by HP filtering the time series of the unemployment actual data from the National Institute of Statistics, quarterly data in the period 1996Q1-2018Q4. The results are presented in Figure 1.

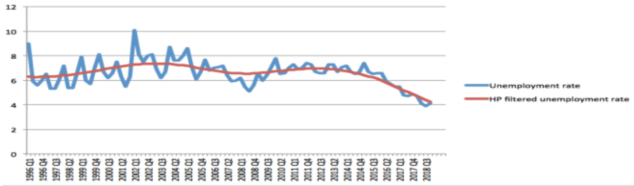

Figure 1.Unemployment rates u_t and u_t^{NHP}

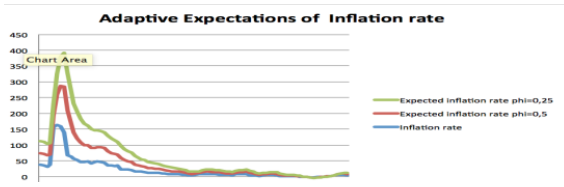

Figure 2: Actual and expected inflation rates $\theta = 0.25$ and $\theta = 0.5$

According to step 1.2 we use (2) in order to compute the lower bound of NAIRU, ϕ_t. First, we comput $\bar{u}$ the treshold of the time- varying NAIRU which is considered Ball-Mankiw constant NAIRU. Second, we estimate the Phillips curve given by (4). As the symmetric Phillips curve does not smooth well the long run data, we consider a shorter period, namely 2010Q1-2018Q4. The estimated Phillips curve is: $\Delta\pi_t = A + au_t + \varepsilon_t = 4{,}198627 \ + 0{,}676761 \ + \varepsilon_t$.

We note that the regression statistics indicate that the regression model is a good fit of the data and our results are reliable. Thus, Ball-Mankiw constant NAIRU computed using (5) is $\bar{u} = \frac{A}{a} = \frac{4{,}198627}{0{,}676761} = 6{,}203$.

Next, folowing step 1.3 we compute unemployment deviation index $\widetilde{U}_t$. According to step 1.4 we compute the expected inflation π_t^e by using an adaptive mechanism. The time series π_t^e is computed recursively by using the actual inflation π_t and $\pi_{-1}^e = \pi_{-2}$

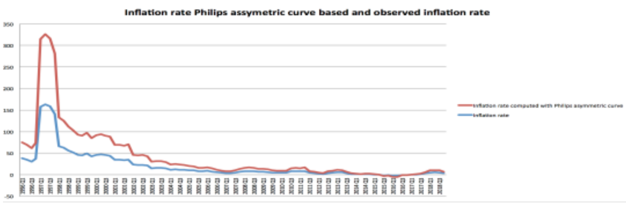

Figure 3: Actual inflation rate and computed asymmetric Phillips curve

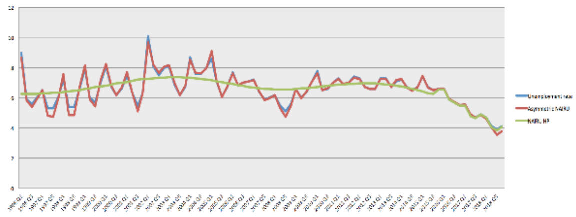

Figure 4: Actual unemployment rate u_t , u_t^{NHP} , u_t^N

We note, based on Figure 2, that one should prefer to select the parameter $\theta = 0{,}5$ which approximates better the adaptive mechanism of inflation.

According to step 1.5 we estimate the asymmetric Phillips curve given by the following equation $\pi_t = 0{,}913673\pi_t^e - 1{,}224823\tilde{U}_t + \varepsilon_t$, where we accept the parameters, debt to satisfactory estimation indicators. One may note in the above Figure 3 that the inflation rate computed using asymmetric Phillips curve, preserves the trend of the real phenomena but it accentuates the shocks as duration and amplitude.

The last two steps of the algorithm 1 consist in computing estimation errors $\varepsilon_t = \pi_t - 0{,}913673\pi_t^e - 1{,}224823\tilde{U}_t$ and the asymmetric time- varying NAIRU given by $u_t^N = (p_t - 0{,}913673 p_t^e - e_t)(\frac{u_t - f_t}{-1{,}224823}) + u_t$.

The results are reflected in Figure 4 where one may note that asymmetric time-varying NAIRU follows the pattern of actual unemployment rate. This proves again that the model fits well the data.
The second phase of the methodology proposed in Section2 consists in computing the assymetric output gaps. The empirical study follows algorithm 2 step by step and compute the unemployment deviations $u_t^c = u_t - u_t^N$ with u_t^N computed above (phase 1). Next we compute potential GDP in logarithms and apply the HP filter to log real GDP. The results reveal negative fluctuations throughout the periods 2005-2007 and 2008-2010 on a general upward trend. They reflect the economic fluctuations before Romania's entry into the EU as well as the economic crisis period 2008-2010. According to step 2.3 we also compute the positive and negative output gaps in logarithms y_t^{c+} and y_t^{c-}. Then following step, 2.4 we determine the optimal delay order by applying Akaike-Schwartz information criterion [13] and obtain p=3 for the unemployment deviation and q=4 for output deviation. As a result to the parametres estimation according to step 2.5 we obtain the following the dynamic Okun's law for Romania.

$$u_t^c = 0.56u_{t-1}^c - 0.41u_{t-2}^c + 0.25u_{t-3}^c + 1.33y_{t-1}^{\varepsilon+} - 1.42y_{t-2}^{\varepsilon+} + 1.75y_{t-3}^{\varepsilon+} - 1.69y_{t-4}^{\varepsilon+} - 2.34y_{t-1}^{\varepsilon-} + \\ + 4.47y_{t-2}^{\varepsilon-} - 5.15y_{t-3}^{\varepsilon-} + 2.90y_{t-4}^{\varepsilon-} + \varepsilon_t$$

where the parameters considered significant are accepted.

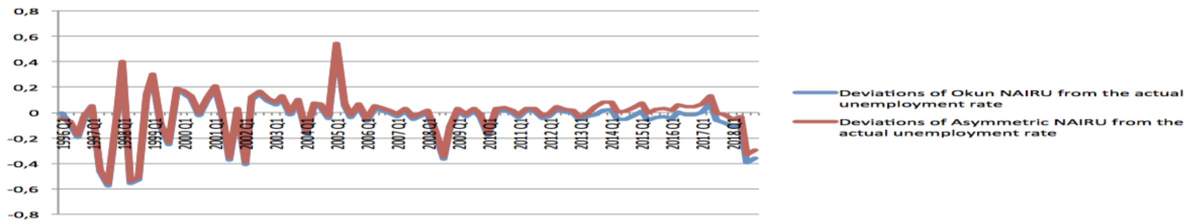

Figure 5. Okun asymmetric deviations vs. actual unemployment deviations from the asymmetric NAIRU

In the above Figure 5 one may note a very close variation of both asymmetric NAIRU computed in step 1.7 and computed unemployment deviations based on asymmetric Okun's law which supports the usage of asymmetry in the empirical studies for Romania.
According to step 2.6. we use the estemated parameters to compute the Okun's coefficients given by (7) and (8) respectively and we obtain

$$\varphi^+ = \frac{\theta_1+\theta_2+\theta_3+\theta_4}{1-\alpha_1-\alpha_2-\alpha_3} = \frac{-0.04}{0.6} = -0.66 \text{ and } \varphi^- = \frac{\eta_1+\eta_2+\eta_3+\eta_4}{1-\alpha_1-\alpha_2-\alpha_3} = \frac{-0.12}{0.6} = -0.2$$

We note that for Romania, the Okun coefficients are both negative, which proves an inverse relationship between unemployment deviations and output gaps. Another particularity is that the Okun coefficient for positive deviations is greater than in the case of negative deviations. This means that a change in the positive output deviation will have a greater effect on the unemployment deviation than in the case of negative deviations.
Finally, we determine the asymmetric output gaps series by using (9) and (10) respectively. Results are presented by the figures below.

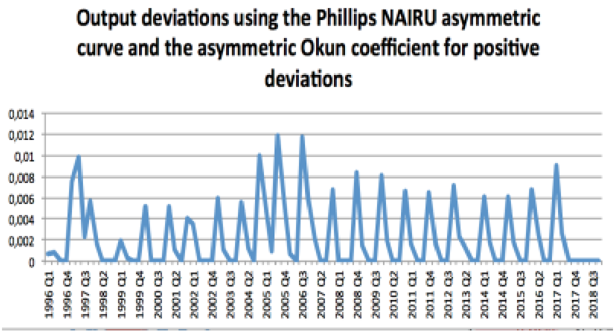

Figure 6. Output deviations y_t^{c+}

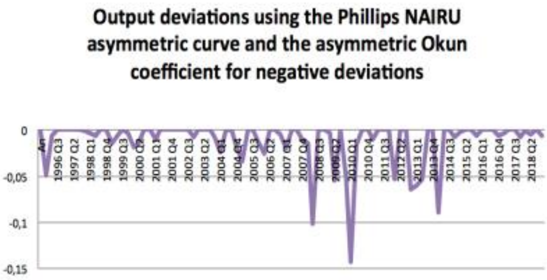

Figure 7. Output deviations y_t^{c-}

The negative deviations of the resulting output gaps point out the crisis period 2008-2010 in Romania which was followed by a hysteresis-type process and prolonged some of the effects until 2014.

5. Conclusions

In this paper we proposed an original two-phase methodology for asymmetric output gap approximation based on an asymmetric Phillips curve and on the asymmetry in Okun's law. Based on the empirical study for Romania we can draw the following conclusions.

On short- term 2010Q1-2018Q4 data are well-adjusted by the symmetric Phillips curve. Also, the constant NAIRU unemployment rate computed by using the Ball- Mankiw method is $\bar{u} = 6{,}203$ and it is economic acceptable. On long-term 1996Q1-2018Q4 data are not well-adjusted by the symmetric Phillips curve and we considered the asymmetric Phillips curve proposed by Debelle and Laxon in 1997 which well-adjusts the Romanian statistical data. Based on that asymmetric Phillips curve we developed an original algorithm. We computed asymmetric NAIRU unemployment rate which preserves the evolution pattern of the actual unemployment rate and its trend estimated by HP filtering and considered as a first NAIRU approximation (see also figure 4).

We note that the Okun's coefficient has to be approach by asymmetry when the economic cycles have different durations and shapes, as it is computed based on the output deviation. The computed Okun's coefficients are both negative. They also sustain the negative relationship between the unemployment deviation and output deviation as the absolute value is greater in expansions then in recessions. This proves a greater sensitivity of the unemployment deviation to the output deviation in expansion then in recession.

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