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Abstract

The use of unobserved component models to estimate the NAWRU has been strongly criticized due to some excessive pro-cyclicality at the sample end, especially in the neighbourhood of turning points. To address this criticism, the European Commission now uses a model-based approach where the information set is augmented with a structural indicator of the labour market to which the NAWRU is supposed to converge in a certain number of years. The resulting NAWRU estimates mixes information about the business cycle and the labour market characteristics. The application to the EU Member States shows that besides moderating pro-cyclicality, this approach also reduces the first revision to the one- and two-year-ahead forecasts of the NAWRU in four-fifth of the countries considered.

JEL Classification: E31, E32, J0, O4

Keywords: Potential output, Natural rate of unemployment, Output gap, Unemployment gap, Phillips curve, NAWRU, Real time reliability.

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1 Introduction

One of the most controversial features of the NAWRU estimates is their degree of pro-cyclicality. Pro-cyclicality refers to a high adherence between the NAWRU estimate and the concurrent observation on unemployment at the sample end. Such pro-cyclical NAWRU estimates are undesired as they downplay the importance of the business cycle in concurrent analysis. This issue is fuelled by the strong increase of European Commission's NAWRU estimates in the EU countries which have been severely hit by the 2009 financial crisis. Now that a turnaround in the unemployment rate is taking place, the question arises whether the NAWRU has shown an excessive persistence at the sample end. The question matters because an excess of pro-cyclicality distorts the NAWRU forecasts and leads to large revisions.

Theoretically, a certain degree of NAWRU pro-cyclicality can be justified by the presence of adjustment frictions in the labour market. Some long-term fluctuations can indeed be noticed in the unemployment rate of several EU countries. Another theoretical explanation which is often put forward to describe the EU labour market since Blanchard and Summers (1986) is offered by the hysteresis hypothesis. By assuming that the NAWRU follows an integrated random walk, the commonly-agreed NAWRU model favours indeed the hysteresis view of the EU labour market (see Havik et al., 2014). The estimation tool further accentuates these features as signal extraction methods tend to generate some pro-cyclicality in trend estimates towards the sample end. On the other hand Orlandi (2012) provides some evidence that unemployment in EU countries reverts to a structural level. So far this evidence has been incorporated in the commonly agreed methodology via a mechanical rule that drives the NAWRU predictions towards a structural indicator of the labour market. This procedure is however arbitrary and, since it does not affect the in-sample estimates, it does not address the problem of pro-cyclicality.

To correct the hysteresis bias and to better integrate the labour market structural reforms, we develop a model-based methodology which, while still capturing the observed non-stationarity of the unemployment rate in EU countries with an integrated random walk, forces the NAWRU to revert to the anchor in the mid-term, depending on the country. The approach is model-based in the sense that it is the fitted model that guides the convergence path to the anchor. Also, the NAWRU estimate is impacted at all sample dates and not only the out of sample predictions as for the mechanical rule. Following Orlandi (2012) the anchor is built in a panel regression of unemployment in EU countries on a set of structural indicators of the labour market which includes the unemployment benefit replacement rate, the labour tax wedge, the degree of union density, the expenditure on active labour market policies. Demand shocks that can affect equilibrium unemployment in presence of labour market rigidities are also considered through the real interest rate, the growth of total factor productivity, and a construction variable that aims to account for boom-bust patterns in the housing sector. In contrast with Lendvai, Salto, and Thum-Thysen (2015) who analyse the impact of replacing the NAWRU with a structural unemployment rate, the anchored NAWRU mixes business cycle information and labour market characteristics. This mixing of different information reduces the weight attached to the concurrent unemployment rate hence alleviating pro-cyclicality.

The econometric literature has mostly concentrated on revisions, i.e. corrections to preliminary estimates following the incoming of new observations, and mostly ignored pro-cyclicality. Orphanides and van Norden (2002), Nelson and Nikolov (2003), Cayen and van Norden (2005), and Marcellino and Musso (2011) for instance warn about large revision errors in real-time output gap estimates. We argue that pro-cyclicality is one source of revisions: as new observations become available, a concurrent trend estimate converges to the local mean of the series, so the more pro-cyclical a concurrent trend estimate and the larger the excursion it must incur to reach the local mean. Reducing pro-cyclicality can thus be expected to also reduce the revisions. We show that anchoring attenuates noticeably the real-time revisions to the one- and two-step-ahead NAWRU forecasts in twenty-two Member States.

In Section 2 the standard NAWRU model is detailed and applied to the EU Member States except Croatia due to data unavailability. The model-based anchoring approach is explained in Section 3 together with a description of the panel regression model fitted to build the anchor. The anchored NAWRU estimates appear sensible especially in the current juncture where the information about structural reforms undertaken in EU countries suggests that the NAWRU should not rise further. We present the implications for the euro area NAWRU aggregate. Using all vintages available as well as the real-time anchor values we show that model-based anchoring moderates the NAWRU pro-cyclicality. This feature appears to be an inherent property of the model-based anchoring approach. Its impact on the real-time revisions to the one- and two-step-ahead NAWRU forecasts is also detailed. Finally, a comparison is drawn with the convergence path implied by the mechanical rule. Section 4 concludes.

2 The NAWRU: model and estimates

The commonly-agreed methodology (see Havik et al., 2014) resorts to the standard unobserved component framework which have been proposed by Kuttner (1994) and Gordon (1997) among others to estimate conceptual variables with time-varying behaviour. The unemployment rate U_t is decomposed into the NAWRU n_t plus the gap c_t assuming that their dynamic is generated by the stochastic linear processes:

$$\begin{aligned} \Delta n_t &= a_{nt} + \eta_{t-1} \\ \Delta \eta_t &= a_{\eta t} \\ \phi_c(L)c_t &= a_{ct} \end{aligned} \tag{2.1}$$

where L denote the lag operator, $\Delta \equiv 1-L$ the first-difference, $\phi_c(L) = 1-\phi_{c1}L-\phi_{c2}L^2$ is an autoregressive polynomial with complex roots, and a_{nt}, $a_{\eta t}$, and a_{ct} are independent and normally distributed white noises with variance V_ℓ, $\ell = n, \eta, c$. The choice of an integrated random walk process for capturing the NAWRU dynamics is first motivated by its generality: if $V_\eta = 0$ it reduces to a random walk, if instead $V_n = 0$ it yields the I(2) model $\Delta^2 n_t = a_{\eta t}$. In addition the gap drives the fluctuations of a labour cost indicator in a Phillips curve with either backward or forward-looking expectations, depending on the country. The backward-looking version in current use for AT, BE, DE, IT, LU, MT, and NL, is such that:

$$\Delta \pi_t = \mu_\pi + \beta_0 c_t + \beta_1 c_{t-1} + \gamma' z_t + a_{wt} \tag{2.2}$$

where $\Delta \pi_t$ represents the change in wage inflation. A second lag of the gap may be added. The vector z_t contains exogenous information about terms-of-trade, labour productivity, and the change in the wage share, with country-specific loadings via the vector of coefficients γ. For the other EU countries use is made of the forward-looking version with solution (see Section II.1 in the Quarterly Report on the Euro Area, 2014):

$$\Delta rulc_t = \phi_r \Delta rulc_{t-1} + \beta_0 c_t + \beta_1 c_{t-1} + a_{wt} \tag{2.3}$$

where $rulc$ represent real unit labour cost and β_1 satisfies the constraint $\beta_1 = \beta_0\phi_{c2}(\phi_r - .99)/(.99\phi_r - 1)$. The shock a_{wt} to the Phillips curves (2.2) and (2.3) is a normally distributed white-noise variable which is independent to the other shocks in the model.

Finally the commonly-agreed methodology allows for a post-estimation adjustment of the NAWRU estimates for the countries which have adopted the forward-looking Phillips curve. The adjustment is made by calculating the mean difference between the NAWRU estimates obtained with the backward-looking against the forward-looking Phillips curve. If this difference is positive then it is subtracted from the NAWRU estimates at each year. The adjustment factors are equal to 0.08 for CY, 0.06 for CZ, 0.51 for DK, 0.92 for EL, 0.67 for ES, 0.72 for FI, 0.26 for FR, 0.20 for HU, 0.43 for IE, 0.29 for LT, 0.19 for LV, 0.28 for PT, 0.94 for SE, 0.08 for SI, 0.05 for SK, and 0.15 for UK. No adjustment is made for the other countries. Further details can be found in Havik et al. (2014).

We apply model (2.1)-(2.3) to estimate the NAWRU in all EU Member States except Croatia. Use is made of the Autumn 2016 data vintage extended with two years of exogenous forecasts provided by DG ECFIN. The sample starts around the year 1965 for the EU15 countries and between 1998 and 2003 for the post-2004 enlargement Member States. The model parameters are estimated by maximum likelihood using Program GAP (Planas and Rossi, 2012). Bounds are put on the variance of the long-term shocks a_{Nt} and $a_{\eta t}$ in order to obtain NAWRU estimates that evolve smoothly. All details including Excel interfaces for Program GAP can be found in the Output Gap page of the ECFIN section in the CIRCA web-site.

For each country, Table 1 reports the estimated values for the autoregressive parameters ϕ_{c1} and ϕ_{c2}, the signal to noise ratio q, and the cycle weight β_0 in the Phillips curve together with its t-statistic $t(\beta_0)$. According to the autoregressive parameters estimates, the unemployment cycle in EU countries fluctuates with amplitude about 0.7 and periodicity between five and thirteen years, typically. Considering the 10% confidence level, the unemployment gap is found to contribute significantly to the evolution of labour cost in all countries except AT, BG, CY, EL, and MT. For AT and BG, significance appears in many of the earlier vintages so the empirical evidence against model (2.1)-(2.3) is only weak. For CY, EL, and MT instead, no significant link between unemployment gap and labour cost could be found in any of the previous vintages. We thus conclude that the estimation results do not invalidate the economic prior in twenty-four countries out of the twenty-seven examined.

Table 1 also reports the signal to noise ratio defined as the ratio of magnitude of long-term to short-term shocks. In model (2.1) however, an ambiguity arises because the NAWRU shocks are split between level and slope shocks, a_{nt} and $a_{\eta t}$. We thus merge them in the equivalent representation $\Delta^2 n_t = \Delta a_{nt} + a_{\eta t-1} = (1-\theta_n L)\tilde{a}_{nt}$ with $V(\tilde{a}_{nt}) = \tilde{V}_n$ to obtain the signal to noise ratio as $q = \tilde{V}_n / V_c$. Its value indicates how much of an incoming innovation in unemployment is assigned to the NAWRU compared to the portion assigned to the cycle, hence summarizing the relative smoothness of the NAWRU. The results in Table 1 shows that the signal to noise ratio exceeds one for BG, CZ, IT, and RO, lies between two-third and one-half for AT, EE, HU, IE, and MT, and is below one-half in the other eighteen cases: a high degree of NAWRU smoothness thus dominates but there are few exceptions among the EU Member States.

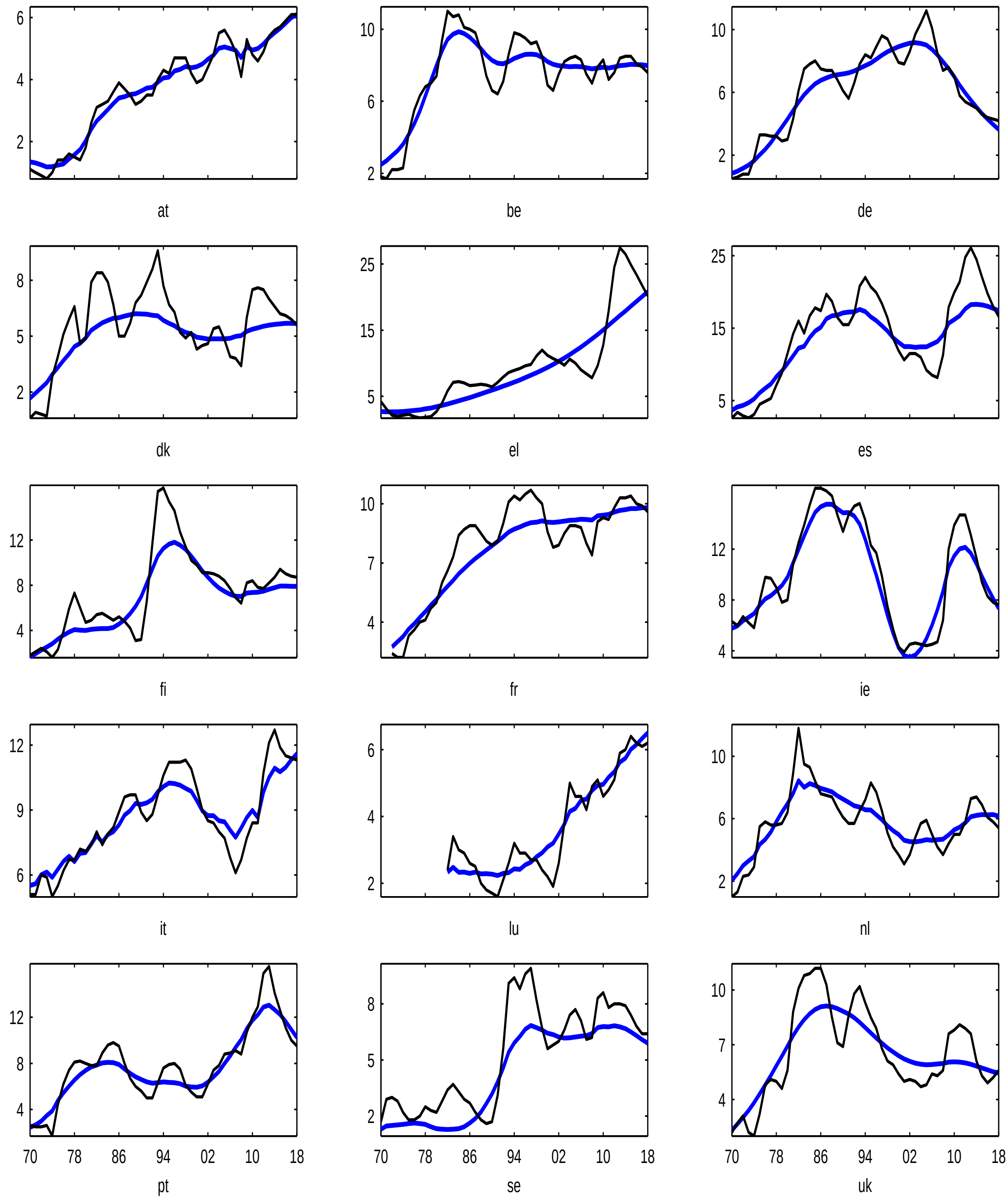
Unemployment and NAWRU estimates are shown in Figure 1a for the EU15 Member States and in Figure 1b for the post-2004 enlargement Member States. A wide variety of patterns appears. Periods of sudden and large increase in unemployment can be noticed, like the beginning nineties for FI and SE and the post-2008 years for EL, ES, IE, and IT. The excursion can be large: for instance in the case of EL and ES the increase of unemployment in the post-2008 years exceeds fifteen percentage points. Figure 1a and 1b show that the integrated random walk process chosen for the NAWRU has the ability to generate paths that are both smooth and sufficiently flexible to accommodate all the variety of developments. Although it has become a standard for US data (see Gordon, 1997), the pure random walk alternative would be less appropriate because, besides leaving more erratic noise in trend estimates, it generates paths that have only a limited flexibility. One example is given by SI where the model has been recently changed to a random walk. Finally, in most countries the proximity at the sample end between unemployment and the NAWRU is noteworthy: this characterizes the pro-cyclicality of the estimates.

Table 1 Parameter estimates for the NAWRU model (2.1)-(2.3)

	ϕ_{c1}	ϕ_{c2}	β_0	$t(\beta_0)$	q
AT	0.88	-0.27	-0.56	-1.52	0.61
BE	1.14	-0.55	-1.00	-2.78	0.17
BG	0.48	-0.20	-1.58	-1.16	1.15
CY	1.47	-0.76	-0.49	-1.07	0.22
CZ	0.71	-0.74	-0.89	-1.76	2.61
DE	1.24	-0.65	-0.68	-2.18	0.10
DK	1.08	-0.36	-0.65	-2.43	0.11
EE	0.84	-0.51	-1.37	-3.69	0.56
EL	1.63	-0.83	-0.36	-0.99	0.02
ES	1.40	-0.57	-0.34	-2.03	0.38
FI	1.34	-0.69	-1.12	-3.84	0.27
FR	1.23	-0.38	-0.30	-1.68	0.14
HU	0.81	-0.21	-1.90	-2.86	0.59
IE	1.15	-0.51	-1.04	-2.36	0.52
IT	1.43	-0.62	-3.49	-3.12	1.42
LT	1.18	-0.68	-1.18	-4.87	0.37
LU	1.02	-0.45	-0.62	-2.27	0.32
LV	1.04	-0.58	-1.57	-4.32	0.14
MT	0.04	-0.31	-0.25	-0.15	0.65
NL	1.12	-0.51	-0.38	-2.29	0.44
PL	1.45	-0.77	-0.82	-2.78	0.03
PT	1.24	-0.56	-1.35	-1.94	0.36
RO	-0.05	0.16	-28.39	-7.04	1.31
SE	1.25	-0.56	-0.99	-2.22	0.23
SI	1.53	-0.82	-0.66	-2.05	0.44
SK	1.27	-0.61	-0.50	-1.74	0.12
UK	1.27	-0.52	-1.02	-2.42	0.05

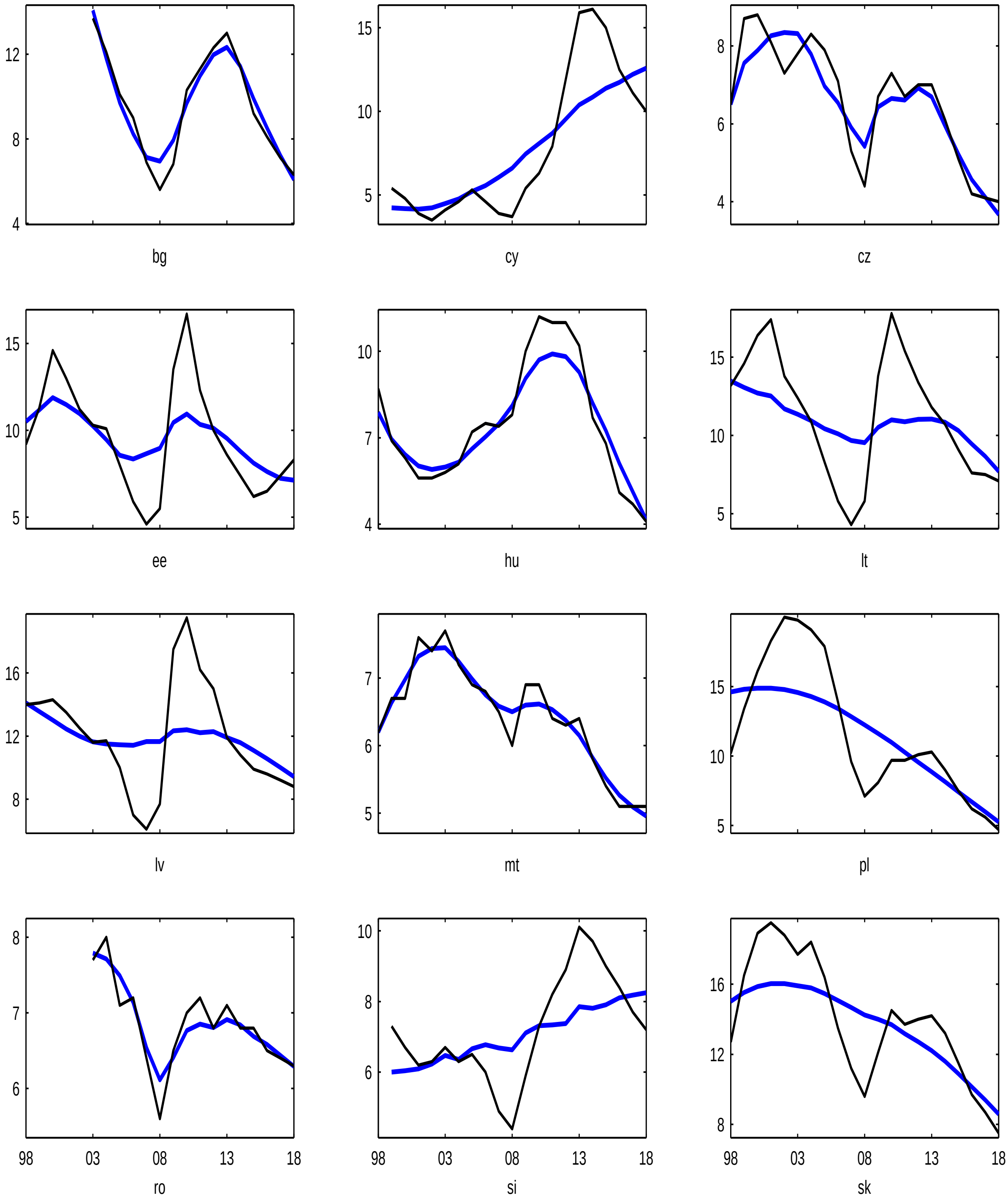
Notes: model estimation is performed by maximum likelihood using the Autumn 2016 vintage data sets extended with two exogenous forecasts; ϕ_{c1} and ϕ_{c2} are the parameters of the autoregressive model for the cycle; β_0 is the coefficient of c_t in the Phillips curve (2.2)-(2.3) with t-statistic $t(\beta_0)$; q refers to the signal to noise ratio implied by equation (2.1).

Figure 1a Unemployment and NAWRU estimates
EU15 Member States, vintage 2016-II



Notes: in each panel, the black line shows unemployment and the blue one the NAWRU.

Figure 1b Unemployment and NAWRU estimates
Post-2004 enlargement Member States, vintage 2016-II



Notes: in each panel, the black line shows unemployment and the blue one the NAWRU.

3 Incorporating structural information in NAWRU estimates

3.1 A model-based approach to anchor the NAWRU

The model-based approach that is being used adds structural unemployment say S_t to the information set under the assumption that the NAWRU converges to this anchor at the horizon, i.e. $n_{T+h} = S_{T+h}$. The anchor in $T+h$ is obtained under the hypothesis of no policy change, so $S_{T+h} = S_T$. As this approach is non-standard the signal extraction formula must be customized. Let $x^T = (x_1, \cdots, x_T)$ denote the set of observations available on variable x_t until time T, and let W represent the labour cost indicator in use, namely the wage acceleration in the backward-looking Phillips curve or the growth of real unit labour cost in the forward-looking version. The hypothesis of gaussian shocks implies that the random variables n_t and n_{T+h} are jointly normally distributed given U^T and W^T according to:

$$\begin{array}{c} n_t \\ n_{T+h} \end{array} \mid U^T, W^T \sim N \left(\begin{array}{c} E(n_t \mid U^T, W^T) \\ E(n_{T+h} \mid U^T, W^T) \end{array}, \Sigma \right)$$

with

$$\Sigma = \begin{pmatrix} V(n_t \mid U^T, W^T) & Cov(n_t, n_{T+h} \mid U^T, W^T) \\ & V(n_{T+h} \mid U^T, W^T) \end{pmatrix}$$

where $V(\cdot)$ and $Cov(\cdot)$ denote variance and covariance. The anchored estimate $n^a_{t|T}$ is defined as $n^a_{t|T} = E(n_t | U^T, W^T, n_{T+h} = S_{T+h})$, and by properties of the normal distribution it verifies:

$$n^a_{t|T} = E(n_t|U^T, W^T) + \frac{Cov(n_t, n_{T+h}|U^T, W^T)}{V(n_{T+h}|U^T, W^T)} \big(n_{T+h} - E(n_{T+h}|U^T, W^T)\big) \tag{3.1}$$

In (3.1), the original estimate $n_{t|T} = E(n_t|U^T, W^T)$ and the anchor $n_{T+h} = S_{T+h}$ are available but the quantities $Cov(n_t, n_{T+h}|U^T, W^T)$, $V(n_{T+h}|U^T, W^T)$, and $n_{T+h|T} = E(n_{T+h}|U^T, W^T)$ must be retrieved. They can be obtained from the Kalman smoother and the NAWRU forecast function. Details are given in the Appendix. Like for the plain

NAWRU estimates, a post-estimation adjustment using the factors given in Section 2 is performed for the countries which have adopted a forward-looking Phillips curve.

Equation (3.1) makes the path of convergence to the anchor model-driven. The weights $d_{t,T+h} = Cov(n_t, n_{T+h}|U^T, W^T)/V(n_{T+h}|U^T, W^T)$ decay exponentially from the maximum value equal to one in $t = T + h$ to an almost-zero value in $t = 1$. The impact of anchoring thus dissipates with the passage of time as the time-distance to the convergence point augments. In the years close to the sample end the forecast error $S_{T+h} - n_{T+h|T}$ determines the relative position of the anchored and non-anchored estimates. At the horizon the NAWRU hits the anchor, i.e. $n^a_{T+h|T} = S_{T+h}$.

A closer look at the linear projection formula (3.1) reveals how model-based anchoring moderates pro-cyclicality. At the sample end the anchored NAWRU verifies:

$$n^a_{T|T} = n_{T|T} + d_{T,T+h}(S_{T+h} - n_{T+h|T}) \tag{3.2}$$

The original, non-anchored, NAWRU estimate is obtained as the linear combination:

$$\begin{aligned} n_{T|T} &= \sum_{\ell=-T+1}^{0} \nu^0_{u\ell} U_{T+\ell} \; + \; \nu^0_{w\ell} W_{T+\ell} \\ &= \nu^0_u(L)U_T + \nu^0_w(L)W_T \end{aligned} \tag{3.3}$$

where ν^0_{u0} is the weight attached to the concurrent observation on unemployment. The h-step-ahead forecast of the NAWRU is similarly obtained as:

$$\begin{aligned} n_{T+h|T} &= \sum_{\ell=-T+1}^{0} \nu^h_{u\ell} U_{T+\ell} \; + \; \nu^h_{w\ell} W_{T+\ell} \\ &= \nu^h_u(L)U_T + \nu^h_w(L)W_T \end{aligned}$$

where ν^h_{u0} weights the concurrent observation on unemployment. Putting both linear combinations into (3.1) yields the concurrent anchored NAWRU estimate as:

$$n^a_{T|T} = (\nu^0_u(L) - d_{T,T+h}\nu^h_u(L))U_T + (\nu^0_w(L) - d_{T,T+h}\nu^h_w(L))W_T + d_{T,T+h}S_{T+h}$$

Hence the anchored NAWRU loads concurrent unemployment with a weight ν^{a0}_{u0} which is equal to:

$$\nu^{a0}_{u0} = \nu^0_{u0} - d_{T,T+h}\nu^h_{u0}$$

Since $0 < d_{T,T+h} < 1$ and $\nu^h_{u0} > 0$ for the trend model in use, the anchored NAWRU puts a lower weight on concurrent unemployment compared to the original estimate, i.e. $\nu^{a0}_{u0} < \nu^0_{u0}$: this mitigates pro-cyclicality. Before turning to empirical results we explain the construction of the anchor.

3.2 Estimates of the structural unemployment rate

Like in Orlandi (2012), the structural unemployment rate S_t is built using a panel regression such as:

$$n_{it} = \alpha_i + \sum_j \gamma_j ST_{ijt} + \sum_j \tau_j X_{ijt} + a_{it}$$

where n_{it} refers to the (non-anchored) NAWRU of country i, α_i is the country-fixed effect, and ST_{ijt} and X_{ijt} are country-specific indicators that account for the labour market structure and for the cyclical position of the economy. The empirical evidence reported in Orlandi (2012) suggests that the replacement rate, union density, labour tax wedge, and the real interest rate are likely to increase the NAWRU, whereas active labour market policies, total factor productivity, and construction activity may have the opposite effect. Bassanini and Duval (2006) have also found these variables to have predictive power for unemployment. We thus estimate the panel regression using these explanatory variables. The data for the labour market variables are collected from Eurostat and OECD databases whereas the cyclical indicators are taken from AMECO. The series cover the period 1985-2016 and are available for all EU Member States except Croatia.

Still following Orlandi, the structural unemployment rate for country i is defined as the portion of the NAWRU explained by the country-specific labour market characteristics and by the sample average of the short-term indicators say $\overline{X}_{ij}$:

$$S_{it} = \alpha_i + \sum_j \gamma_j ST_{ijt} + \sum_j \tau_j \overline{X}_{ij}$$

The cyclical indicators are loaded in average in order to remove short-term fluctuations from the structural unemployment rate. The NAWRU is expected to converge to this structural unemployment rate at some horizon under the hypothesis of no policy change.

3.3 Anchored versus non-anchored NAWRU estimates

We apply model-based anchoring to the NAWRU estimates presented in Section 2. To determine the horizon at which the NAWRU converges to the structural unemployment rate we adopt the rules developed by the Output Gap Working Group (OGWG) and described in Section 4 of Havik et al. (2014). The Economic Policy Committee (EPC) initiated the development of this methodology in November 2012.[1] With the launch of

[1]The EPC is an advisory body to the Commission and the Council. It contributes to the Council's work of coordinating Member States' economic policies.

the Europe 2020 Strategy, at the time the EPC considered it necessary to have a set of integrated, no policy change, macroeconomic projections for the period up to T+10.

Country-specific convergence horizons are displayed in Figure 2. The ten-year horizon dominates for the EU15 Member States but longer convergence periods are retained for most the post-2004 enlargement Member States. This discrepancy stems from the facts that current unemployment rates in the post-2004 enlargement Member States are significantly below their historical average and that these countries have experienced staggeringly high unemployment numbers in the beginning of the 90s when market-based institutions have been developed. Given the relatively short series of observations available for these countries, this yields an upward bias in the estimates of structural unemployment. As a result, the absolute difference in this group of countries between unemployment and structural unemployment is often larger than five percentage points, especially at the end of the sample. Given the OGWG rules, this implies that the convergence of the NAWRU to the structural rate takes more than ten years on average.

Figure 2 Country-specific convergence horizons

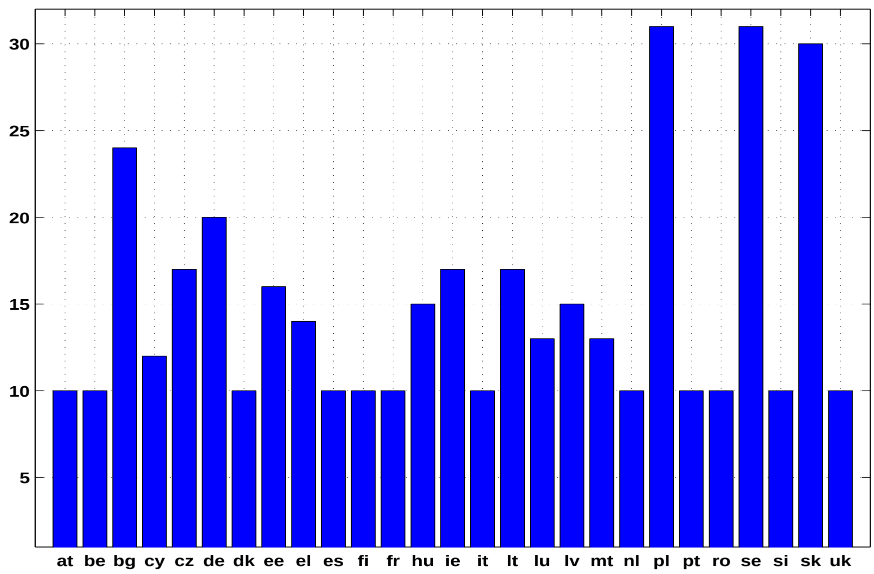


Figure 3a and 3b show the structural unemployment rate together with the NAWRU estimates obtained with and without anchoring, the first Figure gathering the EU15 Member States and the second Figure the post-2004 enlargement Member States. The two Figures focus on the post-2000 years as in the earlier years the two NAWRU estimates are indistinguishable. The structural unemployment rate is represented with a green line; it shows some short-term variability. As a consequence of the financial crisis, unemployment and the NAWRU exceed the structural rate in 2016 in most of the

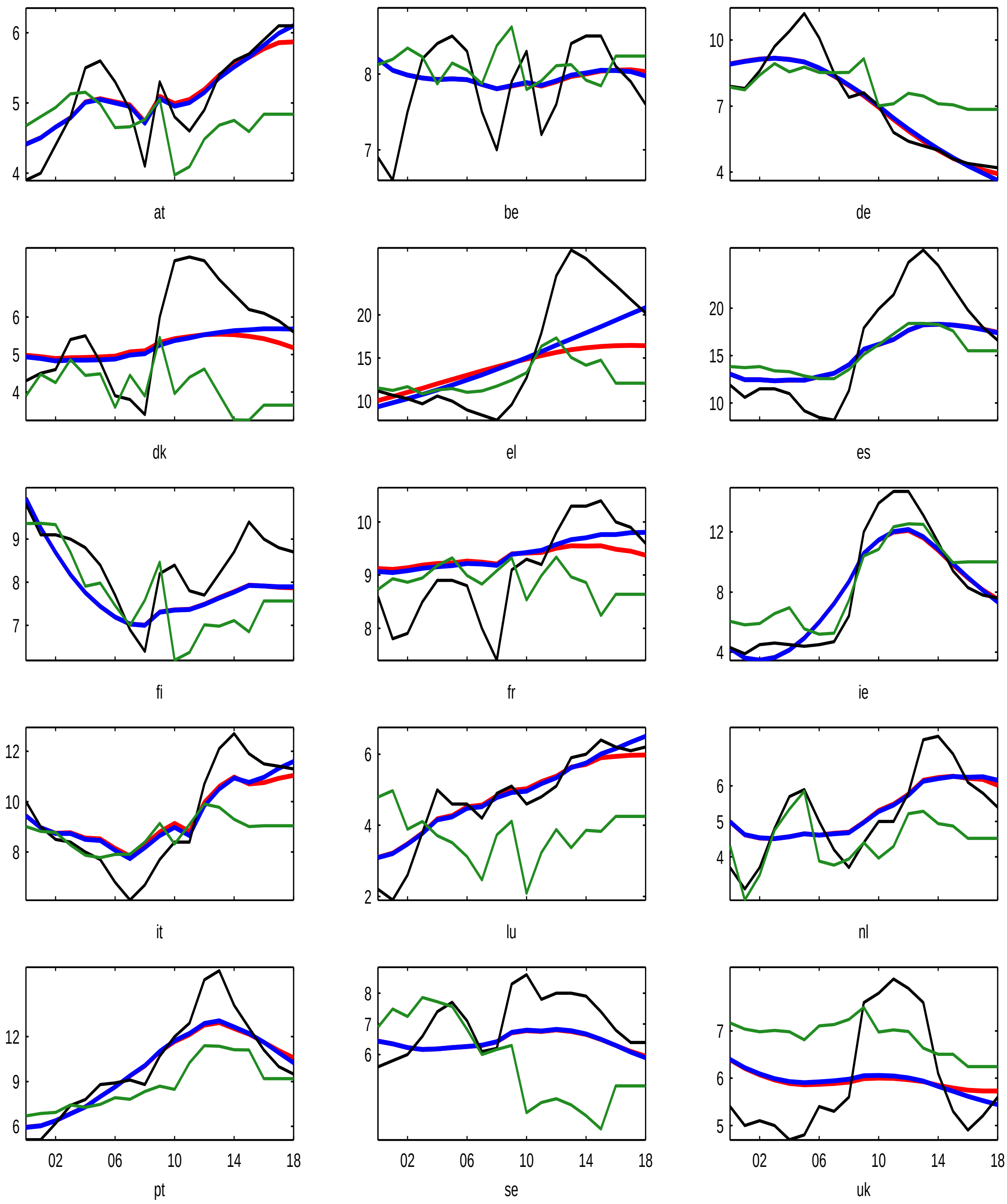
EU15 Member States, namely AT, DK, EL, ES, FI, FR, IT, LU, NL, PT, and SE, the exceptions being BE, DE, IE, and UK. The situation is opposite for the post-2004 enlargement countries where unemployment and the NAWRU in 2016 lie most often below the structural rate, the only exceptions being CY, RO, and SI. Since anchoring shifts the NAWRU estimates towards the structural indicator, anchoring lowers the NAWRU in the years 2016-2018 in those countries where the structural rate in 2016 lies below the actual unemployment rate. In these cases the anchored NAWRU is more distant to the concurrent unemployment rate compared to the original estimate. The opposite situation prevails among the post-2004 enlargement Member States.

Figure 4 which shows the weight assigned to the end-of-sample unemployment observation confirms that model-based anchoring systematically reduces the importance of the last observation in concurrent NAWRU estimates. The weight reduction is equal to one-fourth on average over the twenty-seven countries but there is some heterogeneity: the pro-cyclicality attenuation mechanism is less effective in the case of BG, CZ, and MT where the weight reduction is less than 10%, and more effective in the case of DK, EL, FR, and UK where the weight reduction exceeds one-half.

As a further empirical evidence about pro-cyclicality, Table 2 reports the minimum value taken by the NAWRU during the years 2002-2009, the maximum value during the years 2009-2016, and the range of variation between these two periods. When NAWRU is mostly decreasing over the years 2002-2016 like for BG, CZ, DE, FI, MT, PL, and SK, the range of variation is calculated by subtracting the minimum achieved during the years 2009-2016 to the maximum achieved during the years 2002-2009. The calculations use all vintages available, namely 2002-2016 for the EU15 Member States and 2008-2016 for the post-2004 enlargement ones, as well as the real-time estimates of the structural indicator. Table 2 confirms that model-based anchoring stabilizes the NAWRU in most countries. The countries where the stabilization effect is most operative, namely DK, EL, FR, and UK, correspond to those where the weight assigned to the last observation in concurrent NAWRU estimation is most reduced as shown in Figure 4. Conversely, no stabilization effect appears for the three countries, namely BG, CZ, and MT, where anchoring leaves the weight put on the last observation in concurrent NAWRU estimation almost unchanged.

Figure 3a Original vs anchored NAWRU

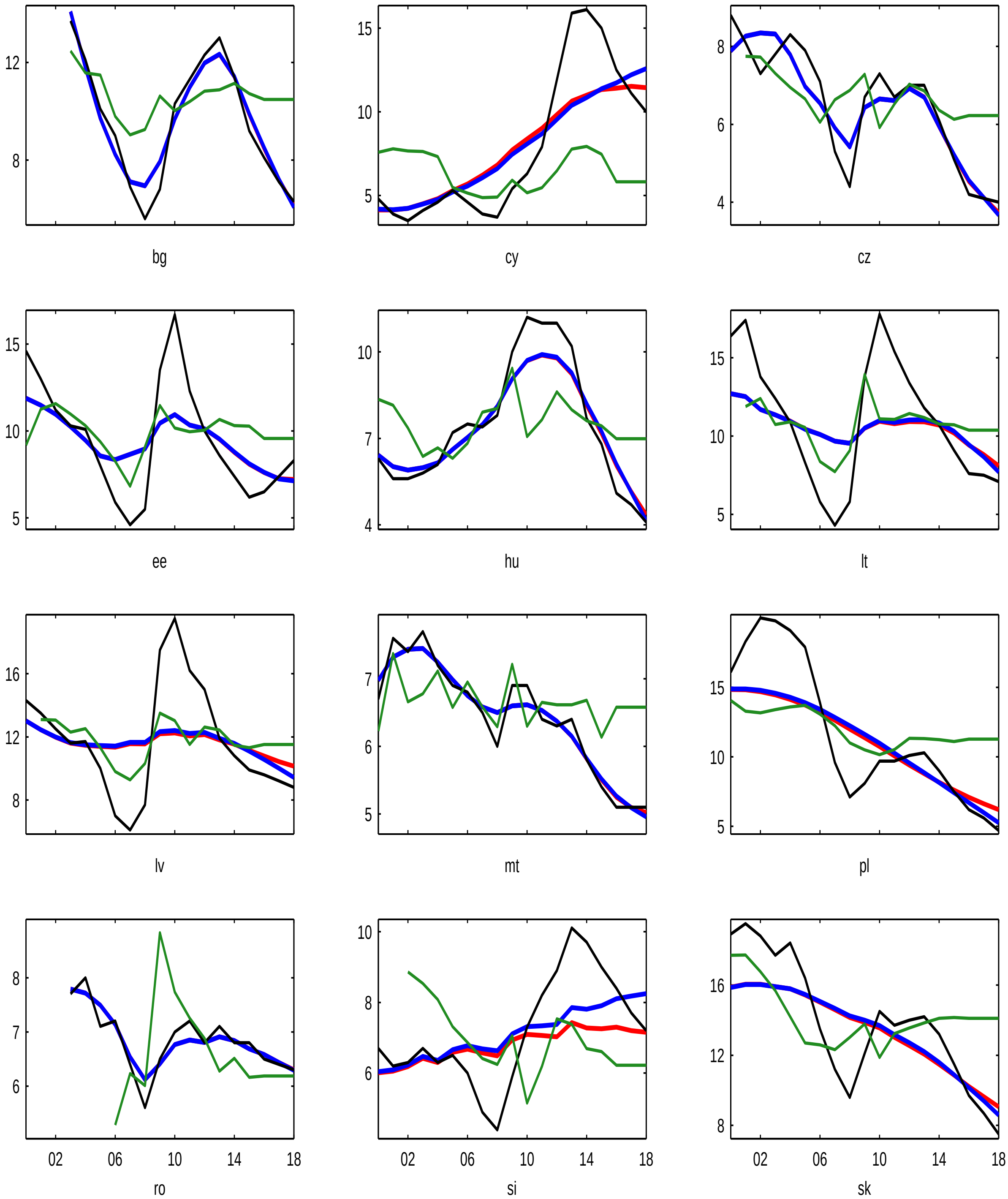
EU15 Member States, vintage 2016-II



Notes: in each panel, the black line shows unemployment, the blue one the original NAWRU estimates, the green one the anchor as calculated in 2016, and the red one the anchored NAWRU.

Figure 3b Original vs anchored NAWRU

Post-2004 enlargement Member States, vintage 2016-II



Notes: in each panel, the black line shows unemployment, the blue one the original NAWRU estimates, the green one the anchor as calculated in 2016, and the red one the anchored NAWRU.

Figure 4 Weight put on concurrent unemployment
when estimating the NAWRU at the sample end

Anchoring versus non-anchoring

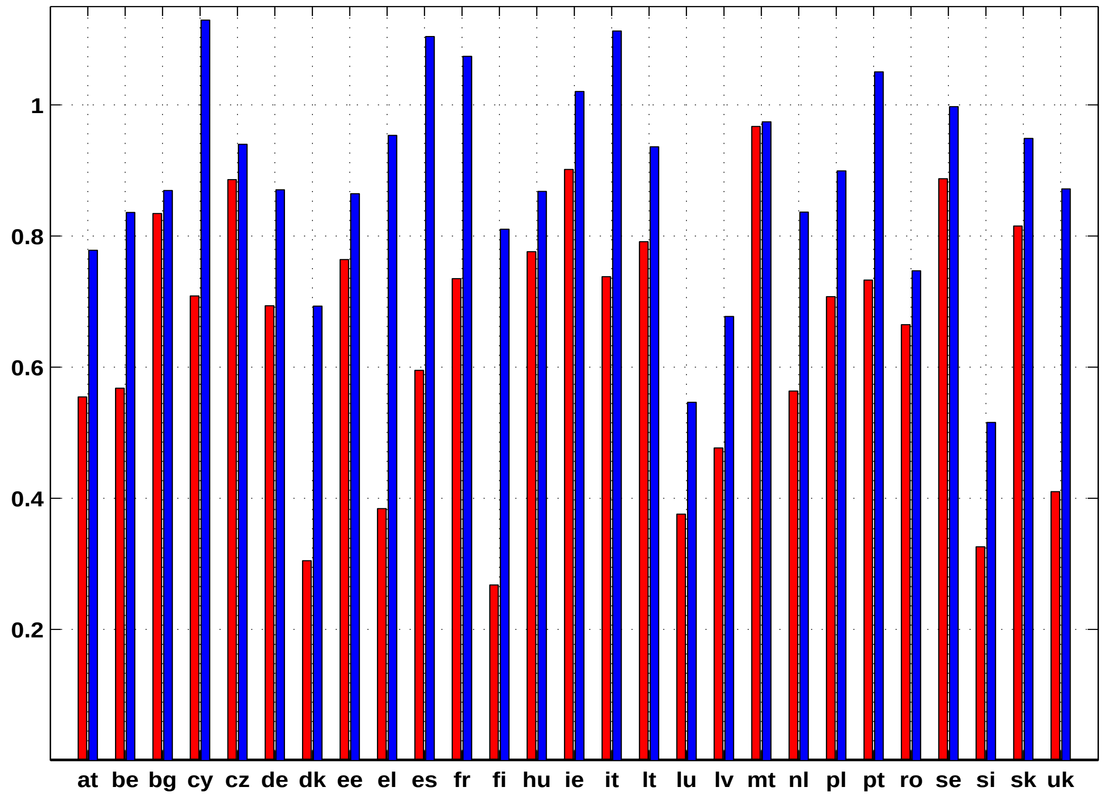


Table 2 NAWRU range of variation, all vintages

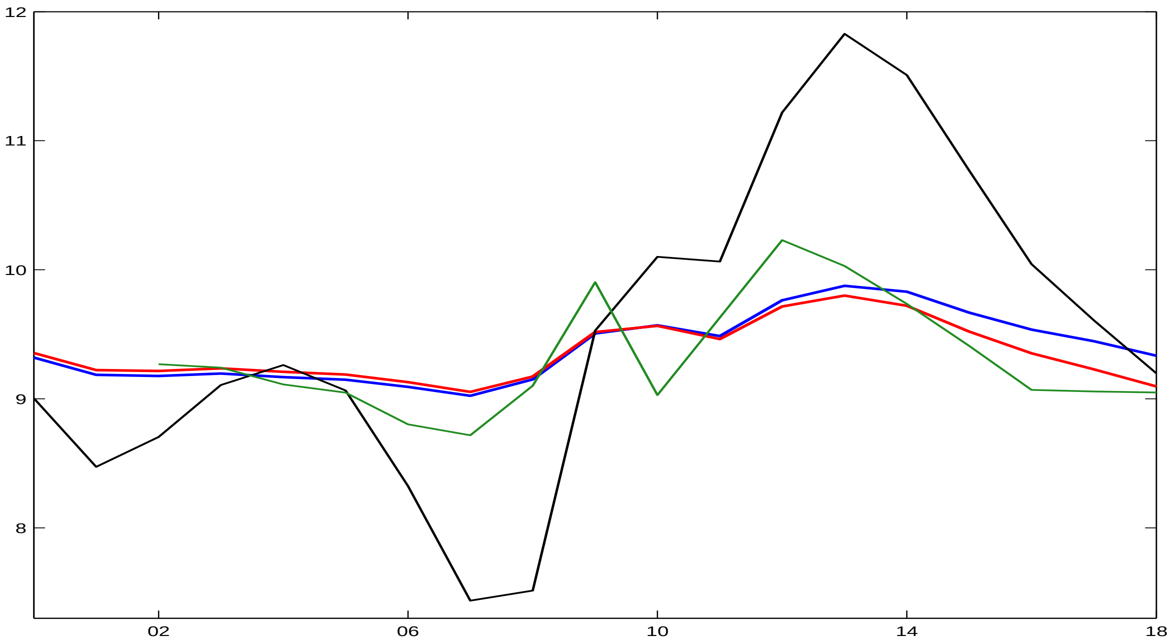
	Non-anchored		Anchored	
	min - max	Diff.	min - max	Diff.
AT	3.60 - 5.82	2.21	3.80 - 5.69	1.88
BE	6.60 - 9.27	2.67	7.37 - 8.87	1.49
BG*	5.79 - 14.49	8.70	5.80 - 14.49	8.70
CY	3.73 - 15.25	11.52	3.69 - 13.80	10.11
CZ*	4.51 - 8.43	3.92	4.55 - 8.43	3.88
DE*	4.29 - 9.43	5.13	4.34 - 9.37	5.04
DK	3.06 - 7.23	4.17	3.56 - 6.47	2.91
EE	5.46 - 16.13	10.67	5.48 - 15.55	10.07
EL	8.29 - 21.34	13.06	7.63 - 17.41	9.78
ES	6.42 - 23.43	17.01	7.63 - 21.19	13.56
FI*	6.34 - 9.52	3.17	6.57 - 9.48	2.91
FR	8.66 - 10.83	2.18	8.98 - 10.36	1.38
HU	5.80 - 11.62	5.82	5.80 - 11.44	5.64
IE	3.76 - 14.28	10.53	3.82 - 14.09	10.28
IT	5.38 - 11.45	6.07	5.84 - 11.08	5.24
LT	7.05 - 14.31	7.26	7.09 - 13.77	6.68
LU	2.77 - 7.21	4.44	2.78 - 6.20	3.42
LV	6.98 - 15.57	8.59	7.32 - 14.60	7.28
MT*	5.26 - 7.53	2.26	5.25 - 7.53	2.28
NL	2.36 - 6.97	4.61	2.44 - 6.31	3.86
PL*	6.69 - 14.83	8.14	7.09 - 14.70	7.62
PT	5.31 - 16.89	11.58	5.54 - 14.79	9.25
RO	6.11 - 9.54	3.43	6.11 - 9.31	3.20
SE	4.54 - 8.87	4.32	4.71 - 8.72	4.01
SI	4.84 - 9.24	4.39	4.93 - 7.53	2.60
SK*	10.11 - 16.87	6.76	10.28 - 16.80	6.52
UK	4.32 - 7.87	3.55	4.88 - 7.22	2.34

Notes: the min is calculated over the years 2002-2009 and the max over the years 2009-2016; for BG, CZ, DE, FI, MT, PL, and SK, the min and max are switched as the NAWRU is mostly decreasing over 2002-2016; use is made of the real-time values of the structural anchor.

Finally, we show in Figure 5 the implied NAWRU for the euro area in the years 2000-2018, calculated as country-average with weights given by the proportion of population at working age. Applying the same weights to the national anchors yields a structural level of unemployment in the euro area equal to 9.05 in 2016. The original and anchored NAWRU differ since 2011 and the difference widens until 2018 where it amounts to 0.2. Anchoring decreases noticeably the contribution of the NAWRU to the rise in unemployment observed in the years 2011-2016.

Figure 5 Euro area unemployment, 2000-2018

Anchored versus original NAWRU



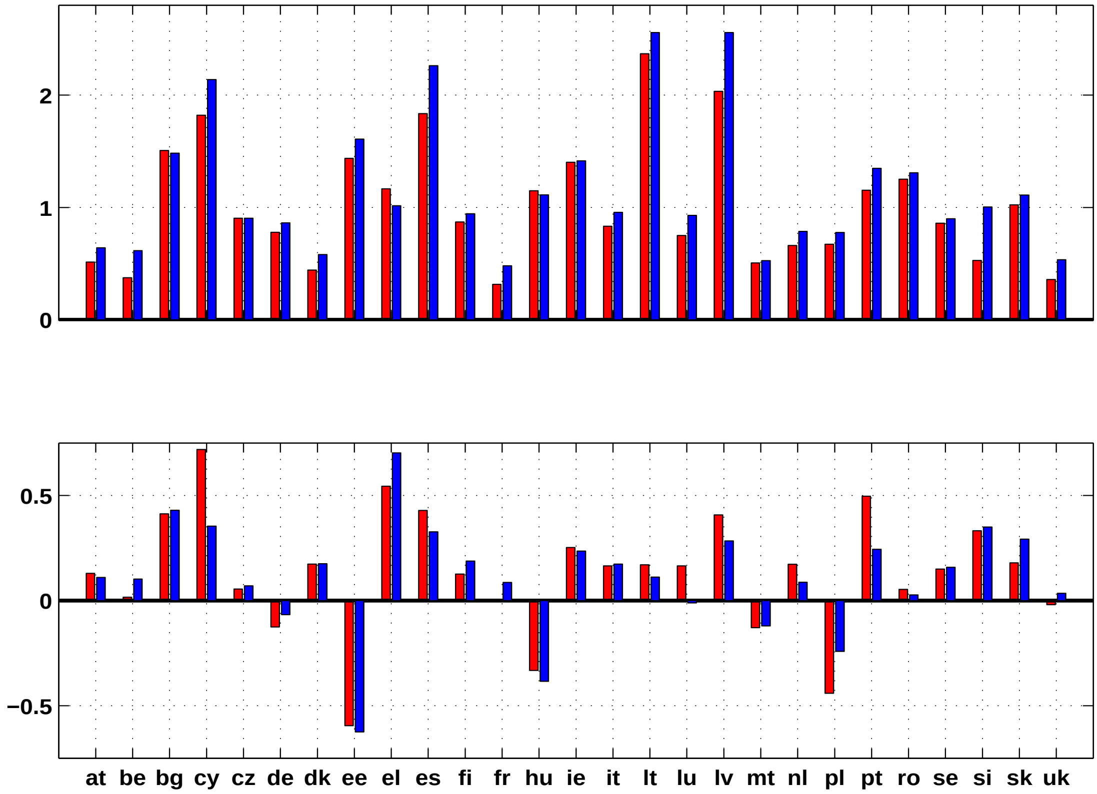
Notes: the black line shows unemployment, the blue one the original NAWRU, the green one the structural unemployment rate, and the red one the anchored NAWRU.

3.4 Real-time revision analysis

Since anchoring reduces the weight ν_{u0}^{0} given to the last observation in concurrent estimation, we also expect anchoring to moderate the revisions in NAWRU estimates. Let a_{uT} denote the innovation in unemployment at time T. According to standard revision analysis (see Pierce, 1980), the product $\nu_{u0}^{0} a_{uT}$ gives the contribution of the unpredictable part of unemployment to the first revision to the one-year-ahead NAWRU forecast made at time $T-1$, i.e. $n_{T|T} - n_{T|T-1}$. Under the simplifying hypothesis that the model parameters are constant, that the data are not subsequently updated, and that the structural rate is constant in periods T-1 and T, it is possible to show that anchoring decreases the first revision $n_{T|T} - n_{T|T-1}$. What happens instead in real-time with data coming through vintages and model parameters re-estimated is however unclear. Taking benefit of the availability of vintages for the endogenous variables as well as for the structural unemployment rate, Figure 6a-6b show the average and standard deviation of the first revision to the one- and two-step-ahead forecast of the NAWRU, i.e. $n_{T|T} - n_{T|T-1}$ and $n_{T|T-1} - n_{T|T-2}$, obtained with and without anchoring. The average revisions are found significant in the only case of EL. For twenty-two countries, anchoring reduces the standard error of the first revision to the one- and two-year-ahead NAWRU forecasts, the reduction being equal to 15% on average across countries for both forecasts. The countries where anchoring does not stabilize the NAWRU forecasts are BG, CZ, EL, HU, IE, and MT. Overall, model-based anchoring helps reducing the first revision to the one and two-year ahead NAWRU forecast in four-fifth of the countries considered. The largest reduction, namely 20%, 30%, 50%, and 30%, is obtained for DK, FR, SI, and UK.

Figure 6a Standard error and average of $n_{T|T-1} - n_{T|T-2}$

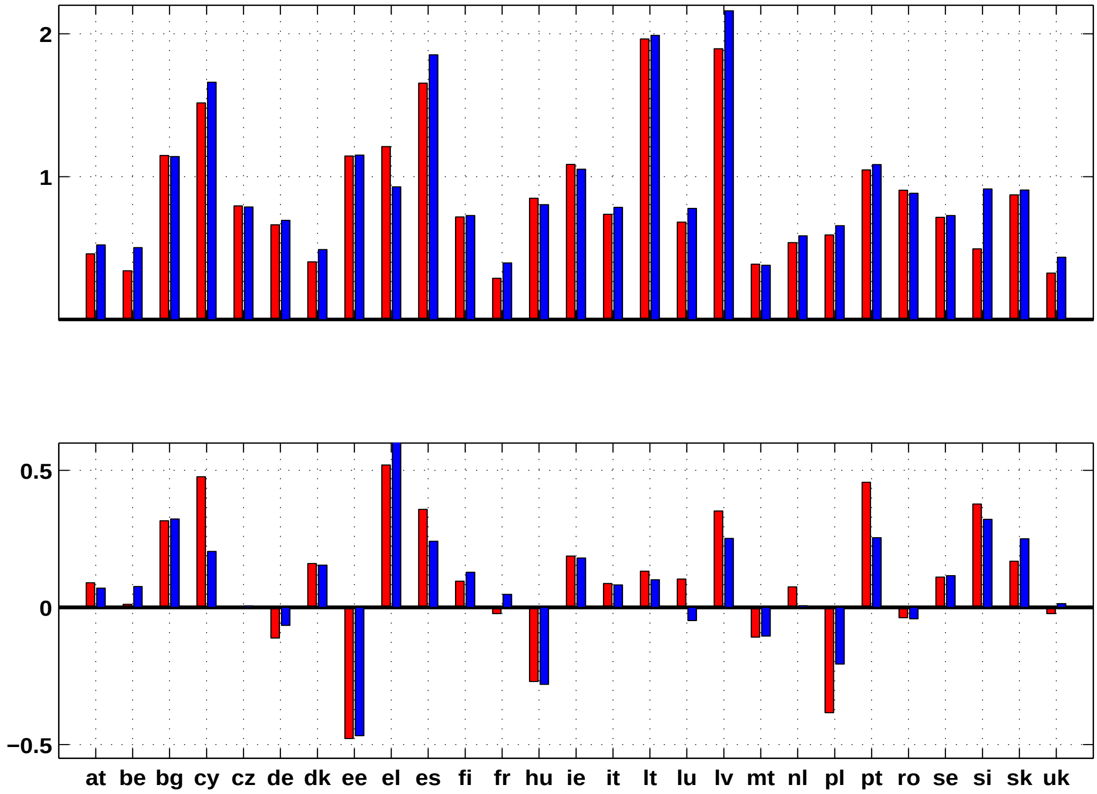
Anchored versus non-anchored NAWRU



Notes: top panel: standard error; bottom panel: average.

Figure 6b Standard error and average of $n_{T|T} - n_{T|T-1}$

Anchored versus non-anchored NAWRU



Notes: top panel: standard error; bottom panel: average.

3.5 NAWRU mid-term forecasts: anchoring vs mechanical extension

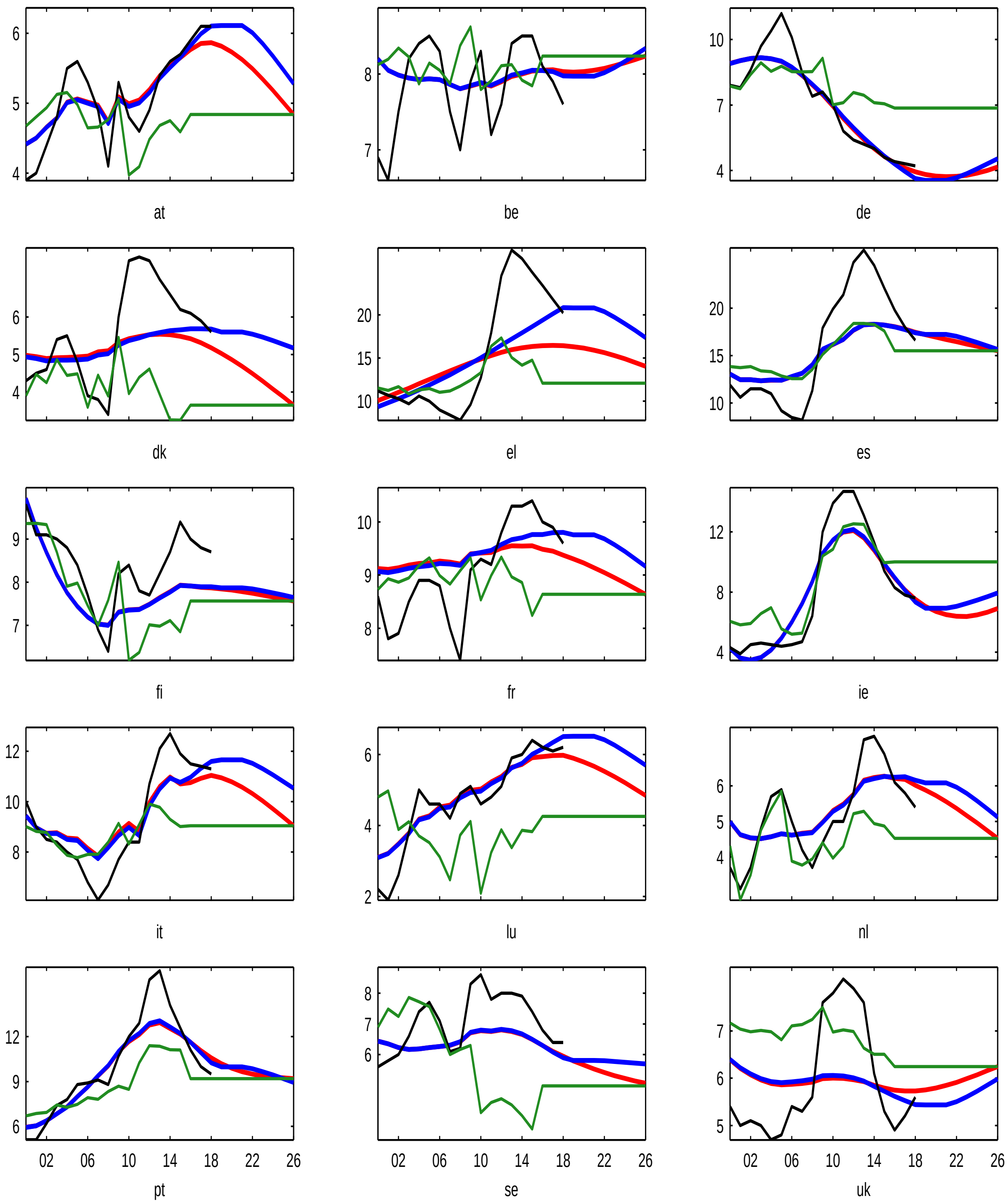
Anticipating the evolution of fiscal imbalances requires extending the NAWRU up to ten years ahead. In the commonly agreed methodology, the NAWRU predictions take the labour market characteristics into account via a mechanical rule that guides the out-of-sample evolution towards the structural indicator. The mechanical rule assumes a NAWRU growth that halves in the first out-of-sample year, vanishes in the next two years, after which a linear convergence to the structural indicator is supposed to take place. The in-sample estimates are left unchanged. To see the enhancement obtained with model-based anchoring, Figure 7a-7b show the paths to T+10 implied by two approaches. The model-based path is generally smoother: less fluctuations are recorded in the out-of-sample years. Also the mechanical rule implies a discontinuity around T+5 visible for instance in the case of CY, EL, ES, and SE which is eliminated by model-based anchoring.

4 Conclusion

We have detailed an innovative model-based procedure for anchoring the NAWRU to a structural indicator of the labour market at a given horizon, typically ten years or more. It yields an anchored NAWRU that mixes information about the business cycle and the characteristics of the labour market. Compared to the plain estimates, the anchored NAWRU enjoys good properties: it shows less pro-cyclicality at the sample end, less variability out of sample compared to the mechanical extension in current use, and the first two NAWRU forecasts undergo a smaller first revision compared to the non-anchored NAWRU in four-fifth of the countries considered.

Figure 7a Mechanical vs model-based NAWRU extension to T+10

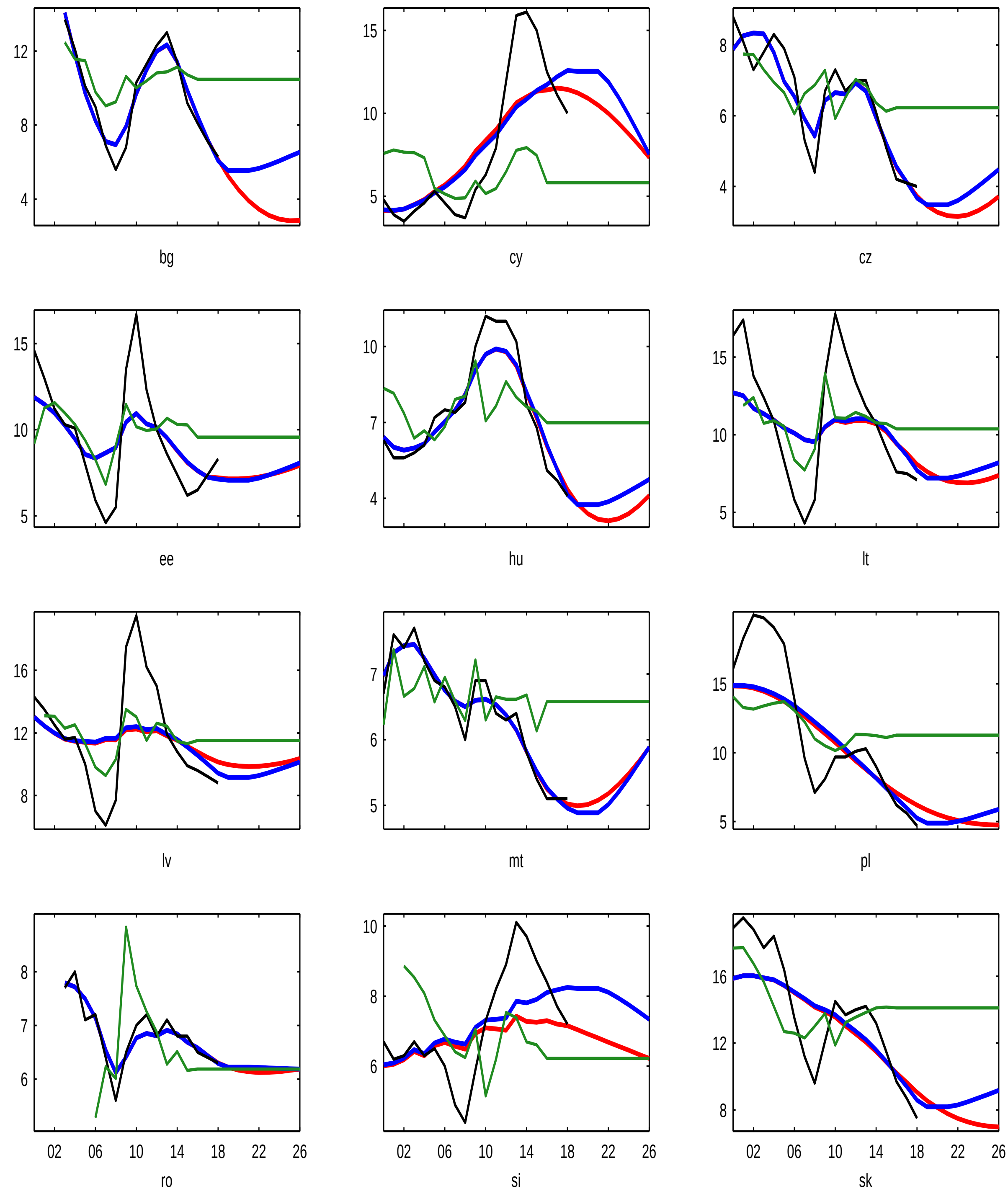
EU15 Member States, vintage 2016-II



Notes: in each panel, the black line shows unemployment, the blue one the original NAWRU estimates with mechanical extension, the green one the anchor as calculated in 2016, and the red one the anchored NAWRU.

Figure 7b Mechanical vs model-based NAWRU extension to T+10

Post-2004 enlargement Member States, vintage 2016-II



Notes: in each panel, the black line shows unemployment, the blue one the original NAWRU estimates with mechanical extension, the green one the anchor as calculated in 2016, and the red one the anchored NAWRU.

A Appendix

We show how to calculate the conditional moments $Cov(n_t, n_{T+h}|U^T, W^T)$, $V(n_{T+h}|U^T, W^T)$, and $n_{T+h|T} = E(n_{T+h}|U^T, W^T)$ that are necessary to apply the linear projection formula (3.1) for anchoring the NAWRU. Let us first cast model (2.1)-(2.3) into a state-space format like:

$$\begin{aligned} x_t &= H\xi_t \\ \xi_{t+1} &= F\xi_t + Re_{t+1} \end{aligned}$$

where $x_t = (U_t, W_t)'$, the vector e_t with variance $V(e_t) = Q$ gathers the model shocks, and the state vector ξ_t contains the unobserved variables so $n_t = s\xi_t$ for some selection vector s. The VAR(1) representation of the state transition dynamics implies:

$$\begin{aligned} E(\xi_{T+h}|U^T, W^T) &= F^h E(\xi_T|U^T, W^T) \\ V(\xi_{T+h}|U^T, W^T) &= F^h V(\xi_T|U^T, W^T)F^{h'} + \\ &+ RQR' + FRQR'F' + \cdots + F^{h-1}RQR'F^{h-1'} \\ Cov(\xi_t, \xi_{T+h}|U^T, W^T) &= Cov(\xi_t, \xi_T|U^T, W^T)F^{h'} \qquad t \leq T \end{aligned} \tag{A.1}$$

The Kalman filter returns the first two conditional moments $E(\xi_T|U^T, W^T) = \xi_{T|T}$ and $V(\xi_T|U^T, W^T)$ involved in the equation above, and the fixed-point smoother the term $Cov(\xi_t, \xi_T|\, U^T, W^T)$ (see Harvey, 1989). By picking up the relevant element the selection vector s then gives:

$$\begin{aligned} E(n_{T+h}|U^T, Y^T) &= sE(\xi_{T+h}|U^T, W^T) = sF^h\xi_{T|T} \\ V(n_{T+h}|U^T, W^T) &= sV(\xi_{T+h}|U^T, W^T)s' \\ Cov(n_t, n_{T+h}|U^T, W^T) &= sCov(\xi_t, \xi_T|U^T, W^T)F^{h'}s' \qquad t \leq T \end{aligned}$$

Plugging these quantities into (3.1) yields the in-sample anchored NAWRU estimator:

$$n^a_{t|T} \; = \; n_{t|T} + \frac{sCov(\xi_t, \xi_T|U^T, W^T)F^{h'}s'}{sV(\xi_{T+h}|U^T, W^T)s'}(S_{T+h} - sF^h\xi_{T|T}) \qquad t \leq T$$

The formula for out-of-sample projections differs slightly. The covariance between the forecasts of ξ_{T+k} and ξ_{T+h}, $0 < k \leq h$, verifies:

$$Cov(\xi_{T+k}, \xi_{T+h}|U^T, W^T) \; = \; V(\xi_{T+k}|U^T, W^T)F^{(h-k)\prime}$$

where $V(\xi_{T+k}|U^T, W^T)$ is given in the second equation of system (A.1). The anchored forecasts are thus given by:

$$n^a_{T+k|T} \quad = \quad n_{T+k|T} + \frac{sV(\xi_{T+k}|U^T, W^T)F^{(h-k)'}s'}{sV(\xi_{T+h}|U^T, W^T)s'}(S_{T+h} - sF^h\xi_{T|T}) \qquad 0 < k \leq h$$

which collapses to $n^a_{T+h|T} = S_{T+h}$ when $k = h$.

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Table 1a Maximum likelihood parameter estimates, vintage 2016-II

	ϕ_1	ϕ_2	A	τ	q	β_0	$t(\beta_0)$
AT	0.88	-0.27	0.52	11.07	0.61	-0.56	-1.52
BE	1.14	-0.55	0.74	9.04	0.17	-1.00	-2.78
BG	0.48	-0.20	0.44	6.26	1.15	-1.58	-1.16
CY	1.47	-0.76	0.87	11.11	0.22	-0.49	-1.07
CZ	0.71	-0.74	0.86	5.48	2.61	-0.89	-1.76
DE	1.24	-0.65	0.81	9.09	0.10	-0.68	-2.18
DK	1.08	-0.36	0.60	13.64	0.11	-0.65	-2.43
EE	0.84	-0.51	0.71	6.70	0.56	-1.37	-3.69
EL	1.63	-0.83	0.91	13.55	0.02	-0.36	-0.99
ES	1.40	-0.57	0.75	16.79	0.38	-0.34	-2.03
FI	1.34	-0.69	0.83	10.00	0.27	-1.12	-3.84
FR	1.23	-0.38	0.62	50.00	0.14	-0.30	-1.68
HU	0.81	-0.21	0.45	13.63	0.59	-1.90	-2.86
IE	1.15	-0.51	0.72	9.78	0.52	-1.04	-2.36
IT	1.43	-0.62	0.79	14.54	1.42	-3.49	-3.12
LT	1.18	-0.68	0.83	8.08	0.37	-1.18	-4.87
LU	1.02	-0.45	0.67	8.81	0.32	-0.62	-2.27
LV	1.04	-0.58	0.76	7.65	0.14	-1.57	-4.32
MT	0.04	-0.31	0.55	4.10	0.65	-0.25	-0.15
NL	1.12	-0.51	0.71	9.50	0.44	-0.38	-2.29
PL	1.45	-0.77	0.87	10.64	0.03	-0.82	-2.78
PT	1.24	-0.56	0.75	10.49	0.36	-1.35	-1.94
RO	-0.05	0.16	-0.43	0.37	1.31	-28.39	-7.04
SE	1.25	-0.56	0.75	10.74	0.23	-0.99	-2.22
SI	1.53	-0.82	0.91	11.16	0.44	-0.66	-2.05
SK	1.27	-0.61	0.78	10.07	0.12	-0.50	-1.74
UK	1.27	-0.52	0.72	12.63	0.05	-1.02	-2.42

Notes: data extended with two forecasts; ϕ_{c1}, ϕ_{c2} are the parameters of the AR(2) model for the cycle; A and τ denote the amplitude and periodicity of the roots for the cycle; β_0 is the coefficient of c_t in the Phillips curve (2.2)-(2.3) with t-statistic $t(\beta_0)$; q is the signal to noise ratio implied by equation (2.1).

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