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On Econometrics with a Human Face and Business Cycles: A Reply to Fioramanti and Waldmann's Criticism on the EU's NAWRU Methodology

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Summary

A recent VOX article by M. Fioramanti and R. Waldmann criticises the way the European Commission estimates the unemployment gap for EU countries and especially the gap for Italy. This economic brief refutes the criticism and, in turn, argues that the implicitly suggested approach from Fioramanti and Waldmann for estimating the unemployment gap leads to results which, firstly, are problematic on purely economic grounds and, secondly, have dubious statistical properties.

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Introduction

A recent VOX article by M. Fioramanti and R. Waldmann (2016, henceforth FW), grandiosely entitled "Econometrics and its consequences for human beings", criticises the way the EU estimates the unemployment gap for EU countries and especially the gap for Italy.[12]

FW's criticism of the EU's commonly agreed methodology is broad-based and is levelled against both the theoretical as well as the empirical underpinnings of the estimation process. In their article, FW are mostly concerned with two questions. Firstly, the question of whether a traditional Phillips curve better fits the data compared to an accelerationist Phillips curve. Currently, the EU obtains the unemployment gap based on a version of an accelerationist Phillips curve. The implied trend of unemployment from the accelerationist Phillips curve is called the non-accelerating wage rate of unemployment (NAWRU). FW disapprove of this theoretical foundation and stress "its failure to capture the information provided by the data and as a consequence, its misleading role in identifying the cyclical position of a country". Secondly, FW question the soundness of the econometric modelling approach as implemented in the NAWRU methodology. In particular, they contend that there is a great deal of "arbitrariness of these [econometrics modelling] restrictions" leading to "the limited informative role of the Phillips curve as specified in the actual procedure", with a danger that "the shape of the NAWRU is given by cherry-picking".

These criticisms need to be examined closely since the unemployment gap is a central driver of the size and sign of the cyclically-adjusted budget deficit. More specifically, since the surveillance of the fiscal policies of the EU's Member States (MS) makes extensive use of estimates of the output gap (of which the unemployment gap is a crucial sub-component) (European Commission, 2015), consequently the unemployment gap determines to a considerable extent the EU's recommendations with respect to the need for fiscal adjustments and the space for carrying out expansionary fiscal policy. Given the policy significance of these calculations, the article ends with a politically provocative rhetorical question: "Do we really want ….technical aspects of an estimation procedure ... to be the key element on which we base our decision on Italy's fiscal strategy in a time when a still high unemployment rate and humanitarian emergencies require the support of government's actions?" In other words, the clear inference from the article is that "econometrics" rather than economics is what is driving not only the EU's NAWRU methodology but also the EU's overall fiscal surveillance procedures.

If one strips away the hyperbole, one is left with the key question as to whether the FW criticism of the EU's NAWRU methodology is justified or not? In the following paragraphs we will argue that FW's implicit conclusions—and criticism in general—is not valid. As discussed in detail below, there are sound reasons why the economics profession (including the economists from the 28 Member States which have drawn up the EU's commonly agreed NAWRU methodology) has moved away from the traditional Phillips curve, most notably its inadequate treatment of inflation expectations. In addition, we will show that not only do FW rely on dubious statistics to justify the non-use of restrictions in the filtering of the NAWRU, more fundamentally FW's less restrictive approach generates an unemployment gap that does not make economic sense.

Traditional vs. Accelerationist Phillips Curve

The original observation of Phillips (1958) was indeed that there is a stable empirical relationship between nominal wage inflation and the unemployment rate. That there is an empirical correlation between the two variables is undisputed. Nevertheless, the traditional Phillips curve was replaced by the accelerationist model in the early 70s; the traditional model was dismissed because of its unrealistic assumptions about expectations formation.

The traditional Phillips curve suggests that there is a systematic relationship between unemployment and (wage) inflation which could be exploited by policy (increase inflation in order to lower unemployment). This unemployment inflation trade-off is implied by the (implicit) assumption made in the traditional Phillips curve that inflation expectations are constant. This interpretation of the relationship between inflation and unemployment caused problems when inflation started to increase in the 1970s. In his presidential address, Friedman (1968) correctly predicted that inflation and unemployment would move together, a phenomenon the traditional Phillips curve could not explain. The stagflation did

indeed happen both in the US and the EU. The stagflation episode confirmed that wage setters are taking into account information about inflation (and productivity growth).

This assumption of constant inflation and productivity growth was not only problematic in the 1970s but it is also problematic in recent years in which inflation remained stubbornly below the inflation target and a protracted slowdown of productivity growth occurred. Using Italy as an example, one can illustrate the possible biases inflicted on assessing labour market slack by only looking at wage inflation, but leaving aside consumer price inflation and productivity developments. Pre-crisis productivity growth was at about 1% and consumer price inflation at 2.2%. After 2009, productivity growth dropped to 0.5% and consumer price inflation to 1%. If one assumes that wages are still set under pre-crisis inflation and productivity growth expectations, one biases the unemployment gap estimate by $1/\beta*1.7\%$. With the coefficient β (the slope of the Phillips curve) between 0.5 and 1, the unemployment gap is overestimated in the range between 1.7% and 3%.

Taking inflation expectations seriously is what distinguishes the accelerationist model from the traditional Phillips curve. This does not necessarily imply that the accelerationist model in a strict sense (where the change in wage inflation is linked to the unemployment gap) is the best representation of the Phillips curve. This particular specification results from assuming wage setters have static inflation expectations. A modern version of the expectations-augmented Phillips curve is the New Keynesian Phillips curve which assumes rational, forward-looking, inflation expectations. In our experience, this model provides a better fit in general. This is also the Phillips curve specification which we use for most Member States (see Havik et al., 2014).

The empirical fit and significance of ECFIN's unemployment gap estimates

Table 1 demonstrates the importance of inflation and productivity growth expectations in wage determination. The Table shows the results from a panel regression across the 15 old Member States of the European Union (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and United Kingdom). This regression captures the spirit of the accelerationist model, namely that nominal wage growth is determined by inflation expectations (with a coefficient of 1), expected productivity growth and a measure of slack in the labour market. We approximate inflation expectations by a linear combination of an explicit price expectation measure (ECFIN forecast for consumer price inflation) and lagged wage inflation.[3] Labour market slack is measured by ECFIN's unemployment gap estimate. As can be seen, the fit of these regressions in Columns 1 to 4 is quite high (R-squared > 0.5) and the coefficients are stable across two different sample periods (2003-2016 and 2008-2016). This highlights the importance of inflation expectations for wage setting, though the accelerator model with backward-looking expectations (i.e., with lagged wage growth) is not favoured by the data. This especially holds for the sample period between 2008 and 2016.

FW discuss the issue that since the R-squared of the traditional model is larger than the R-squared of the accelerationist Phillips curve, the former model ought to be more valid than the latter. However these results are largely due to the fact that different data transformations for the dependent variable are used in both specifications, namely the level of wage inflation in the traditional Phillips curve and the change in wage inflation in the accelerationist Phillips curve. In order to show this, we reformulate the accelerationist Phillips curve in terms of wage inflation as an endogenous variable and lagged wage inflation with a coefficient of 1 as an additional explanatory variable (see Column 5 in Table 1) and compare it to the standard accelerationist specification (see Column 6 in Table 1). As expected the coefficient of the unemployment gap is identical and equally significant in both specifications, while the fit as measured by the R-squared drops from 0.8 to a number close to 0. This highlights the necessity to carefully consider data transformations when discussing the "proper" size of the R-squared. The reason why there is a difference in the R-squared is entirely due to the fact that specification 5 shows that using a proxy for expected inflation (lagged wage inflation) is very important for explaining wage inflation.

Finally, we also want to emphasise that contrary to what is claimed by FW, the effect of the unemployment gap on inflation is generally significant for all the individual member states in the EU's analysis. Among the 15 member states analysed by FW, we only have a non-significant estimate of the unemployment gap effect in the case

of Greece, whereas for all other MS the effect is significant at the 10% statistical level or better.

Table 1: **The Wage Phillips Curve**

Column 1 to 4: $\pi_t^w = \beta(U_t - U_t^*) + \varphi\pi_t^{PCE,E} + (1-\varphi)\,\pi_{t-1}^w + \theta P_t^e + c + \epsilon_t$
Column 5: $\pi_t^w = \beta(U_t - U_t^*) + 1\pi_{t-1}^w + c + \epsilon_t$
Column 6: $\Delta\pi_t^w = \beta(U_t - U_t^*) + c + \epsilon_t$

	(1) 2003-2016	(2) 2008-2016	(3) 2003-2016	(4) 2008-2016	(5) 1967-2016	(6) 1967-2016
β	-0.33***	-0.44***	-0.30***	-0.39**	-0.24***	-0.24***
t-stat	4.25	-4.55	-4.63	-4.21	-3.00	-3.00
φ	0.62***	0.95***	0.72***	0.95***	1.00	--
t-stat	7.15	7.92	8.29	8.37	--	--
$1-\varphi$	0.38***	0.05	0.28***	0.05		
t-stat	4.35	0.40	3.18	0.40		
θ	--	--	0.68***	0.38***	--	--
t-stat	--	--	4.35	2.33	--	--
R-squared	0.53	0.56	0.59	0.59	0.83	0.02
Observations	210	135	210	135	678	678
N countries	15	15	15	15	15	15

** p < 0.1, ** p < 0.05, *** p < 0.01, robust standard errors.*

Notes: The Table reports different panel regression results with country fixed effects, where nominal wage inflation π_t^w is explained by the unemployment gap, $U_t - U_t^*$, inflation expectations, $\pi_t^{PCE,E}$, the lag of nominal wage inflation and expected labour productivity, P_t^e. Regressions are carried out by imposing the restriction that the effects of past and expected inflation sum up to one. Inflation expectations $\pi_t^{PCE,E}$ are measured by the change in the PCE deflator for the current year as projected by the European Commission in the previous year. Similarly, expectations of labour productivity P_t^e for the current year are proxied by the forecasts of the European Commission in the previous year. The unemployment gap is the difference between actual and structural unemployment (NAWRU), as reported by the European Commission. Columns 1 to 4 contain regression results for either the period 2003-2016 or 2008-2016, adopting the specification as given in the first equation in the header of the Table. Columns 5 contain regression results for the period 1967-2016, adopting the specification as given in the second equation in the header of the Table. Column 6 contains regression results for the period 1967-2016, adopting the specification as given in the third equation in the header of the Table.
Source: DG ECFIN analysis

The Phillips Curve and the Estimation of the Unemployment Gap

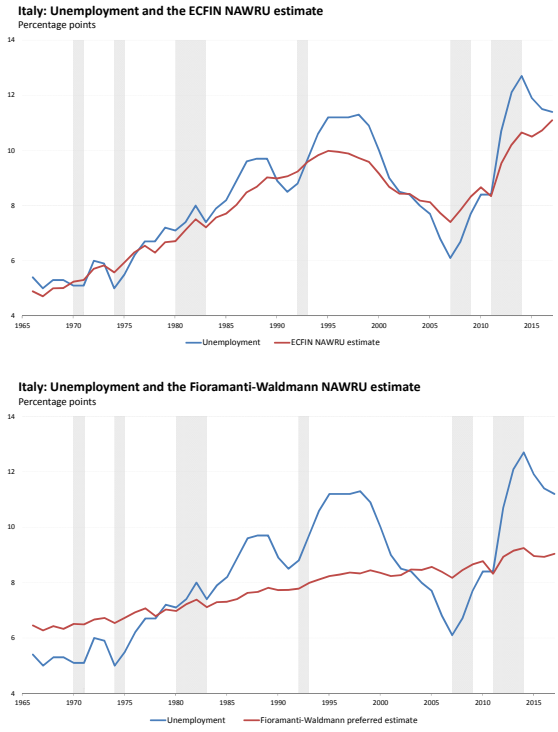
FW argue that the EU is imposing restrictions on the NAWRU such as to obtain a very cyclical NAWRU. The authors then stress that removing the restrictions would yield very different (and more plausible) results. They go to great lengths to convey the impression that imposing restrictions is not necessary in (Kalman) filtering and if imposed, these restrictions are somewhat arbitrary.

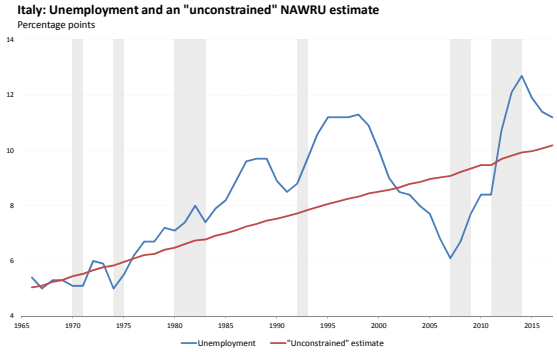
Unfortunately, decomposing a variable (in our case, unemployment) into an unobserved trend and a cycle requires some restrictions; otherwise the filtering process is likely to end up in corner solutions. Since many of the (European) unemployment series display non-stationarity, the restriction one usually imposes is that the cyclical part of unemployment, the unemployment gap, is a stationary process, while the NAWRU follows a random walk (and is non-stationary).[4] This is an issue akin to the selection of the smoothness parameter for the Hodrick-Prescott filter (Gordon, 1997). It is now well understood that if one does not impose restrictions, estimating the model parameters may lead to a trend and a cycle that violate this common intuition: namely, the model estimation may lead to either a constant or a deterministic trend for the NAWRU, depending on how the latter is modelled, and a non-stationary cycle (see e.g. King et al.; 1995, Staiger et al., 1997; and Laubach, 2001, among others).

To illustrate this point, Figure 1 shows three different NAWRU models: First the ECFIN specification, second the FW specification (removing the important restriction on a lower bound for the variance of the trend) and a completely 'unrestricted' model (completely agnostic on how much more volatile is the cycle relative to the trend). The completely 'unconstrained' model

illustrates the point that in shorter samples the Kalman filter has a tendency to identify a non-stationary cycle—since it attributes all of the variation in unemployment pertaining to the unemployment gap—and a stationary trend. The specification by FW resembles very closely this completely 'unconstrained' model, whilst the EU model has the desired statistical properties for the trend (medium term non-stationary fluctuations) and the cycle (unemployment gap that fluctuates but remains stationary).

Figure 1: **Different NAWRU specifications**





Notes: In the upper panel, the Figure shows the unemployment rate in Italy (blue line) and an estimate of the NAWRU adopting the specification used by the EU (red line). In the middle panel, the Figure depicts an estimate of the NAWRU adopting the specification used by the EU, but reduces the variance of the trend component of unemployment as done by FW (red line). In the lower panel, the Figure shows an estimate of the NAWRU (red line), in which the maximum likelihood procedure derives endogenously the signal-to-noise ratio, i.e. without imposing any constraints on estimation. Shaded regions show recessions for Italy as dated by the Economic Cycle Research Institute (ECRI).
Source: DG ECFIN analysis

One can demonstrate the above result even more formally. In Table 2 we regress the NAWRU as well as the unemployment gap, derived either with the EU's or FW's variance bounds restrictions. Each of these variables, x_t, is regressed on a constant, their own lag and, in four specifications, on a trend. Table 2 shows that the NAWRU estimate of the FW specification becomes a trend stationary process (since the Wald test rejects the null hypothesis that the coefficient of the lag of the FW trend is one, in column 7), while the cycle from FW becomes a non-stationary process (since the Wald test cannot reject the null hypothesis that the coefficient of the lag of the unemployment gap is one, in column 5 and 6). This is exactly the opposite of what general intuition would suggest.

Table 2: **Unemployment components and their stationarity**

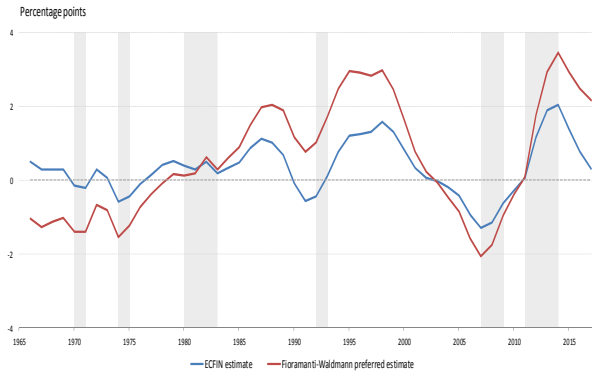
$$x_t = c + \epsilon t + \beta x_{t-1}$$

Dependent variable	(1) ECFIN Unemployment gap	(2) ECFIN Unemployment gap	(3) ECFIN NAWRU	(4) ECFIN NAWRU	(5) FW Unemployment gap	(6) FW Unemployment gap	(7) FW NAWRU	(8) FW NAWRU
ϵ	0.00	--	0.01	--	0.00	--	0.03	--
t-stat	0.37	--	0.75	--	0.52	--	3.64	--
β	0.85	0.85	0.94	0.98	0.93	0.94	0.46	0.98
t-stat	11.76	12.05	18.44	46.19	17.34	22.23	3.31	31.10
F-test (β=1)	0.04	0.04	0.28	0.42	0.18	0.17	0.00	0.46

Notes: The Table reports 8 different regressions with either the NAWRU or the unemployment gap being a dependent variable. The two variables are derived using either the EU's or FW's variance bounds restrictions. Each of these variables, x_t, are regressed on a constant, their own lag and, in four specifications, on a trend. The row starting with 't-stat' reports the t-statistics of the respective coefficient. The row starting with 'F-test (β=1)' reports the results of a Wald test for the null hypothesis that the β coefficient is equal to one (non-stationarity). Shaded regions show recessions for Italy as dated by the Economic Cycle Research Institute (ECRI).
Source: DG ECFIN analysis

The restrictions imposed on the cycle and the trend (EU) yield more plausible results over the whole sample period compared to the less constrained/unconstrained model (FW) not only on statistical grounds but also on economic grounds. Figure 2 shows the unemployment gap from the ECFIN and FW specifications. Firstly, despite the fact that the Italian economy went through various booms and recessions over the sample period, the unconstrained model (red line) identifies only one complete unemployment cycle, which lasts from around 1980 to 2009. Furthermore, it fails to capture the cyclical boom in the late 1980s, even though standard labour market indicators, such as the change in wage inflation are pointing towards an acceleration of wage growth over that period (note that FW are trying to identify an accelerationist model). In contrast, the EU model (blue line) captures the cyclical boom in that period. Moreover, the EU model describes all economic downturns in Italy following the 1970s, except one in the beginning of the 1980s, similar to the way the Economic Cycle Research Institute (ECRI) dates recession turning points (grey shaded regions). Secondly, FW identify the 1960s as a period with a positive unemployment gap even though there was no wage pressure. The EU estimate does not show a gap in the 1960s. Thirdly, though there is nearly consensus among the economics profession that there was an increase in the structural unemployment rate in the 1970s, associated with the stagflation period, this is not signalled by the FW specification. Both the NAWRU from the EU model and the unemployment rate move up in this period. Finally, if we look at the period after 2009, and if we take the wage indicators suggested by the standard NAWRU model seriously, the unemployment gap looks significantly overestimated in the unconstrained model, since we do not see a deceleration of nominal unit labour cost growth that could generate such an unemployment gap.

Figure 2: **Italy, Cyclical components of unemployment from two different NAWRU estimations**



Notes: This Figure depicts an estimate of the unemployment gap, for which we adopt the variance bounds currently used by the EU on the disturbances in the cyclical and trend components of unemployment (blue line) as well as an estimate of the unemployment gap, for which we adopt the "preferred" variance bounds specification by FW (red line). Shaded regions show recessions for Italy as dated by the Economic Cycle Research Institute (ECRI).
Source: DG ECFIN analysis

Concluding Remarks

Based on the evidence provided in sections 1 and 2, we believe that the alternative NAWRU approach suggested by FW is problematic on both statistical and economic grounds. We also object to the spurious claims made by FW in the VOX article with respect to the EU's current NAWRU methodology. In contrast to the FW assertions, we have argued here that the EU's standard NAWRU model successfully identifies the cyclical unemployment rate which is consistent with firstly the empirical data, secondly, with standard labour market and cyclical indicators; and finally, with any rational empirical assessment of structural unemployment developments over the period from the mid-1960s to the present day. We are also convinced that the arguments which led to the rejection of the traditional Phillips curve in the EU's methodology, especially the strong assumption about the lack of information concerning the recent inflation and productivity developments of wage setters, are as valid today as they were in the 1970s.

References

European Commission (2015), "Making the Best Use of the Flexibility within the Existing Rules of the Stability and Growth pact", Communication from the Commission to the European Parliament, The Council, the European Central Bank, The Economic and Social Committee, the Committee of the regions and the European Investment Bank, Strasbourg, 13 January, COM(2015) 12 final provisional.

Fioramanti, M. and R. Waldmann (2016), "The Stability and Growth Pact: Econometrics and its consequences for human beings", VoxEU.org, 19 November 2016.

Friedman, M. (1968), "The Role of Monetary Policy", American Economic Review, 58(1), 1-17.

Gordon, R. J. (1997), "The Time-Varying NAIRU and its Implications for Economic Policy", Journal of Economic Perspectives, Vol. 11(1), pp. 11-32.

Havik, K., K. Mc Morrow, F. Orlandi, C. Planas, R. Raciborski, W. Roeger, A. Rossi, A. Thum-Thysen, and V. Vandermeulen (2014), "The Production Function Methodology for Calculating Potential Growth Rates and Output Gaps", European Economy, Economic Paper N 535.

King, R. G., J. H. Stock, and M. W. Watson (1995), "Temporal Instability of the Unemployment-Inflation Relationship", Economic Perspectives of the Federal Reserve Bank of Chicago, May-June, 2-12.

Kuttner, K. N. (1994), "Estimating Potential Output as a Latent Variable", Journal of Business and Economic Statistics, 12, 3, 361-368.

Laubach, T. (2001), "Measuring the NAIRU: Evidence from Seven Economies", The Review of Economics and Statistics, Vol. 83(2), pp. 218-231.

Phillips, A. (1958), "The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957", Economica, 25, 283–299.

Staiger, D., J. H. Stock, and M.W. Watson (1997), "How Precise Are Estimates of the Natural Rate of Unemployment?", in Romer, C. D. and D. H. Romer (eds.), Reducing Inflation: Motivation and Strategy. Chicago: University of Chicago Press.

Staiger, D., J. H. Stock, and M. W. Watson (2001), "Prices, Wages, and the U.S. NAIRU in the 1990s", in Alan B. Krueger and Robert M. Solow (eds.), The Roaring Nineties: Can Full Employment Be Sustained?, Russel Sage Foundation.

Annex 1: EU's NAWRU Model

To estimate the unemployment gap the EU proposes a method, consistent with the mainstream literature which constitutes a combination between purely structural and purely statistical approaches (Havik et al., 2014). The NAWRU is estimated in the Phillips curve framework as the rate of unemployment that is consistent with stable inflation expectations. A very general model of the unemployment gap can be specified as a bivariate system—Equations 1 and 2 below— similar to Kuttner (1994):

Unemployment, Eq. 1: $C_t = \alpha_1 C_{t-1} + \alpha_2 C_{t-2} + \varepsilon_t^c$, where $U_t = U_t^* + C_t$

Phillips Curve, Eq. 2: $f(\pi_t^w) = \gamma_1 + \theta(L) f(\pi_{t-1}^w) + \beta(L) C_t + \delta(L) X_t + \varepsilon_t^P$,

Trend, Eq. 3: $U_t^* = \mu_t + U_{t-1}^* + \varepsilon_t^T$, where $\mu_t = \mu_{t-1} + \varepsilon_t^\mu$,

where U_t and U_t^* denote unemployment and the NAWRU at time t; by definition, the unemployment gap C_t is the difference of unemployment and the NAWRU; $f(\pi_t^w) = \pi_t^w - E(\pi_t^w)$ denotes a function of wage inflation and wage inflation expectations; $\theta(L)$, $\beta(L)$ and $\delta(L)$ are polynomials in the lag operator; X_t is a vector of possible supply shocks (typically import prices). The disturbance ε_t^P is assumed to be i.i.d. normal with mean zero and variance $var(\varepsilon_t^P)$. ε_t^P accounts for supply shocks that influence the inflation-unemployment trade-off.

There are two key issues concerning the estimation of the bivariate system—Equations 1 and 2. The first one is the specification of the wage inflation function, $f(\pi_t^w)$. It has now become a common practice to assume that expectations follow a random walk (see Staiger et al., 1997). In this case, the expectation of wage inflation in period t equals wage inflation in the previous period, $E(\pi_t^w) = \pi_{t-1}^w$, so that in Eq. 2 we can postulate a relationship between the change in wage inflation $f(\pi_t^w) = \Delta\pi_t^w$ and the unemployment gap. This is the specification that we adopt for a few countries and in particular for Italy. The second issue relates to the modelling and empirical properties of the unobserved trend of unemployment, the NAWRU, as well as the unemployment gap. Here, the literature has also broadly accepted that the NAWRU varies over time and follows a random walk (Gordon, 1997, and Staiger et al., 2001). To capture the labour market hysteresis observed in many European economies (see Laubach, 2001), Havik et al. (2014) assume that the NAWRU follows a random walk with a stochastic drift, Eq. 3 above. In this equation, the disturbances ε_t^P and ε_t^μ are i.i.d. normally distributed with mean zero, and variances $var(\varepsilon_t^P)$ and $var(\varepsilon_t^\mu)$. Finally, note that the dynamic behaviour of the unemployment gap is described by an AR(2) process, Eq. 1, where ε_t^c acts as a white noise innovation with variance $var(\varepsilon_t^c)$. The system formed by Equations 1 and 2 can be expressed in its state-space form and can be estimated by maximum likelihood using the Kalman filter. In the case of Italy, the coefficients in the polynomials in the lag operator $\theta(L)$ and $\delta(L)$ are assumed to be null.

The amount of time variation in the NAWRU is governed by the signal-to-noise parameter $\omega = [var(\varepsilon_t^T) + var(\varepsilon_t^\mu)]/[var(\varepsilon_t^c) + var(\varepsilon_t^P)]$. This is an issue akin to the selection of the smoothness parameter for the Hodrick-Prescott filter (Gordon, 1997). The larger the parameter, the more volatile the NAWRU is; if the parameter equals null the NAWRU becomes a constant. In principle, all components of the signal-to-noise ratio can be estimated by the maximum likelihood procedure. Note that for several countries the European Commission has been agnostic about where this parameter lies: That is, although the Commission imposes bounds on the variances of the trend and cycle of unemployment, in several cases none of these bounds have been reached. This means that the maximum likelihood procedure pinned down the parameter ω by itself, endogenously, and that the time-series properties of the unemployment gap passed the internal quality check within the Commission of how the cyclical

component should behave. This internal quality check is nothing else than an expert opinion as to what phase of the business cycle the particular economy finds itself in, and whether the phases of the estimated unemployment gap coincide with our understanding of the business cycle for the particular country. This is also the approach proposed by Gordon (1997): One carries out sensitivity analysis and chooses variance bounds by visual inspection of the resulting NAWRU estimates, such that "the NAIRU can move around as much as it likes, subject to the qualification that sharp quarter-to-quarter zigzags are ruled out". Such an approach was adopted by the Commission, taking into account a number of factors including the combination of goodness-of fit and plausibility of the estimated equations, the NAWRU estimates and the statistical importance of the unemployment gap in the Phillips curve.

[1] The calculation of unemployment gaps, and economy wide output gaps, is based on the EU's commonly agreed Production Function (PF) methodology. The objective of having this, rules based, EU method is to ensure cross country consistency in terms of the quality and robustness of the estimations. The PF methodology is agreed by the Member States at a technical level (in the Output Gap Working Group) and subsequently endorsed by the Economic Policy Committee (EPC) and, in the event of a major change, the ECOFIN Council. Its day-to-day implementation is carried out by the EU Commission.

[2] We understand under accelerationist Phillips curve any specification which takes the Friedman-Phelps critique of the traditional Phillips curve seriously and, implicitly or explicitly, accounts for the fact that workers and firms negotiate over the expected real, i.e. inflation-adjusted, wage. This definition includes two well-known variants of the Phillips curve—the traditional "accelerationist" specification and the so-called New Keynesian Phillips curve; the former in general approximates inflation expectations using a moving average of past inflation, while the latter assumes that inflation expectations are "rational" and consistent with the predictions of all agents in the economy.

[3] Due to data availability—more precisely, expectations on price inflation and labour productivity—we run our benchmark regressions only for the period between 2003 and 2016.

[4] See the Annex for more clarifications on the restrictions.