Time Varying NAIRU Estimates in Central Europe

Balázs Varga[1]
12 May 2011

Abstract. This paper estimates Phillips curve relationships on newly transitioned Central European countries: the Czech Republic, Hungary, Poland and Slovakia. For the estimation Gordon's triangle model is used with the Kalman filter, where the time varying NAIRU is described as a latent variable following a random walk, and its deviation from unemployment affects on inflation among other factors. In the case of Hungary the inclusion of inflation forecasts is also considered. The results show that only the Czech Republic exhibits a significant inflation – unemployment tradeoff. In the case of Hungary, professional forecasts are found to play an important role in the shaping of inflation.

JEL (Journal of Economic Literature) codes: C32, E24

Keywords: unemployment, Phillips curve, time varying NAIRU, Kalman filter

1 Introduction

More than twenty years have passed since Central European countries shifted their regime from communism to capitalism. The old system differed a lot from the new one not only in terms of price levels, but also in the measure of unemployment. For the former, the prices of most goods were determined by the government which leaded to substantial diversions from open market prices. As far as unemployment is concerned, virtually no one was actively seeking work because state owned companies absorbed all workforces – it's a different question whether newcomers in firms actually did have any work to do, intra-firm unemployment was flourishing. It's therefore clear that the classic short-term tradeoff between inflation and unemployment known as the Phillips curve surely didn't exist in the old regime. The question remains whether it exists – and how it exists – now, after 20 years of free market regime.

The economic transition for these countries was dramatic: as prices drastically rose to open market levels, the structure of demand changed as a result of reorientation of trade in former Soviet bloc countries. Supply could not change in the same pace which resulted in the coexistence of excess demand and excess supply in different structures, causing a significant decrease in output through a bottleneck effect. Output decline brought about an increase in

[1] OTP Fund Management Ltd. and Corvinus University of Budapest, e-mail: balazs.varga@uni-corvinus.hu. The author acknowledges financial support from OTKA (Hungarian Scientific Research Fund) grant #73782, and is grateful to Zsolt Darvas for his valuable advice.

unemployment – and finally this shows us an idea why the inflation – unemployment tradeoff couldn't work during the years of transition. What's more, in the coming years both inflation and unemployment consolidation took place in more or less the same time – the second half of the nineties – which could further weaken the Phillips curve effect.

The main goal of this paper is to find out whether the Phillips curve effect is present in Central European transition economies now, as it is present in nearly any developed country. The studied countries are the Czech Republic, Hungary, Poland and Slovakia, also known as the Visegrad Four. For the reason we set up and estimate a state space model based on a time varying latent NAIRU, called the triangle model by Gordon (1998). This model setup is a highly useful tool for analyzing inflation and unemployment together, because it allows us to investigate (i) the evolution of NAIRU sequence; (ii) the dynamics of inflation; and (iii) the correspondence between the two variables. We extend our model in a similar way to Driver et al (2006) in the sense of also using expected inflation series which serve as a forward looking element in the Phillips curve approach. Thus we will be also able to evaluate what role expectations and inflation forecasts play in inflation dynamics.

The structure of the paper is as follows. Section 2 shows a brief theoretical background, the model setup and solution methodology. Section 3 discusses the data, including inflation expectation data and their processing methods. Section 4 presents the results and finally, section 5 concludes.

2 Theoretical background and methodology

Gordon's (1997,1998) triangle model can be thought of as the bivariate representation of the well known backward looking Phillips curve: while unemployment itself follows a random walk, it forms a short run relationship with inflation through a demand pressure term in inflation dynamics – specifically, the deviation of unemployment from a time varying NAIRU. Thus, in this setting, NAIRU accomplishes just what it's defined for: a level of unemployment which does not carry any inflationary pressures.[2] Inflation, besides depending on this deviation term, is also determined by its own inertia and some exogenous supply shocks.

By introducing forward looking dynamics, the model can be augmented to fit the New Keynesian Phillips Curve concept where price stickiness causes inflation expectations to play an important role in price determination. In many NKPC theoretical models inflation only

[2] There are more different NAIRU representations in the literature, but not all bear with the original concept: some univariate approaches identify NAIRU simply as a trend in unemployment, see for example Papell et al (2000) or Camarero et al (2005).

depends on forward looking terms, but in practice it's much more plausible that inflation will be composed of both forward and backward looking elements. Therefore, similarly to Driver et al (2006) who find forward looking terms to bear significance in inflation regressions of the US and the UK, we also consider the use of expectations series as regressors.

We introduce now our state space model which – following loosely the notation of Driver et al (2006) – has the form:

$$u^*_t = u^*_{t-1} + \eta_t \tag{1}$$

$$\pi_t = \alpha(u_t - u^*_t) + \beta(L)\pi_{t-1} + \gamma\pi_{t-1} + \delta(L)z_t + \varepsilon_t \tag{2}$$

$$\eta_t \sim N(0, \sigma_\eta^2),\ \varepsilon_t \sim N(0, \sigma_\varepsilon^2),\ \mathrm{cov}(\eta_t, \varepsilon_t) = 0 \tag{3}$$

where π_t is annual price inflation; u_t is unemployment and u^*_t is the time varying NAIRU; α, $\beta(L)$, γ and $\delta(L)$ are coefficients and lag polynomials of coefficients, η_t and ε_t are error terms associated with the state equation (1) and signal equation (2). Finally, z_t represents exogenous supply side shocks, namely change in the log of real oil prices and change in the log of real import prices. The length of lag structures $\beta(L)$ and $\delta(L)$ is chosen so that we can be parsimonious with the number of usable observations on one side and have as much significant terms as possible on the other. This led us to using 4 lags of inflation and 1-1 lag of oil and import price shocks.

The model is estimated by using the Kalman filter via maximum likelihood; this allows us to simultaneously estimate both the NAIRU sequence (with the Kalman filter and smoother running inside the likelihood function) and all the unknown coefficients (by maximizing the likelihood function). Besides the coefficients in the signal equation, we also have the ability to estimate the starting value of the NAIRU sequence and exactly one of the error term variances σ_η^2 and σ_ε^2. We can't estimate both because of an apparent NAIRU identification issue, instead – similar to the literature – we place a restriction on their ratio $\sigma_\eta^2/\sigma_\varepsilon^2$, also known as the signal-to-noise ratio. We set the value of the ratio to 0.16, which is in line with the findings in Gordon (1997) and Driver et al (2006) and also the fact that the unemployment of transition economies is comparable to the UK in terms of volatility.[3] We also warn that because of arbitrarily choosing an important parameter for the estimation, the results should rather be regarded as tendencies, and not point estimates.

Though not highly important, we would like to draw a close correspondence with FLS at this point. The flexible least squares (FLS) approach was introduced in the late eighties by Kalaba and Tesfatsion (1990), studied by a handful of papers (see e.g. Darvas and Varga, 2010), and basically means a probability free solution to the state space model estimation. Without

[3] The cited authors used 0.04 for the US and 0.16 for the UK, based on volatility measures, sensitivity analyses and the desired smoothness of NAIRU sequences.

placing any normality assumptions on the error terms, the method introduces a weighting parameter μ, with the help of which it defines a weighted sum of two sums-of-squares (SS): the SS of the signal equation error term and the SS of the state equation error term. The weighted sum is then minimized and a filtering procedure introduced. Though it can be intuitively seen quite easily, it has been later shown – for example by Montana et al (2009) – that FLS is identical to Kalman filtering, and μ corresponds to the reciprocal of the signal-to-noise ratio. Thus, by making a restriction on the signal-to-noise ratio – and not separate values on each error variance, we plainly follow the FLS approach: in our case μ equals to 1 / 0.16 = 6.25. The equivalence of the two methods puts us somewhat at ease: the Kalman filter doesn't need our error terms to be normally distributed (though the ML estimation does need it for best properties).

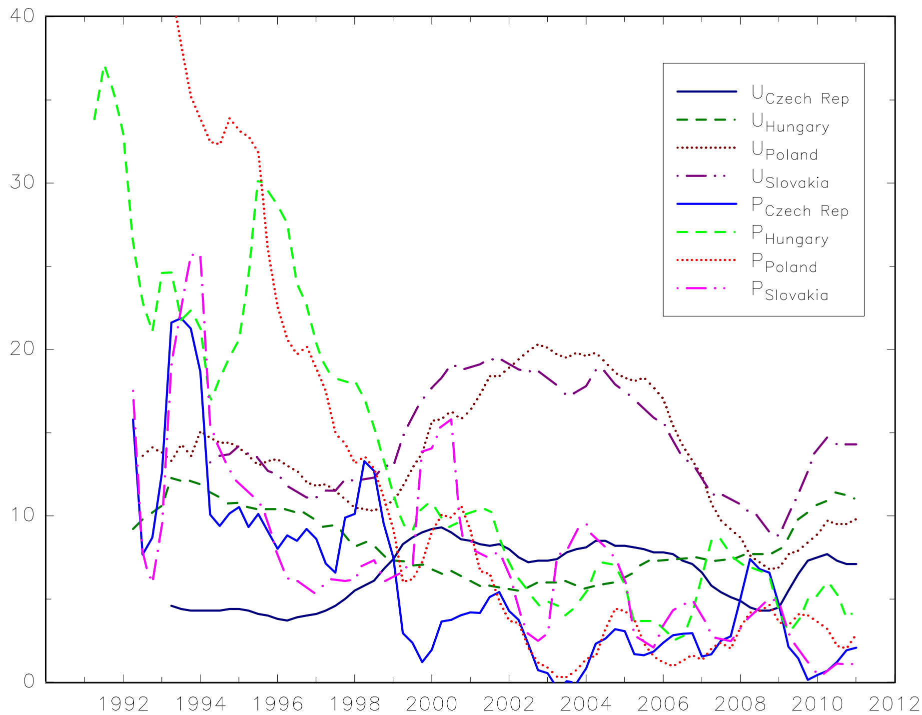


Figure 1 – An overview of unemployment and annual inflation rate time series

Both are given in percentage points, darker colors represent unemployment, lighter colors show inflation series.

3 Data

When comparing estimation results for different countries, it is crucial to have data as comparable to each other as possible. Therefore, the time series for any given variable in this research were always taken from the same source. We tried to extend the sample as long as possible, but concerning transition economies this is always a problematic issue: we had to stop at the beginning – even sometimes middle – of the nineties. Fortunately, as we mentioned before, evidence for Phillips curve relationship is likely to show itself only more recently.

Most of our data are fairly standard: quarterly CPI and unemployment series come from the OECD statistics database, and can be seen for all 4 countries on figure 1 as an overview. Import prices are deflators from Eurostat's national accounts database. Oil price comes from Bloomberg and is the Ural Mediterranean Oil Price Index converted to national currencies – we chose this over the WTI because this Russian index might have a bit more to do with Central European import oil prices. All the data mentioned in this paragraph start somewhere between 1990Q1 and 1996Q1 while all end on 2010Q4.

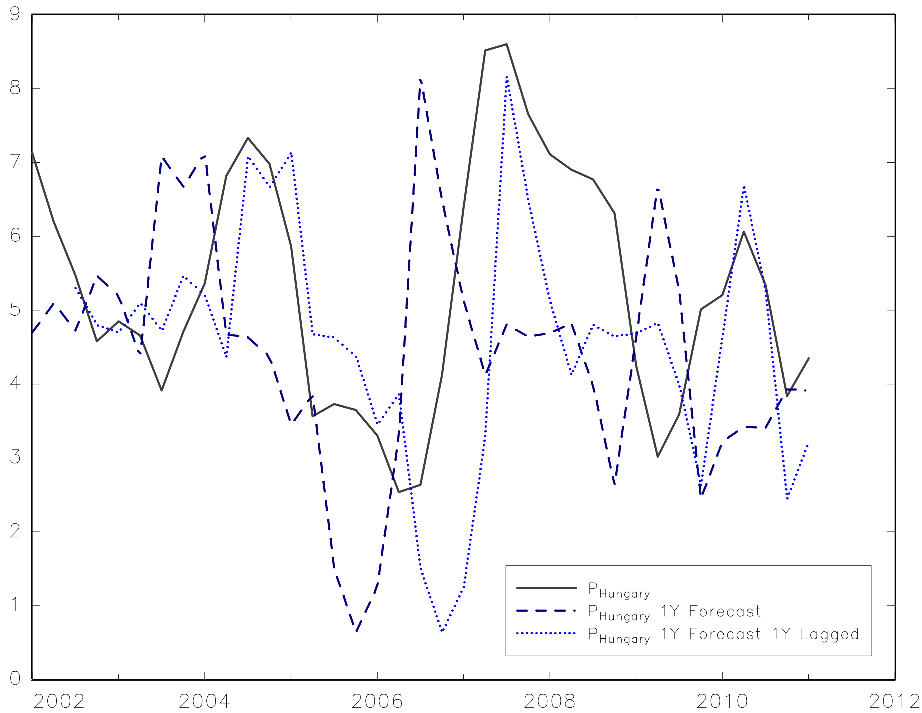


Figure 2 – Hungarian annual inflation, its 1-year forecast and lagged forecast at evaluation dates

Series are given in percentage points.

Inflation forecast time series are fairly harder to acquire. One series which we are using in this first draft of the paper is the professional forecast of the National Bank of Hungary (MNB). These estimates are parts of the MNB's Quarterly Report on Inflation series, can be downloaded from the bank's website and date back to 2001Q2. The forecasts, along with realized inflation series are plotted on figure 2, and by visually examining them we can not see any lagging which would mean a series of uninformative guesses.

We are eagerly planning to use another, longer and more complete source of inflation expectations in a next version of this paper, namely the public survey results of the European

Commission.[4] These series would cover all our four countries, however, they are qualitative results only, and need to be transformed into quantitative information. There are several methods to deal with such data, for example Berk (1999) offers one which does not even assume the unbiasedness of expectations, which is favorable for us. The method, along with our findings on the EC database will be reviewed in the remainder of this section in a next version of this paper.

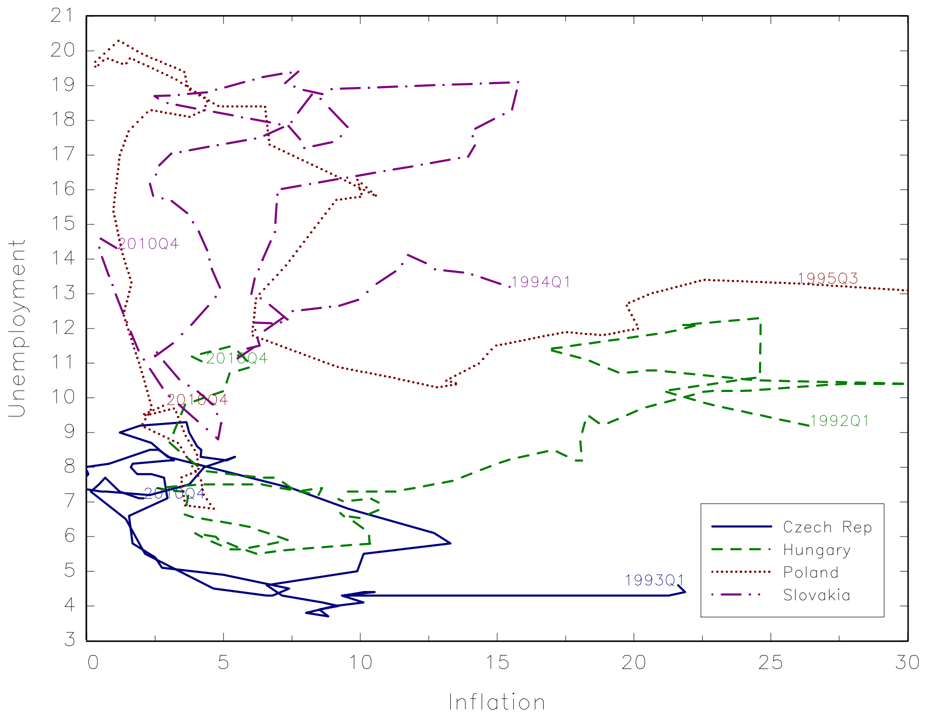


Figure 3 – Evolutions of inflation – unemployment pairs

Both annual inflation and unemployment series are given in percentage points.

4 Results

Our departing point for analyzing the results is inspecting figure 1 where we can see all the inflation and unemployment series. It can be clearly seen that during the nineties most of the series declined, and some of them did so from extraordinarily high levels (e.g. Polish and Hungarian inflation). This is in line with our logic presented in section 1, but is bad news for any Phillips curve models. Even if we cut our sample to the last decade, the unemployment series in Poland and Slovakia suffered large shocks, which is presumably not the consequence of an inflation – unemployment tradeoff.

[4] There are some arguments against public surveys, concerning the unbiasedness and efficiency of such data. This would lead us to some other professional / consensus forecasts available at Reuters Poll or Consensus Economics. In a next version of the paper these will also be considered.

Our doubts subside if we look at figure 2, which shows the same data from another perspective: the countries' trajectories are plotted on the inflation – unemployment plane. This is a preferred plot of Phillips curve correspondences because in case of a short run tradeoff, parts of trajectories should lie on downward sloping curves. However, downward sloping curves can only be noticed in the case of the Czech Republic: what's more, the trajectory of this country not only shows a clear negative connection, but most of its inflation and unemployment levels are very close to those of developed countries.

Model	Czech Rep	Hungary	Hungary (with infl forecast)	Poland	Slovakia
Sample	1996Q3 2010Q4	1995Q3 2010Q4	2001Q2 2010Q4	1995Q3 2010Q4	1994Q2 2010Q4
U-U*	-0.34 (-2.33)	-0.01 (-0.63)	0.00 (-0.00)	-0.02 (-1.08)	-0.01 (-0.46)
PIFCST			0.19 (2.87)		
PI1	1.09 (6.82)	1.25 (11.30)	1.41 (7.58)	1.23 (10.68)	1.06 (9.68)
PI2	-0.03 (-0.20)	-0.33 (-1.64)	-0.67 (-2.42)	-0.36 (-1.93)	-0.01 (-0.08)
PI3	-0.38 (-2.34)	-0.03 (-0.17)	0.01 (0.02)	-0.13 (-0.69)	-0.14 (-1.03)
PI4	0.02 (0.16)	0.05 (0.52)	0.08 (0.55)	0.16 (1.59)	0.03 (0.29)
RPIM1	0.07 (1.02)	-0.03 (-0.76)	0.00 (-0.07)	0.06 (2.51)	-0.03 (-0.33)
RPOIL1	0.02 (3.42)	0.01 (1.25)	0.01 (1.88)	0.01 (1.91)	0.01 (1.24)

Table 1 – Estimated coefficients for the four countries

Note: t-statistics are in parentheses.

Now we turn to examining the estimation results on the longest available samples which are presented on table 1, while the estimated NAIRU sequences are shown on figures 4 and figures 5 to 7 in the Appendix. Concerning the coefficients of NAIRU in the inflation regressions, the Czech Republic vastly differs from the others, for it has a significantly negative coefficient. What's more, the value of -0.34 is greatly in line with the findings of Driver et al (2006) for the US and UK, or with Richardson et al (2000) who estimated time varying NAIRU regressions for 21 developed countries. Looking at the evolution of the Czech NAIRU on figure 4, a significant decline can be observed: both the Kalman filtered and smoothed estimates have their lower confidence limits on higher level at the beginning of the sample, than their upper limits at the end of the sample. The permanent decline and high level of NAIRU suggests that the Czech Republic – while being the most developed country among the studied four – is still on its way of development to have a stable low inflation – low unemployment environment.

Looking at the other three countries' results, there cannot be established any connection between inflation and unemployment which makes all estimations of the time varying NAIRU's invalid. The Kalman filtered and smoothed estimates are nearly constant and have enormous standard errors which is the consequence of the unidentifiable relationships. Perhaps in case of these countries there are still much stronger different forces between inflation and unemployment.

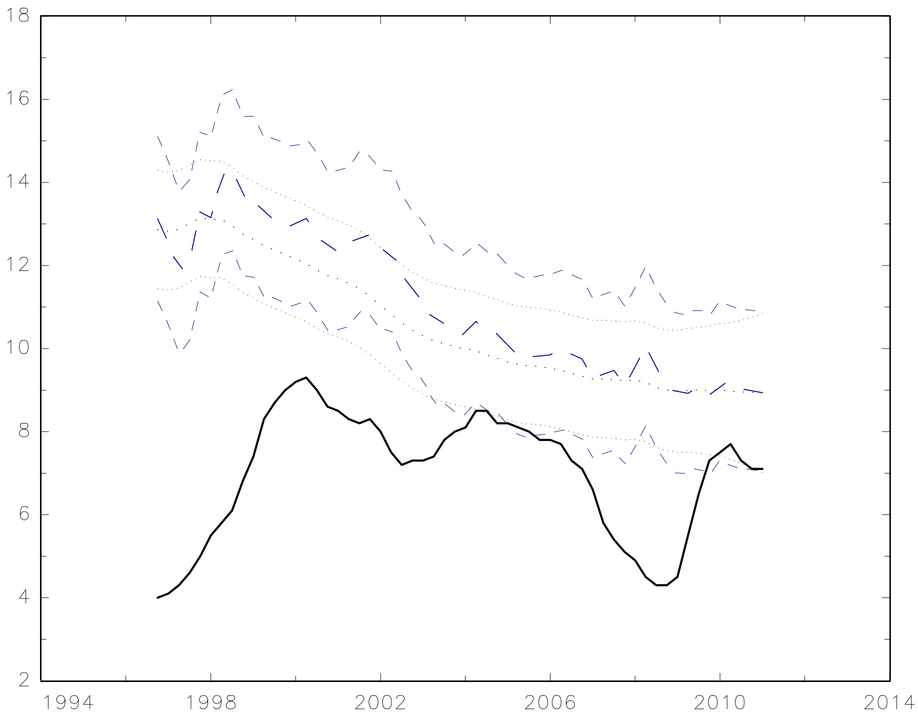


Figure 4 – Czech Republic – unemployment rate, Kalman filtered and smoothed NAIRU estimates
The black solid line is the unemployment rate, filtered estimates with 2-sigma confidence intervals are marked with blue slashed lines, smoothed estimates with 2-sigma confidence intervals are marked with red dots.

Apart from NAIRU coefficients, lagged inflation and exogenous shocks do have a significant impact on inflation at all four countries, and in the case of Hungary we can see a significant positive impact of inflation forecasts. The coefficient value of 0.19 is very close to the findings of Driver et al (2006): depending on model setups, she reports values between 0.27 and 0.28 for the US, and values between 0.10 and 0.14 for the UK.

Our results seem to be fairly robust: we re-estimated the regressions on smaller samples (particularly on the last decade), and there seemed no improvement on the NAIRU coefficients at all. We must mention however that even the full samples are small, further truncation leads to extremely small samples of 40 observations or less. A very similar result was found after altering all the parameters playing important role in the Kalman filter and maximum likelihood estimation: the signal-to-noise ratio, the starting values and variances of starting values. Because of no significant difference or improvement over the baseline results we omit the report of these estimations.

5 Conclusion

This paper envisaged a difficult task: estimate time varying NAIRU’s for countries which are known to have their inflation and unemployment driven by stronger forces than Phillips curve relationships: namely the long lasting structural conversion from the previous regime. This version of the paper presents two important results: (i) among the Visegrad Four, the Czech Republic has a lot more desirable inflation and unemployment levels, and also exhibits a significant Phillips curve relationship; and (ii) as the case of Hungary shows, professional inflation forecast may play an important role in the shaping of current inflation.

For a next version of this paper, we will evaluate public forecasts for all four countries, while anticipating that we can find more evidence on the effect of inflation expectations. And perhaps if we wait another decade and collect a bigger sample farther away in time from the regime changes, slowly but surely all transition countries will exhibit a strong empirical Phillips curve relationship.

References

Berk, J. M. (1999): *Measuring Inflation Expectations: a Survey Data Approach*, Applied Economics, 31, pp1467-1480

Camarero M., J. L. Carrion-i-Silvestre and C. Tamarit (2005): *Unemployment Dynamics and NAIRU Estimates for Accession Countries: a Univariate Approach*, Journal of Comparative Economics, 33(3), pp584–603

Darvas, Zs and B. Varga (2010): *Time-varying Coefficient Methods to Measure Inflation Persistence*, paper presented at the ECOMOD 2010 Conference in Istanbul, Turkey, 7th-10th July 2010

Driver, R., J. V. Greenslade and R. Pierse (2006): *Whatever Happened to Goldilocks? The Role of Expectations in Estimates of the NAIRU in the US and the UK*, Oxford Bulletin of Economics and Statistiscs, 68(1), pp45-79

Gordon, R. J. (1997): *The Time Varying NAIRU, and its Implications for Economic Policy*, Journal of Economic Perspectives, 11, pp11–32

Gordon, R. J. (1998): *Foundations of the Goldilocks Economy: Supply shocks and the Time Varying NAIRU*, Brookings Papers on Economic Activity, II, pp297–346

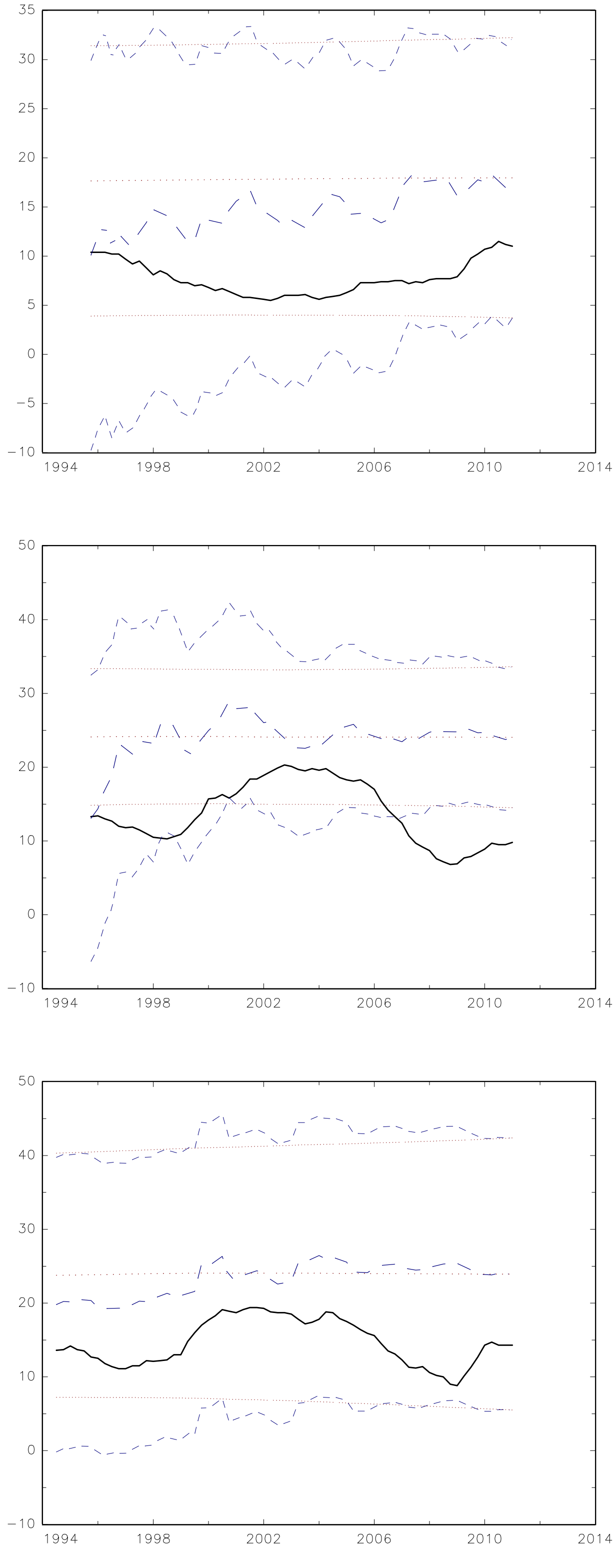
Kalaba, R. and L. Tesfatsion (1990): *Flexible Least Squares for Approximately Linear Systems*, IEEE Transactions on Systems, Man, and Cybernetics, 20, pp978-989

Montana, G., K. Triantafyllopoulos and T. Tsagaris (2009): *Flexible Least Squares for Temporal Data Mining and Statistical Arbitrage*, Expert Systems with Applications, 36, 2(2), pp2819-2830

Papell, D. H., C. J. Murray and H. Ghiblawi (2000): *The Structure of Unemployment*, The Review of Economics and Statistics, 82(2), pp309-315

Richardson, P., L. Boone, C. Giorno, M. Meacci, D. Rae and D. Turner (2000): *The Concept, Policy Use and Measurement of Structural Unemployment: Estimating a Time Varying NAIRU Across 21 OECD Countries*, OECD Economics Department Working Papers, 250, OECD Publishing.

Appendix: Additional figures



Figures 5 through 7 – Hungary, Poland and Slovakia
Unemployment rates, Kalman filtered and smoothed NAIRU estimates

The black solid line is the unemployment rate, filtered estimates with 2-sigma confidence intervals are marked with blue slashed lines, smoothed estimates with 2-sigma confidence intervals are marked with red dots.