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Reassessing the NAIRUs after the Crisis

Stéphanie Guichard,

Elena Rusticelli

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ABSTRACT/RÉSUMÉ

Reassessing the NAIRUs after the Crisis

The financial crisis has resulted in a substantial increase in unemployment in the OECD. This paper shows that this increase has reversed the reduction in structural unemployment which has been estimated to have occurred in most OECD countries since the late 1990s. Structural unemployment is defined as a time-varying NAIRU derived from the information contained in a reduced Phillips curve equation (linking inflation to the unemployment gap) by means of a Kalman filter. The overall limited revisions in historical NAIRU estimated in 2008 after such a large labour market shock support the robustness of the OECD approach. This approach is therefore extended to almost all OECD countries. Alternative specifications of the Phillips curve are proposed for some specific groups of countries.

JEL classification codes: C32; E24; E31; J3; J6
Keywords: Unemployment; NAIRU; structural unemployment; Phillips curve

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Un réexamen des NAIRUs après la crise

La crise de la crise financière a entraîné une augmentation importante du chômage dans l'OCDE. Ce document montre que cette augmentation a inversé la tendance á la réduction du chômage structurel que l'on avait été estimé avoir eu lieu dans la plupart des pays de l'OCDE depuis la fin des années 1990. Le chômage structurel est défini comme à un NAIRU variant dans le temps et dérivé de l'information contenue dans une équation de courbe de Phillips réduite (reliant l'inflation à l'écart du chômage au chômage structurel) au moyen d'un filtre de Kalman. Les révisions dans l'ensemble limitées du NAIRU historique estimés en 2008 après un tel choc sur le marché du travail supportent la robustesse de l'approche de l'OCDE. Cette approche est donc étendue à presque tous les pays de l'OCDE. Des spécifications alternatives de la courbe de Phillips sont proposées pour certains groupes spécifiques du pays.

Codes JEL : C32 ; E24 ; E31 ; J3 ; J6
Mots Clés : Chômage ; NAIRU ; chômage structurel ; courbe de Phillips

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REASSESSING THE NAIRUS AFTER THE CRISIS

by

Stéphanie Guichard and Elena Rusticelli[1]

1. The financial crisis has resulted in a substantial increase in unemployment in the OECD. Although the situation of individual countries is exceptionally diverse, most countries have seen unemployment increasing substantially and for some of them unemployment has more than doubled (OECD, 2011a). These increases are likely to have reversed the reduction in structural unemployment (defined here as the rate of unemployment consistent with stable inflation *i.e.* the so-called NAIRU, or non-accelerating inflation rate of unemployment) which has been estimated to have occurred in most OECD countries since the late 1990s.[2]

2. Assessing the level of the NAIRU and its evolution over time is important in many respects. First, it is essential to measure the unemployment gap which is an important indicator for assessing the outlook for inflation and so has implications for monetary policy. The NAIRU is also a key component of potential output and therefore of cyclically-adjusted fiscal indicators which provide a measure of fiscal imbalances. Lastly, movements in the NAIRU provide some indication of the success or otherwise of structural labour market policies.

3. The goals of this paper are fourfold:

- First, the paper assesses how the NAIRUs have evolved during the financial crisis, until the first quarter of 2011. When the crisis hit, *ad hoc* procedures were implemented to assess its impact on the NAIRU notably via hysteresis effects (see Guichard and Rusticelli 2010). As unemployment rates have started to turn around or at least stabilise, a reassessment of the impact of the financial crisis on the NAIRU was needed and has been performed using the OECD's traditional approach of a time-varying NAIRU estimated by Kalman filter in a Phillips curve framework.[3]

- Second, the paper provides a further assessment of the overall robustness of the OECD's traditional approach by measuring the magnitude of the revisions of historical NAIRU series since the previous update which was run just before the crisis.

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1. The authors are members of the Macroeconomic Analysis Division of the OECD Economics Department. They would like to thank OECD country desks for helpful discussions, suggestions and support and to Diane Scott for assistance in preparing the document. The views expressed in this paper are those of the authors and do not necessarily represent those of the OECD or its member countries.

2. See Gianella *et al.* (2008).

3. The general background to, and details of, previous OECD work estimating time-varying NAIRUs within the Phillips curve framework are given by Richardson *et al.* (2000). The previous update using this approach can be found in Gianella *et al.* (2008).

- Third, the paper extends the OECD NAIRU framework to a wider set of member countries that were not covered by previous updates

- Last, the paper explores alternative specifications of the Phillips curve. Notably, it considers whether there are alternative indicators other than price inflation which might be used to assess the magnitude of the unemployment gap in the case of euro area peripheral countries. It investigates in particular whether the influence of the unemployment gap on relative unit labour costs gives a more reliable NAIRU than when the signal equation is the traditional Phillips curve. In addition, it considers Phillips curves including the difference between actual inflation and an inflation target to allow for the possibility that, ceteris paribus, inflation is attracted towards the target.

4. The main findings are:

- The overall limited revisions in historical NAIRU estimations after such a large labour market shock support the robustness of the OECD approach.

- The methodology has been extended successfully to all OECD member countries, except for Estonia, where due to the lack of a sufficiently long time series for inflation, the NAIRU has been computed as the HP-filtered unemployment rate.[4] In two cases (Slovenia and Turkey), however, the absence of a statistically significant impact of the estimated unemployment gap on inflation is a cautionary limitation of the estimates for these countries.

- The NAIRUs have increased during the crisis in most countries mostly in line with expected hysteresis effects.

- Still, a limitation in this work is the major uncertainty on the macroeconomic situation at the time of writing, including the possibility of further increase in unemployment (see OECD, 2011b).

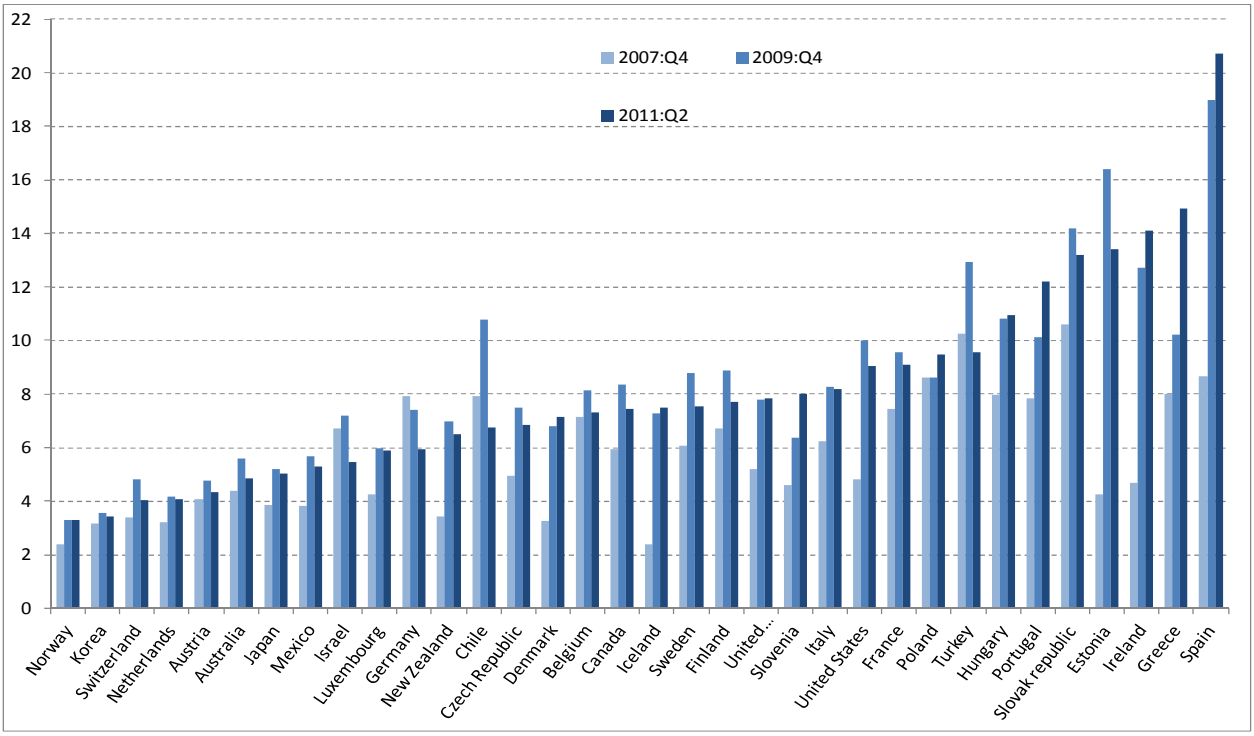
5. The remainder of the paper is organised as follows: the first section reviews the evolution of unemployment during the crisis; the second section presents the updated NAIRU estimates and compares them with the 2008 update; and the third section investigates alternative specifications for some countries.

The evolution of unemployment during the crisis

6. In the OECD as a whole, unemployment increased by almost 3 percentage points to 8.5% between the end of 2007 and the end of 2009, and has only slightly declined since then. This area-wide evolution masks an exceptional diversity in labour market performances across the OECD. One extreme case is Germany that has experienced a fall in unemployment since 2007, while other countries (*i.e.* Norway, Korea, Switzerland, the Netherlands, Austria, Australia and Japan) have been able to maintain unemployment rates at relatively low levels (Figure 1). On the opposite side, unemployment has at least doubled in some countries (*i.e.* Denmark, Estonia, Iceland, Ireland, the United States) and is above 10% in seven countries (Estonia, Greece, Hungary, Ireland, Portugal, Slovak Republic and Spain) with no sign of any decline for five of them.

4. With a lambda set to 20000.

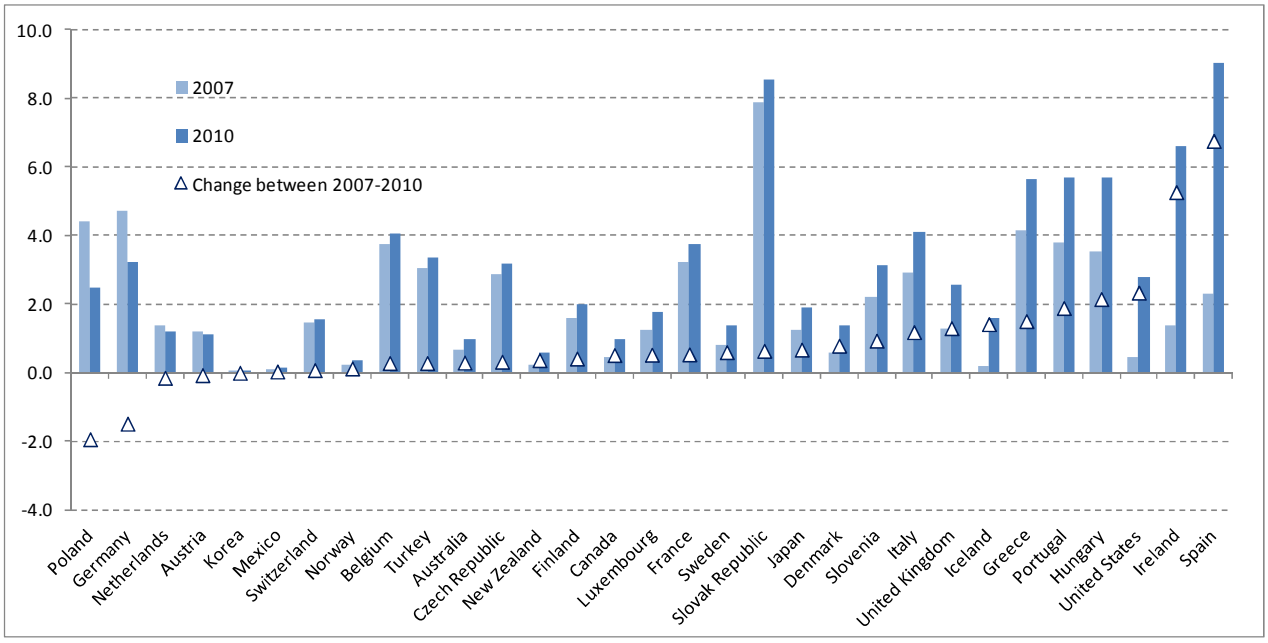
Figure 1. Evolution of unemployment during the crisis



Source: OECD.

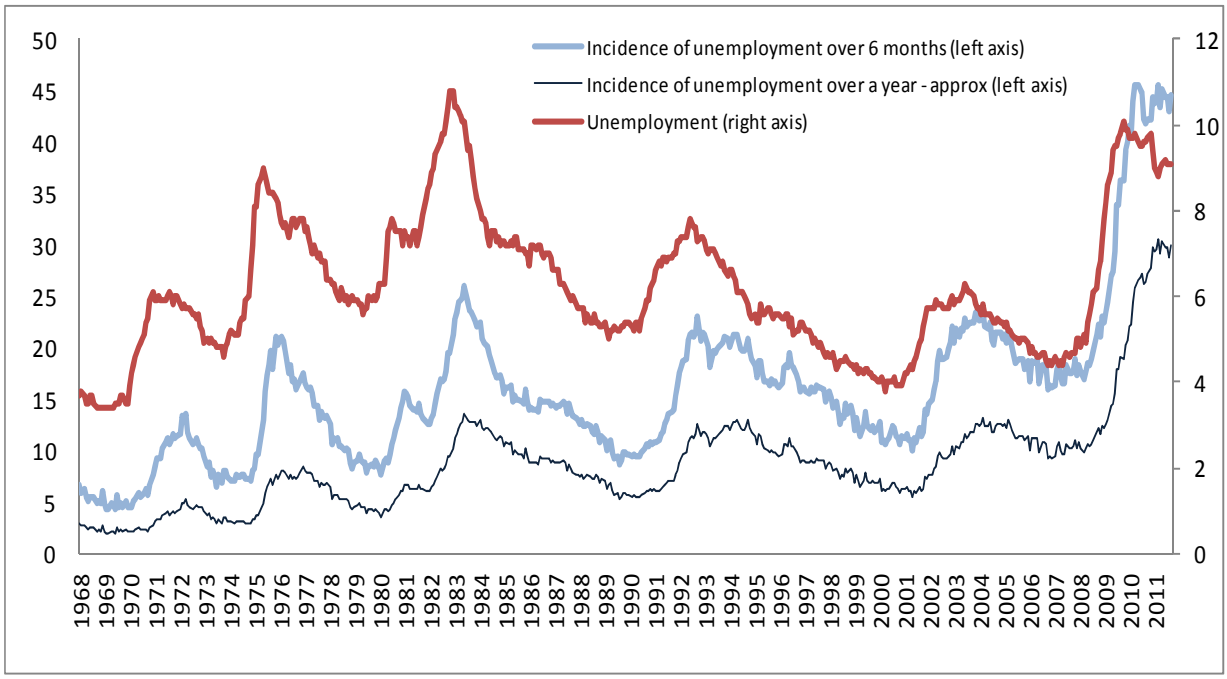
7. This increase in unemployment has been accompanied by an increase in long-term unemployment, which is particularly important in some countries, including those that have been hit the most by the financial and construction sector crisis such as Spain and Ireland (Figure 2). In the United States, the increase in long-term unemployment has also been large and unprecedented in post war history (Figure 3). Regarding the US situation, the debate on the reasons for higher long-term unemployment during this crisis, including notably the role of the housing market crisis, the extension of long-term unemployment benefits and the sectors (financial, housing, construction) most affected by the crisis, is still being debated (see for instance Hornstein and Lubik, 2010, Estevão and Tsounta, 2011, Sahin *et al.,* 2011).

Figure 2. Evolution of long-term unemployment rate (more than 12 months) during the crisis



Source: OECD annual labour force dataset.

Figure 3. Long-term unemployment in the United States



Note: The monthly series of incidence of unemployment over a year has been built using the monthly series of incidence of unemployment over 6 months and the relative share of unemployment between 6 to12 months in unemployment over 6 months.

Source: OECD, BLS.

8. This increase in long-term unemployment suggests a likely increase in structural unemployment or NAIRU in most OECD countries. As suggested notably by Ball (2009), long-term unemployment plays a key role in hysteresis effects leading to a higher NAIRU. Workers who have been unemployed for some time tend to become less attractive to employers. Not only the human capital of the unemployed diminishes over time, but also, as a result of recruitment costs, potential employees are frequently evaluated on the basis of frequency and duration of their periods of unemployment. Job search may also diminish as the unemployed lose contact with the labour market and awareness of job offers. There is indeed empirical evidence that long-term unemployed have a smaller influence on wage bargaining than the short-term unemployed (Guichard and Rusticelli, 2010, Llaudes, 2005 and Elmeskov and MacFarlan, 1993). As a result real wages do not fall sufficiently for the long-term unemployed to be "priced back" into the labour market. Hence increases in the proportion of the long-term unemployed may push up the structural unemployment rate consistent with a stable inflation rate (*i.e.* the NAIRU).

9. This link between long-term unemployment and structural unemployment has been used over the past two years to take into account the likely impact of the crisis NAIRU. Indeed NAIRU estimations made by the Secretariat since 2008 have departed from the traditional assumption that, between the Kalman filter updates that take place on average every three years, the NAIRU is kept unchanged at its last estimated value unless there are substantial structural policy changes. The estimation of the NAIRU after 2007Q4 were based on the evolution of unemployment and long-term unemployment together with assumptions regarding the strength of hysteresis effects (see Guichard and Rusticelli, 2010).

The reassessment of the NAIRU

Overview of the OECD approach to assess the NAIRU

10. The reassessment of the NAIRU proposed here is based on the usual OECD approach of extracting the time-path of the NAIRU from the information contained in a reduced Phillips curve equation (linking inflation to the unemployment gap) by means of the Kalman filter. More precisely, a time-varying NAIRU, treated as an unobserved stochastic variable, is derived from its ability to explain inflationary developments. Hence this estimation does not require specifying explicitly all factors affecting the NAIRU (see Gianella *et al.,* 2008 for an attempt to assess these factors).

11. This concept of a time-varying NAIRU is consistent with a reduced-form system of a structural wage-price setting model. In such a theoretical framework, formalised by Layard, Nickell and Jackman (1991), the NAIRU is the unemployment rate prevailing in the absence of any temporary supply shocks and at a constant rate of inflation, after the dynamic adjustments of wages and inflation have taken place. Typical temporary supply shocks are those reflecting changes in real import prices or changes in real oil prices, which are expected to revert to zero over a relatively short time horizon of around one to two years. Temporary supply shocks may also include the deviation of labour productivity from its long-term trend. Such temporary shocks may alter the rate of inflation, but the NAIRU will be unchanged once they have passed, provided they are not aggravated by policy mistakes or long-lasting modifications of expectations. This approach assumes the absence of structural breaks in the relationship between inflation and the unemployment gap in the Phillips curve. It is possible however that over the recent period for a given level of the unemployment gap, inflation pressures are less if subsidized work sharing is important as has been the case in Germany during the crisis. However, the presence of such a break is rejected in Germany.[5]

5. This test was run of the value of the NAIRU estimated over the single complete sample period as there are too few observations to obtain sufficiently reliable estimates of an endogenous NAIRU after the breakpoint.

12. The reduced-form Phillips curve approach for the estimation of time-varying NAIRUs for the member countries has been adopted by the OECD since 2000 and improved over time (see Box 1 for details). In the last update, Gianella *et al* (2008) made the cross-country specification uniform for a group of twenty-two countries and paid particular attention to the modelling of the statistical properties of the NAIRU, along the lines of Laubach (2001).[6] The present study relies on this approach and applies to eleven other OECD member countries Chile, Czech Republic, Hungary, Iceland, Israel, Poland, Mexico, Slovak Republic, Slovenia, Spain, and Turkey for which data availability previously limited the use of such an approach.

Box 1. Overview of the OECD framework for estimating the NAIRU

The OECD approach to estimate time varying NAIRU information contained in a reduced Phillips curve equation (linking inflation to the unemployment gap) by means of the Kalman filter presented in more details in Gianella e*t al.* (2008).

The Phillips curve equation includes three types of short-term supply shocks: (i) oil price shocks, via the introduction of real oil price inflation, weighted by the oil intensity of production, (ii) the impact of trade prices and globalisation trends via the inclusion of real import price inflation weighted by import penetration and (iii) the deviation of labour productivity from its long-term trend. Domestic inflation is measured by the change in the core consumer price index where sufficiently long time spans of data are available and by the change in the headline consumer price index otherwise. It is assumed that there is no feedback from inflation to unemployment as in Gordon (1997), meaning that there is no simultaneity bias issue when allowing the contemporaneous unemployment rate to enter the Phillips curve. Assuming dynamic homogeneity to hold, the relationship takes the following form:

$$\Delta\pi_t = \sum_{j=1}^{m} \chi_j \Delta\pi_{t-j} + \beta(U_t - U_t^*) + \sum_{j=0}^{n} \eta_j MGS_{t-j}^{SH}(\pi_{t-j}^{MGS} - \pi_{t-j})$$

$$+ \sum_{j=0}^{l} \kappa_j OIL_{t-j}^{SH}(\pi_{t-j}^{OIL} - \pi_{t-j}) + \beta \ln(pdy / pdypot)_t + v_t \qquad (1)$$

where π is core CPI or headline CPI inflation, MGS^{SH} is the import content of domestic demand (calculated as $MGS_t^{SH} = M_t/(Y_t + M_t - X_t)$ where M, X and Y denote total imports, total exports and domestic output.) π^{MGS} is import price inflation (goods and services), OIL^{SH} is the oil intensity of production (calculated as the ratio between oil supply and domestic output), π^{OIL} is oil price inflation, *pdy* is actual labour productivity and *pdypot* its estimated long-term trend productivity and v_t is the residual. The term U_t-U_t* is the difference between the unemployment rate and the NAIRU and is expected to have a negative impact on inflation. The appropriate number of lags (*m*, *n* and *l*) for the three right-hand-side inflation variables is determined by starting with four lags each and then dropping statistically insignificant lags. In a few cases, where the fourth lag of the change in inflation was significant, a fifth lag was tested for and added when significant. All data are taken from the *OECD Economic Outlook* database except the oil intensity of production which comes from the IEA.

The presence of a constant in the Phillips curve is also tested for all countries. The presence of such a constant may imply that when the unemployment gap is closed and supply shocks are absent, inflation will be consistently rising or declining. However, it may just reflect the fact some variables used do not have a zero mean, or capture elements of price and wage setting behaviour in the absence of direct measures of inflation expectations, particularly in those countries in which expectations of future inflation are relatively stable. Some attempts to explicitly take into account the anchoring of inflation expectations on the central bank target over recent decades in the large OECD countries had, however, limited success (see last section).

Assumptions on the stochastic process followed by the NAIRU follow Gianella *et al.* (2008) and rely on two transition equations specifying the time-series properties of respectively the NAIRU and the unemployment gap (the gap between the NAIRU and the unemployment rate).

First the NAIRU is modelled as a simple random walk process, as supported by statistical tests and its transition equation takes the following form:

6. This extension was already introduced by Mourougane *et al*. (2005), but not generalised for all countries in a uniform framework.

$$U_t^* = U_{t-1}^* + \varepsilon_t \quad (2)$$

where the error term ε_t is assumed to be normally distributed with mean zero and variance σ_ε^2 and uncorrelated with the error term of the Phillips curve equation v_t.

Second, a law of motion is imposed on the unemployment gap to ensure that the unemployment rate converges to its structural rate in the absence of shocks, consistently with Friedman (1968) who showed that the unemployment rate cannot deviate permanently from its natural rate. Following Laubach (2001), the unemployment gap is assumed to follow an autoregressive process. This implies that that the level of the NAIRU can be inferred not only on the basis of the information on inflationary pressures in the economy, but also on the basis of the unemployment rate dynamics themselves. As shown by Laubach (2001), the stability and robustness of the results -- notably to changes in the sample period or the initial parameters -- is largely improved when using this additional transition equation. The transition equation for the unemployment gap is written as:

$$U_t - U_t^* = \psi(L)(U_{t-1} - U_{t-1}^*) + \zeta_t \quad (3)$$

where the error term ξ_t is normally distributed with mean zero and variance σ_ζ^2 and uncorrelated with ε_t. It is modelled as an AR(2) process (as suggested by the work of Jaeger and Parkinson (1994)). Although not necessary for the solution of the model, constraints have been imposed on the sum of the autoregressive parameters to ensure sensible time-series properties of the unemployment gap and prevent convergence problems that might arise if the sum of the two coefficients was close to unity. The value chosen for the sum of the autoregressive parameters varies across countries, between 0.7 and 0.9.

Some assumptions are also required on several of the parameters of the model.

First, the values and variances of the two state variables (the NAIRU and the unemployment gap) in the initial period have to be pre-specified. They are obtained directly from the maximum likelihood procedure by specifying a reasonable prior for the initial value together with a large variance term (Laubach, 2001). The initial value of the NAIRU has been set equal to the average unemployment rate around the first year of the sample period and the initial value of the unemployment gap being set equal to the difference between the unemployment rate in the initial period and the prior for the NAIRU.

Second, assumptions are made about the relative variances of the residuals of the three equations. The variance of the error term in the transition equation of the NAIRU relative to the one of the error term in the Phillips curve equation ($\sigma_\varepsilon^2 / \sigma_v^2$) determines the smoothness of the NAIRU series. The smaller this so-called 'signal-to-noise ratio', the less volatile will be the resulting NAIRU. In the extreme case of $\sigma_\varepsilon^2 / \sigma_v^2$ = 0, the NAIRU will be constant, whereas it will soak up all the residual variation in the Phillips curve equation if, for a given value the variance of the errors of the transition equation for the unemployment gap, signal-to-noise ratio' approaches infinity. Similarly, the smaller the relative variance of the transition equation of the unemployment gap the more volatile will be the NAIRU series.

While in principle the Kalman filter allows estimating the three variances of the errors in (1), (2) and (3) together with the other parameters of the model, this often leads to disappointing results as the resulting NAIRU series are too smooth (Richardson *et al*., 2000). As a consequence, as in previous empirical applications the variances have been fixed (see, for example, Laubach, 2001, and Llaudes, 2005).

13. The uncertainty around the NAIRU estimates has been computed by 1 000 Monte Carlo replications of the state space setting defined to estimate the Phillips curve, the NAIRU and the unemployment gap for each country. Standard errors and relative confidence bands have been obtained following the Hamilton approach (1986) described in Giannella *et al.* (2008), which allows distinguishing two sources of uncertainty: the parameter uncertainty associated with the arbitrary choice of the initial state vector and the filter uncertainty intrinsic to the application of a Kalman filter. The total uncertainty, *i.e.* the standard error of the estimated NAIRU, is then the sum of the two types of uncertainty and is used to calculate the 90% confidence bands around the NAIRU reported in Figure 5. This measure of uncertainty does not take into account the uncertainty associated to the choices of variances of the residuals in the state

space model, which are kept identical to those chosen to estimate the unknown true NAIRU and the unemployment gap in the Phillips curve.

Empirical results

Phillips curve

14. The usual NAIRU estimation approach was successfully extended to Chile, Czech Republic, Hungary, Iceland, Israel, Poland, Mexico, Slovak Republic, Slovenia, Spain, and Turkey (Table 1).[7] Estonia is the only OECD country where the sample was really too short and it was not possible to estimate a NAIRU using this framework. There was a noticeable improvement in the Phillips curve estimation in some of these countries where an HP filter was previously used in the past (Chile, Czech Republic, Hungary in particular): the overall fit of the equation is better and the unemployment gap became significant in some cases where it was not significant before. For the countries where this approach was already used before, this update was the occasion to re-check the Phillips curve specification and the significance of explanatory variables that had been selected in the 2008 estimation. In most of the cases the Phillips curve specification has not changed, although oil price inflation has been included for the first time in Germany and Norway. In the cases of Poland, New-Zealand, and Turkey the deviation of productivity from its trend was found to be statistically significant and added to the reduced-form Phillips curve.[8] In only a few cases, was a constant found to be statistically significant.

15. The unemployment gap is found to have a statistically significant impact (to at least the 10% level, and in most cases much more) on the change in domestic inflation in all countries (except Slovenia *and Turkey) supporting the underlying theoretical framework. The impact of the unemployment gap on* inflation is however quite small in Belgium, Finland, Ireland, the Netherlands, Poland, Spain and Sweden implying relatively high sacrifice ratios (a summary measure of the percentage point years of unemployment in excess of the NAIRU required in order to achieve a permanent reduction in inflation by 1 percentage point). In the case of Japan, where the unemployment gap was not found to be significant in the previous vintage of estimations described in Gianella *et al.* (2008), the Phillips curve was revisited to include a dummy variable on the coefficient of the unemployment gap during the period of deflation. This new specification now implies a negative and significant impact of the unemployment gap on inflation up to 1995 and no impact during the recent period of deflation.

Precision of the estimates

16. The analysis of the source of uncertainty shows that the contribution of the parameter uncertainty to the total uncertainty over the whole estimation sample is limited, ranging from 1% to 11% (in the case of Turkey). It is however substantially larger when only the first year is considered; for instance it reaches 80-85% of the total uncertainty for the first year in the case of Austria, Canada and United Kingdom.

7. For Spain, Poland and Slovenia previous OECD estimates were derived from a similar but not identical framework, see Kierzenkowski *et al.* (2008) and OECD (2009).

8. This term was already present for Poland in the estimation from Kierzenkowski *et al.* (2008). It was tried for all countries, but had no impact on inflation in most cases.

17. The average standard error of the NAIRU derived from the Monte Carlo simulation is reported in Table 1. Few countries show a significantly high standard error. Among those falling in the 90th percentile of the NAIRU standard errors distribution are Mexico and Turkey, with a standard error of 1.44 and 1.42 respectively and characterised by a very volatile core inflation index, as well as Finland, with an average standard error of the NAIRU of 1.38 and a highly volatile unemployment rate. On the contrary, the length of the observation sample does not seem to be a prior limit for the convergence of the filter and hence the amplitude of the filter uncertainty.

Table 1. Phillips curve estimation results

	USA		JPN		DEU		FRA		ITA		GBR (cpi)		CAN (cpi)	
Dependent variable $\Delta\pi$	1965Q2-2011Q1		1971Q3-2011Q1		1970Q4-2011Q1		1970Q4-2011Q1		1968Q3-2011Q1		1970Q4-2011Q1		1962Q1-2011Q1	
	COEF	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*
$\Delta\pi(-1)$	-0.47	-6.41	-0.14	-2.82	-0.61	-7.92	-0.39	-5.64	-0.14	-2.05	-0.49	-6.56	-0.55	-8.37
$\Delta\pi(-2)$	-0.26	-3.37			-0.36	-4.21	-0.32	-4.49	-0.15	-2.18	-0.25	-3.21	-0.4	-5.45
$\Delta\pi(-3)$	-0.18	-2.38			-0.29	-3.49	-0.14	-2.03			-0.32	-3.95	-0.29	-3.87
$\Delta\pi(-4)$	-0.17	-2.31	-0.12	-2.61	-0.28	-3.79					-0.17	-2.39	-0.39	-5.92
$U-U^*$	-0.04	-3.47	-0.17	-2.04	-0.07	-2.92	-0.1	-2.64	-0.05	-1.77	-0.14	-2.52	-0.1	-3.01
$Dummy*(U-U^*)$			0.16	1.65										
$\omega^m*(\pi^m(-1)-\pi(-1))$	0.16	2.03							0.18	3.12	0.43	5.13	0.13	2.07
$\omega^m*(\pi^m(-4)-\pi(-4))$											0.24	2.75	0.11	1.78
$\omega^{oil}(-1)*(\pi^{oil}(-1)-\pi(-1))$	0.02	2.21			0.03	2.1	0.06	4.6					0.05	3.25
Sacrifice ratio	3.3		0.5 (7.9 after 95)		2.3		1.2		1.6		1.0		1.6	
Dummies			1974Q1, 1997Q2Q3				1982Q3		1975Q1 1976Q1		1979Q3Q4			
Adj R2	0.22		0.69		0.29		0.34		0.29		0.33		0.36	
Avg. standard deviation	0.49		0.60		1.18		0.72		0.66		0.47		0.8	

	AUS (cpi)		AUT		BEL		CHE		CHL (cpi)		CZE		DNK	
Dependent variable $\Delta\pi$	1964Q1-2011Q1		1969Q1-2011Q1		1961Q2-2011Q1		1975Q1-2011Q1		1986Q1-2011Q1		1995Q4-2011Q1		1972Q1-2011Q1	
	COEF	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*
$\Delta\pi(-1)$	-0.81	-11.96	-0.76	-10.38	-0.50	-7.56	-0.29	-3.55	-0.59	-6.24	-0.55	-6.59	-0.60	-8.16
$\Delta\pi(-2)$	-0.54	-6.78	-0.49	-5.68	-0.38	-5.67			-0.30	-3.05			-0.33	-4.49
$\Delta\pi(-3)$	-0.27	-4.04	-0.25	-3.43					-0.20	-2.12				
$\Delta\pi(-4)$									-0.13	-1.53				
$U-U^*$	-0.18	-3.48	-0.13	-1.86	-0.04	-1.67	-0.07	-2.12	-0.22	-2.91	-0.15	-1.74	-0.09	-2.18
$\omega^m*(\pi^m(-1)-\pi(-1))$			0.28	3.94	0.16	4.71	0.08	2.99			0.14	2.15	0.21	3.20
$\omega^m*(\pi^m(-4)-\pi(-4))$														
$\omega^{oil}(-1)*(\pi^{oil}(-1)-\pi(-1))$	0.08	2.46							0.12	3.37				
Sacrifice ratio	0.9		1.2		2.9		1.1		0.6		0.7		1.4	
Dummies	2000Q3													
Adj R2	0.46		0.44		0.27		0.11		0.28		0.48		0.34	
Avg. standard deviation	0.56		0.43		0.89		0.53		1.25		0.65		0.75	

	ESP		EST		FIN		GRC (cpi)		HUN		ISL		IRL	
Dependent variable $\Delta\pi$	1978Q1-2011Q1		2000Q1-2011Q1		1970Q1-2011Q1		1975Q1-2011Q1		1995Q3-2011Q1		1990Q1-2011Q1		1978Q3-2011Q1	
	COEF	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*
Cst	-0.07	-2.47												
$\Delta\pi(-1)$	-0.58	-7.30	-0.48	-3.90	-0.53	-8.67	-0.51	-6.49	-0.24	-2.55	-0.23	-2.41	-0.64	-8.61
$\Delta\pi(-2)$	-0.15	-1.83			-0.33	-5.14	-0.34	-4.00					-0.24	-2.78
$\Delta\pi(-3)$					-0.12	-1.99	-0.15	-1.85					0.30	3.98
$\Delta\pi(-4)$							-0.19	-2.96			-0.31	-3.84		
$U-U^*$	-0.02	-1.75	-0.01	-0.47	-0.04	-2.37	-0.11	-1.94	-0.20	-2.69	-0.18	-3.26	-0.03	-1.74
$\omega^m*(\pi^m(-1)-\pi(-1))$			0.21	3.45	0.11	2.08			0.10	2.78	0.08	2.75	0.21	3.45
$\omega^m*(\pi^m(-4)-\pi(-4))$														
$\omega^{oil}(-1)*(\pi^{oil}(-1)-\pi(-1))$	0.03	1.87												
Sacrifice ratio	5.0				3.1		1.2		0.4		0.5		2.9	
Dummies	1986Q1				72Q1,73Q3, 76Q2								2009Q1, 2009Q4	
Adj R2	0.39		0.33		0.53		0.27		0.23		0.29		0.6	
Avg. standard deviation	1.21				1.38		0.77		0.29		0.31		0.32	

	ISR		KOR (cpi)		LUX		MEX		NLD		NOR (cpi)		NZL	
Dependent variable $\Delta\pi$	1995Q4-2011Q1		1975Q1-2011Q1		1976Q1-2011Q1		1993Q1-2011Q1		1962Q1-2011Q1		1971Q1-2011Q1		1980Q1-2011Q1	
	COEF	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*
Cst							-0.34	-3.13						
$\Delta\pi(-1)$	-0.59	-4.97	-0.56	-7.48	-0.47	-5.61	-0.49	-6.06	-0.50	-7.37	-0.68	-8.89	-0.20	-3.21
$\Delta\pi(-2)$	-0.41	-3.51	-0.40	-5.32	-0.23	-2.53	-0.58	-5.45	-0.26	-3.80	-0.30	-3.97		
$\Delta\pi(-3)$					-0.15	-1.70	-0.33	-4.09						
$\Delta\pi(-4)$							-0.24	-3.31						
*U-U**	-0.34	-1.74	-0.22	-2.00	-0.17	-2.00	-0.57	-3.04	-0.06	-1.84	-0.15	-1.74	-0.10	-1.73
$\omega^{m}*(\pi^{m}(-1) - \pi(-1))$							0.55	7.89	0.07	2.32				
$\omega^{m}*(\pi^{m}(-2) - \pi(-2))$													0.16	3.27
$\omega^{m}*(\pi^{m}(-4) - \pi(-4))$														
$\omega^{oil}(-1)*(\pi^{oil}(-1) - \pi(-1))$			0.14	3.67			0.12	2.50			0.07	1.56		
Lprod													0.05	3.13
Sacrifice ratio	0.4		0.6		0.7		0.3		1.7		0.8		0.8	
Dummies							1995						86Q4, 87Q1, 89Q3	
Adj R2	0.3		0.32		0.18		0.69		0.23		0.33		0.57	
Avg. standard deviation	0.54		1.07		0.31		1.44		0.6		1.52		0.51	

	POL (cpi)		PRT (cpi)		SVK (cpi)		SVN (cpi)		SWE (cpi)		TUR	
Dependent variable $\Delta\pi$	1995Q1-2011Q1		1980Q1-2011Q1		1995Q2-2011Q1		1999Q1-2011Q1		1961Q2-2011Q1		1983Q2-2011Q1	
	COEF	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*
Cst					-0.23	-2.56					-0.53	-1.60
$\Delta\pi(-1)$	-0.42	-3.87	-0.47	-5.27	-0.73	-8.72	-0.36	-3.62	-0.63	-9.89	-0.65	-10.32
$\Delta\pi(-2)$	-0.34	-3.26	-0.26	-2.87	-0.35	-3.45			-0.42	-6.55	-0.27	-4.48
$\Delta\pi(-3)$	-0.17	-1.78			-0.36	-3.51						
$\Delta\pi(-4)$					-0.29	-2.85						
$\Delta\pi(-5)$					-0.15	-1.76						
*U-U**	-0.12	-2.24	-0.11	-1.91	-0.12	-2.52	-0.05	-0.52	-0.05	-1.44	-0.01	-0.02
$\omega^{m}*(\pi^{m}(-1) - \pi(-1))$	0.15	3.08	0.34	2.98					0.22	2.69	0.43	1.65
$\omega^{m}*(\pi^{m}(-4) - \pi(-4))$	-0.15	-2.75										
$\omega^{oil}(-1)*(\pi^{oil}(-1) - \pi(-1))$												
$\omega^{oil}(-4)*(\pi^{oil}(-4) - \pi(-4))$	-0.09	-2.09										
Lprod	0.17	2.93										
Sacrifice ratio	1.1		0.9		1.5		1.8		2.7			
Dummies	1995Q3, 1990s		1983Q2Q3		1999Q3, 2003Q1		1999Q3, 2008Q4				1994Q2, 2001Q2	
Adj R2	0.43		0.24		0.75		0.54		0.36		0.73	
Avg. standard deviation	0.78		0.82		0.2		0.65		0.68		1.42	

Note: CPI indicates that inflation is measured using headline CPI inflation instead of core inflation. The average standard deviation of the NAIRU is derived from the Monte Carlo simulations.

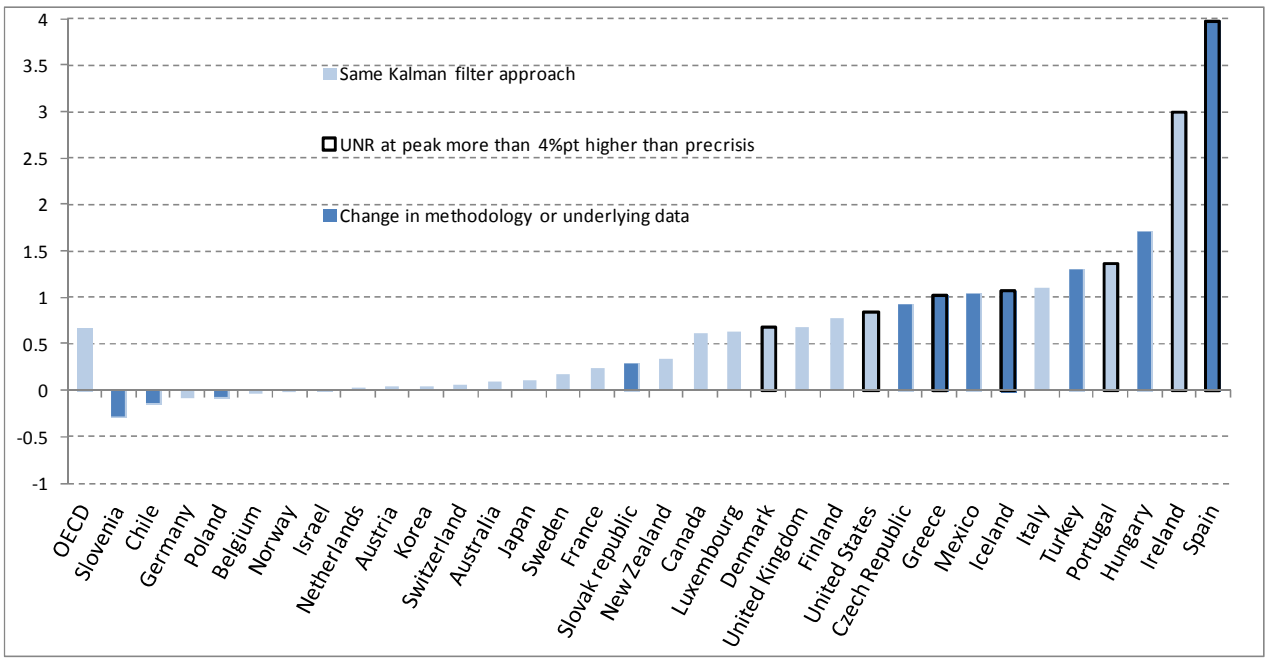
Revision of pre-crisis history

18. Despite the financial crisis and the recession that have hit most OECD countries, the profiles of the updated NAIRU series are very similar to the previous estimates for most countries, giving some support to the Kalman filter approach (Figures 4 and 5). In 40% of the cases, the estimated NAIRU before the crisis and the newly re-estimated ones are almost identical. Nevertheless, in more than half of the cases, the NAIRU were previously underestimated before the crisis. This is mainly due to the fact that the estimation in 2008 ended with unemployment at a cyclical low and so tended to exaggerate the fall in NAIRU, especially against the background of fast and strong increases in unemployment during the crisis and the absence of disinflation in most OECD countries. For six of the G7 countries the end-2007 NAIRU has been revised upwards, with the largest revision of 1.1 percentage points for Italy. Germany is the only G7 country for which the pre-crisis NAIRU has been revised down, but nearly all of this downward revision is due to a change of definition for the unemployment series.

19. Overall, the largest differences with Gianella *et al.* (2008) and previous *Economic Outlook* estimates are due to: *i)* revisions in unemployment series (Greece, Germany); *ii)* changes in the methodology: Canada where the starting point assumptions had to be corrected; Spain where a drift in the NAIRU was previously included; and Poland, Chile, Mexico, Czech Republic, Israel, Iceland, Hungary,

Slovakia, Slovenia, and Turkey where an HP filter was previously used; *iii)* countries where unemployment has increased dramatically since the last update (Ireland, Greece, Spain).[9]

Figure 4. Reassessment of the pre-crisis levels of the NAIRU (comparison of the 2007Q4 level: new update- *Economic Outlook* 89 May 2011)



Source: OECD calculations.

Evolution of the NAIRU following the crisis

20. As mentioned, over the past two years the OECD relied on the relationship between unemployment and long-term unemployment and assumptions regarding the strength of hysteresis effects to estimate the NAIRU after 2007Q4 and project it (see Guichard and Rusticelli, 2010). The increases in the NAIRU since 2007Q4 implied by the Kalman filter update are broadly consistent with these estimated hysteresis effects on the NAIRU in the majority of countries. It confirms the absence of NAIRU increases in the countries where unemployment fell during the crisis (Germany) or increased only marginally and/or temporarily. In a few cases hysteresis effects were less than anticipated but from a higher starting point (for instance Italy). On the other hand, much stronger than expected hysteresis effects were found in the United States and Slovak Republic.

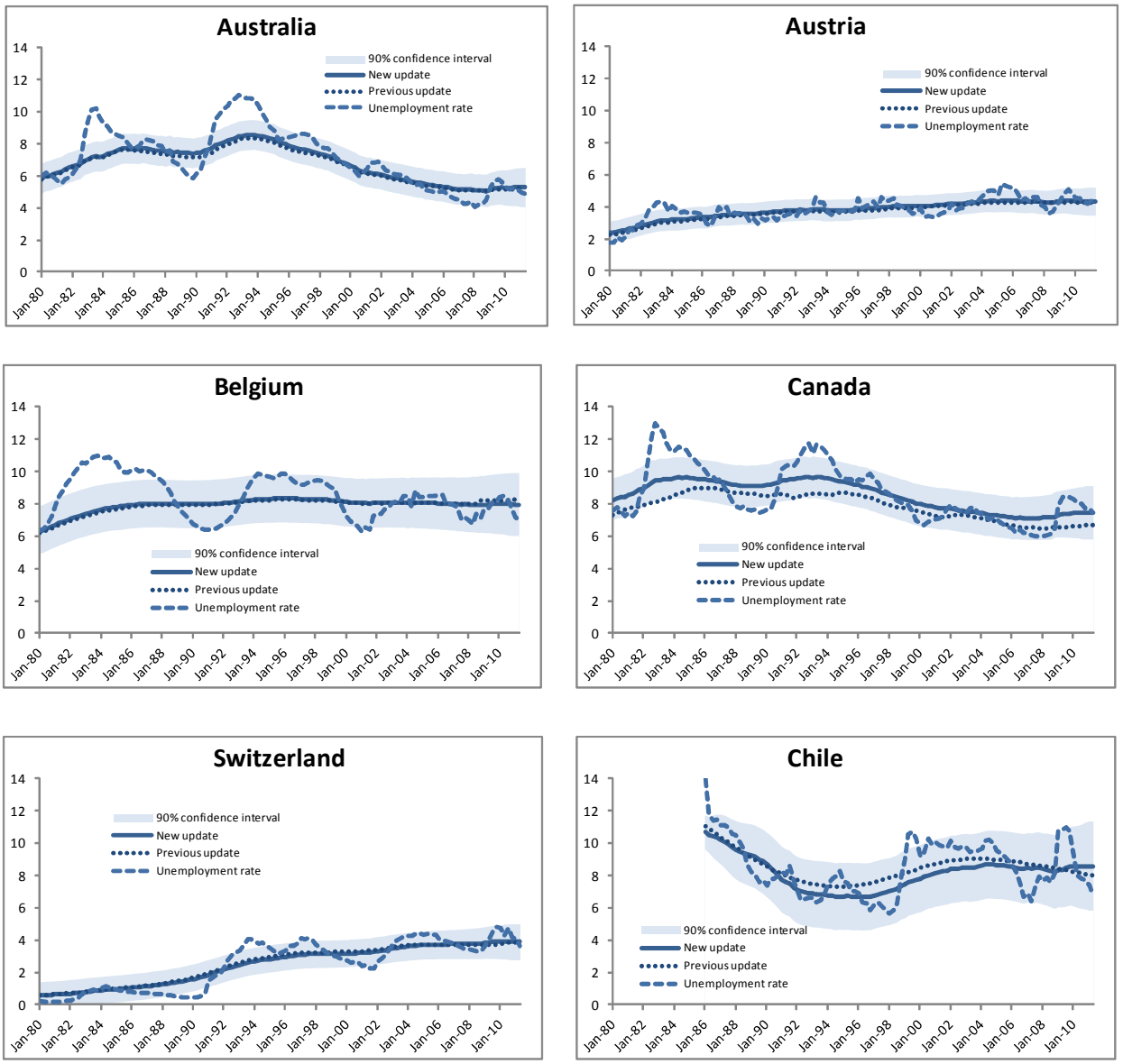
21. To take into account the possible sensitivity of the approach to end-points and the difficulty of capturing the effects of recent policy changes, for the last two years of the estimated NAIRUs, exceptional changes were accepted on request of OECD country specialists.[10] This concerned however only three

9. In the case of Iceland, given the volatile quarterly profile of the underlying series prior to 1990, the Kalman filter approach has only been used since 1990 and an HP filter was applied for the earlier part of the sample.

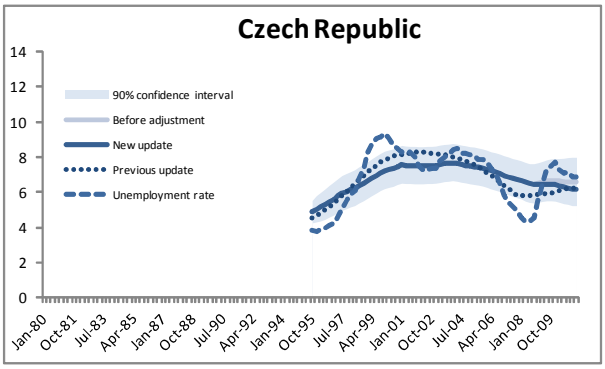
10. This sensitivity is, nevertheless, much less than with other filtering approaches (see for instance Richardson *et al*. 2000). This was confirmed by simple tests comparing the changes to 2007 estimates when ending the estimation in 2007Q4 and 2011Q1 using an HP filter and the current Kalman filter and Phillips curve approach.

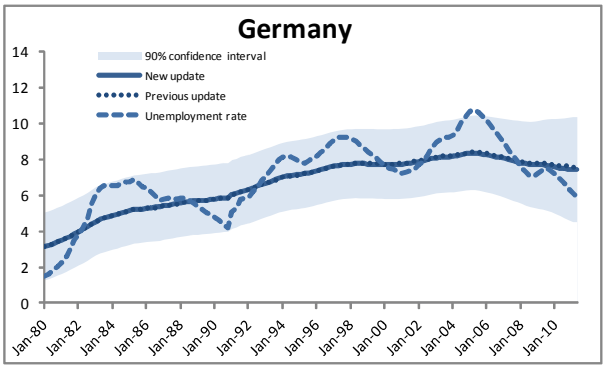
countries. In Sweden and Czech Republic the end of period increases in the NAIRUs have been removed to reflect the continuation of labour market reforms.[11] In Ireland, on the other hand, an upward *ad-hoc* adjustment has been applied to reflect the large ongoing adjustment in the construction sector and the difficulty to find other jobs for former construction workers who are likely to become structurally unemployed. Last, a step increase in the NAIRU has been added to Portugal in 2011Q1 to follow the step increase in unemployment induced by a change in the methodology in the data collection.

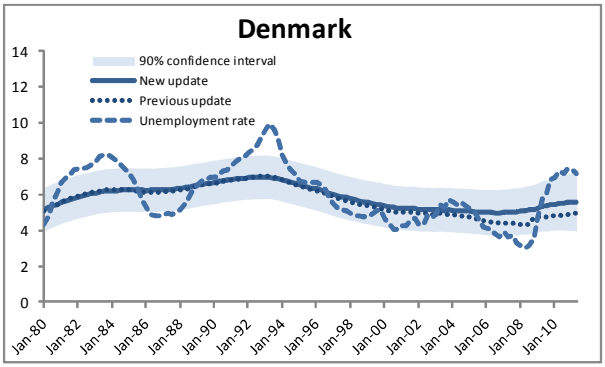
Figure 5. NAIRU updates

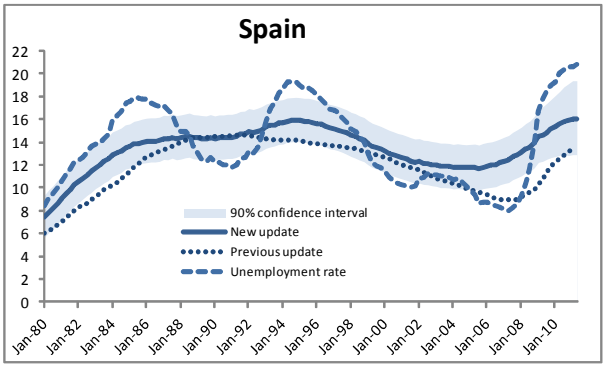


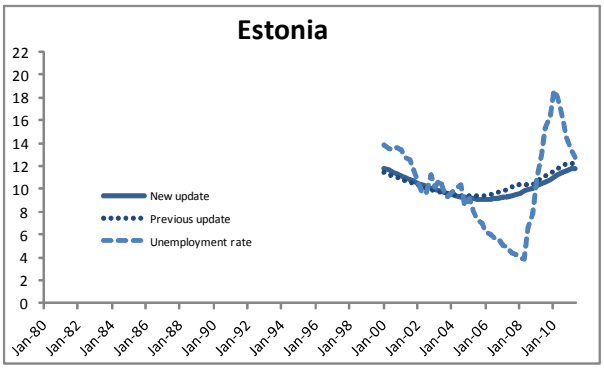
11. In Sweden, this concerns, in particular, a large reform of the unemployment insurance in 2007 (including: the introduction of decreasing replacement rates with unemployment duration, stricter eligibility criteria), large increases in the earned-income tax credit (in 2009 and 2010) and a reform in the sickness and disability benefit scheme. In Czech Republic, reforms likely to have affected the NAIRU include more flexible working hour schemes, a phased liberalisation of the rental market which should favour labour mobility and a reform of sickness benefits.

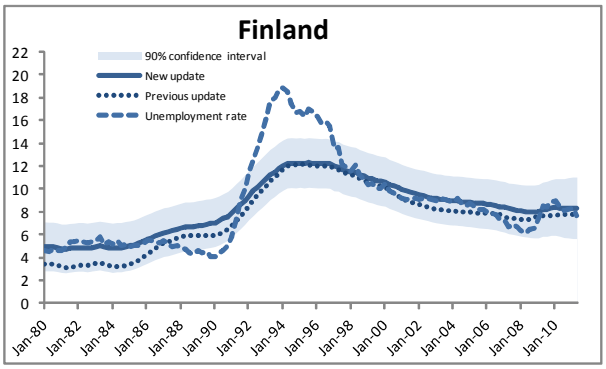

Czech Republic
90% confidence interval
Before adjustment
New update
Previous update
Unemployment rate

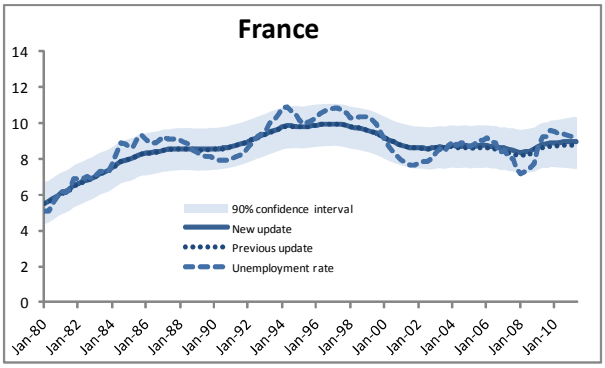

Germany
90% confidence interval
New update
Previous update
Unemployment rate

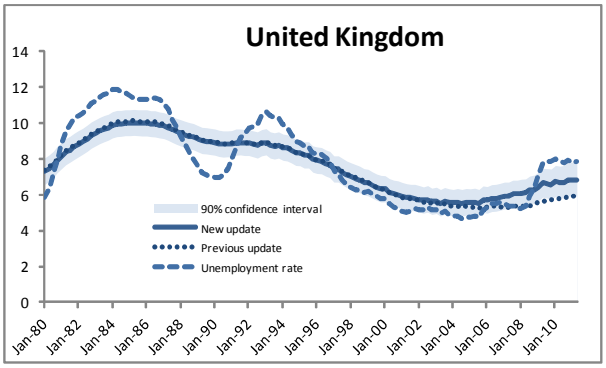

Denmark
90% confidence interval
New update
Previous update
Unemployment rate

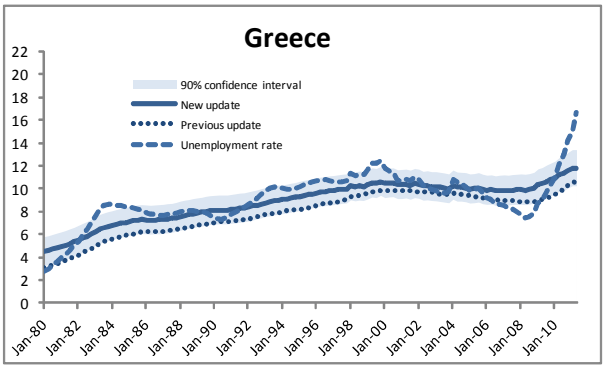

Spain
90% confidence interval
New update
Previous update
Unemployment rate

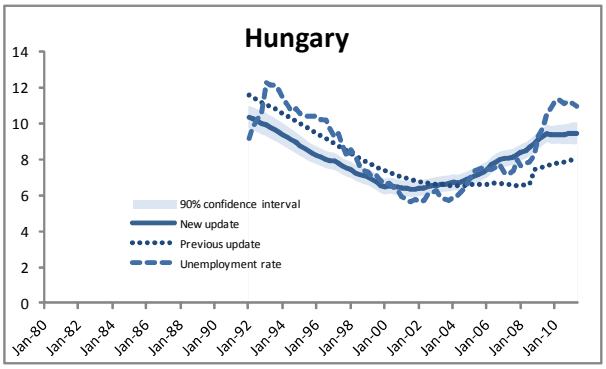

Estonia
New update
Previous update
Unemployment rate

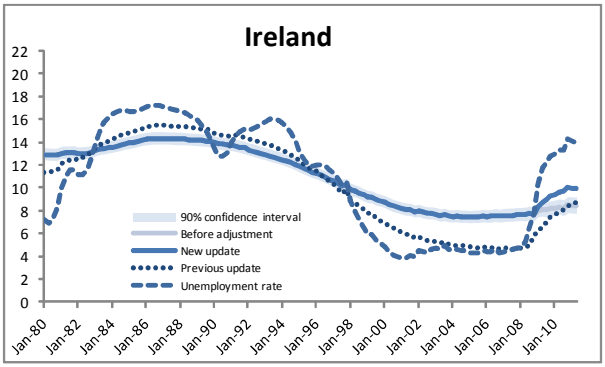

Finland
90% confidence interval
New update
Previous update
Unemployment rate

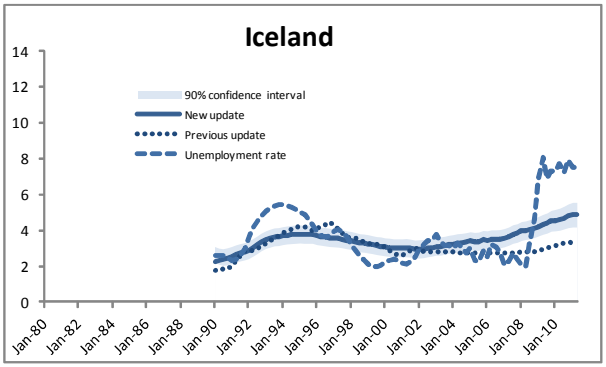

France
90% confidence interval
New update
Previous update
Unemployment rate

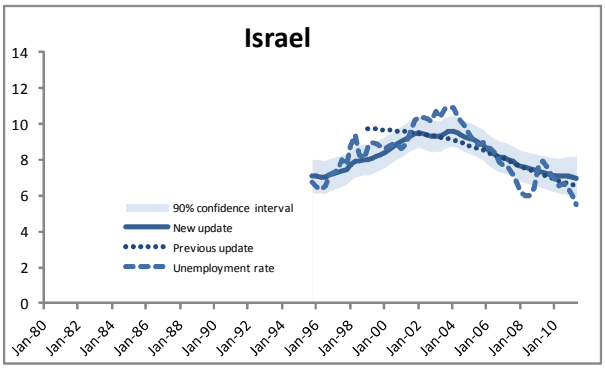

United Kingdom
90% confidence interval
New update
Previous update
Unemployment rate

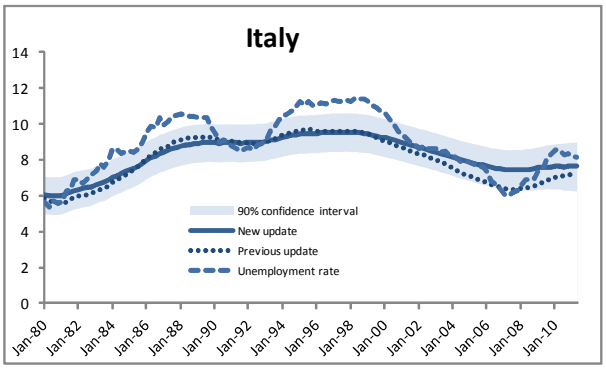

Greece
90% confidence interval
New update
Previous update
Unemployment rate


Hungary
90% confidence interval
New update
Previous update
Unemployment rate


Ireland
90% confidence interval
Before adjustment
New update
Previous update
Unemployment rate


Iceland
90% confidence interval
New update
Previous update
Unemployment rate


Israel
90% confidence interval
New update
Previous update
Unemployment rate


Italy
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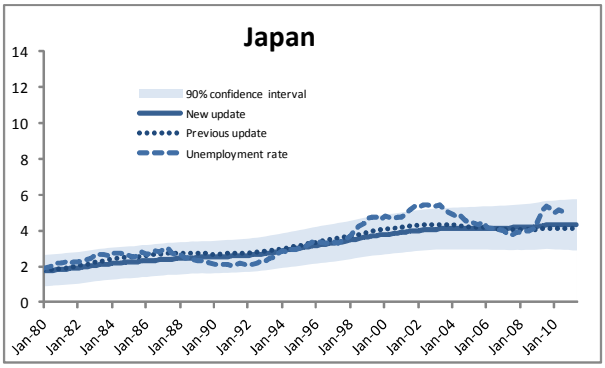
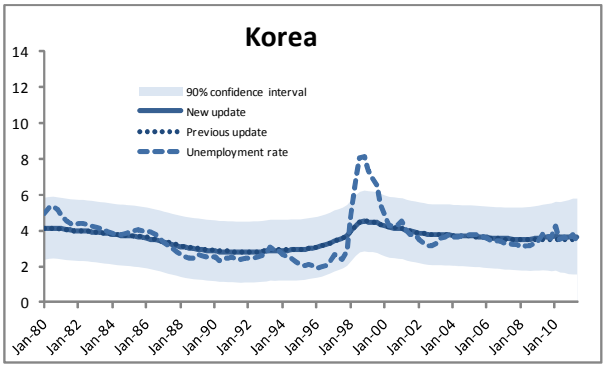
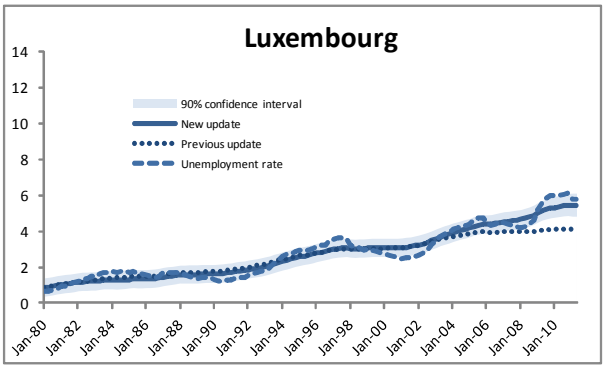
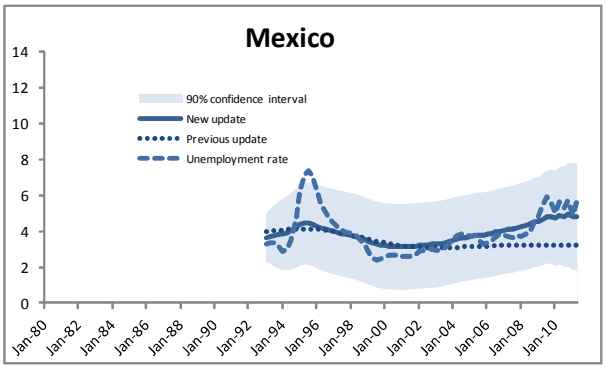
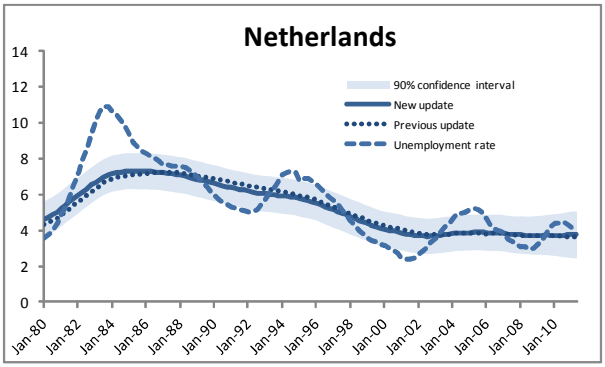
New update
Previous update
Unemployment rate

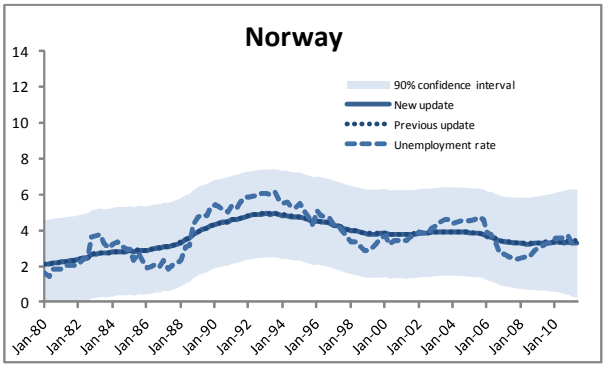

Japan
90% confidence interval
New update
Previous update
Unemployment rate

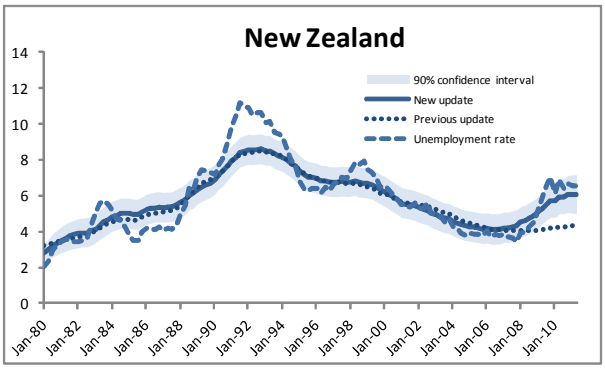

Korea
90% confidence interval
New update
Previous update
Unemployment rate

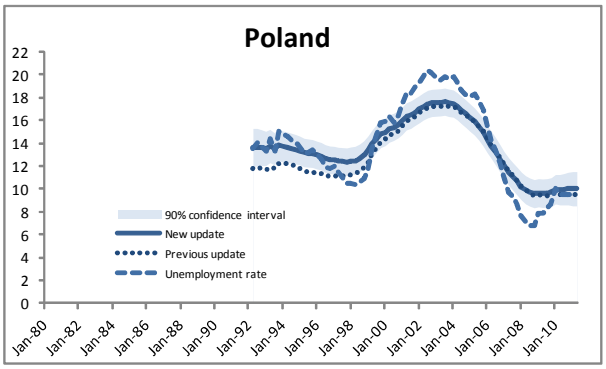

Luxembourg
90% confidence interval
New update
Previous update
Unemployment rate

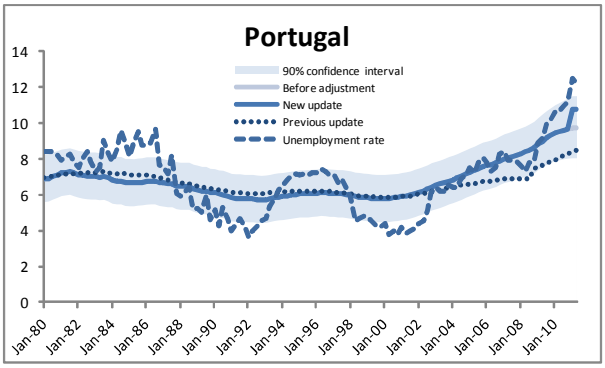

Mexico
90% confidence interval
New update
Previous update
Unemployment rate

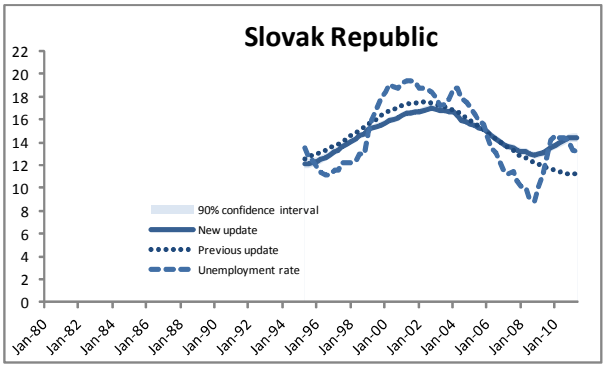

Netherlands
90% confidence interval
New update
Previous update
Unemployment rate

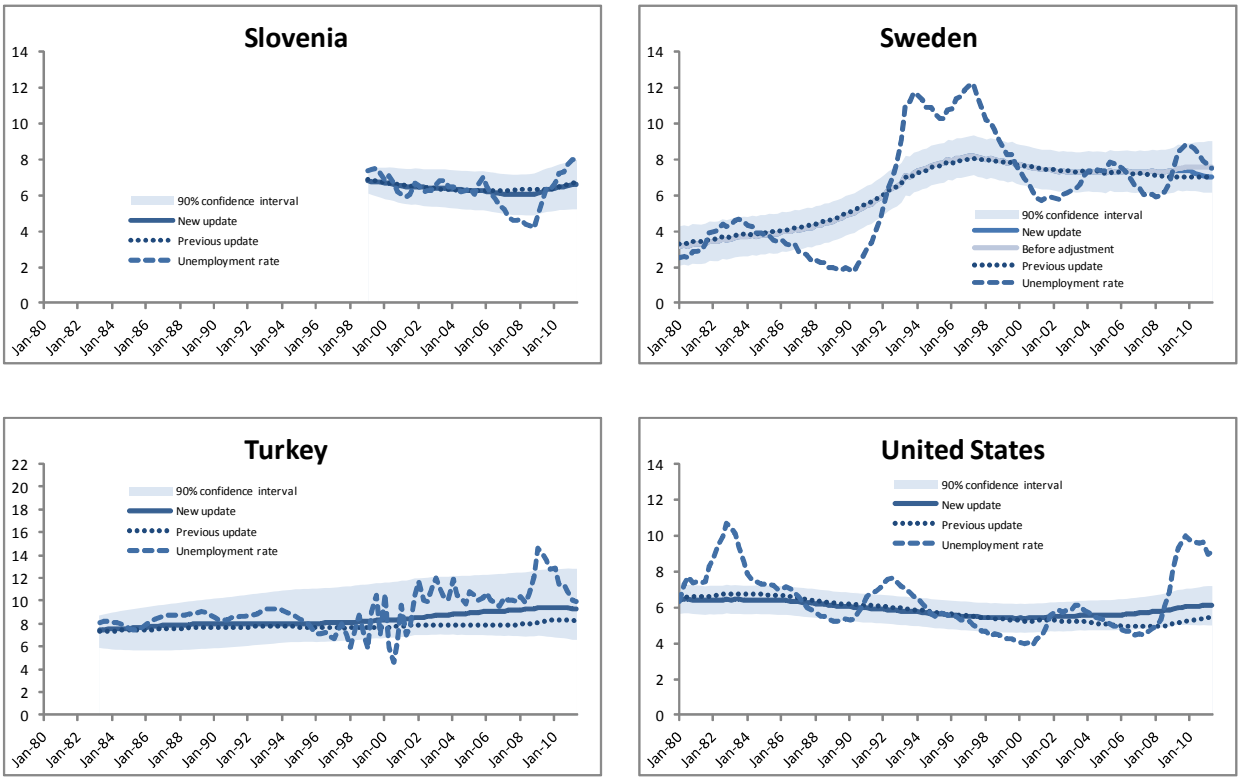

Norway
90% confidence interval
New update
Previous update
Unemployment rate


New Zealand
90% confidence interval
New update
Previous update
Unemployment rate


Poland
90% confidence interval
New update
Previous update
Unemployment rate


Portugal
90% confidence interval
Before adjustment
New update
Previous update
Unemployment rate


Slovak Republic
90% confidence interval
New update
Previous update
Unemployment rate

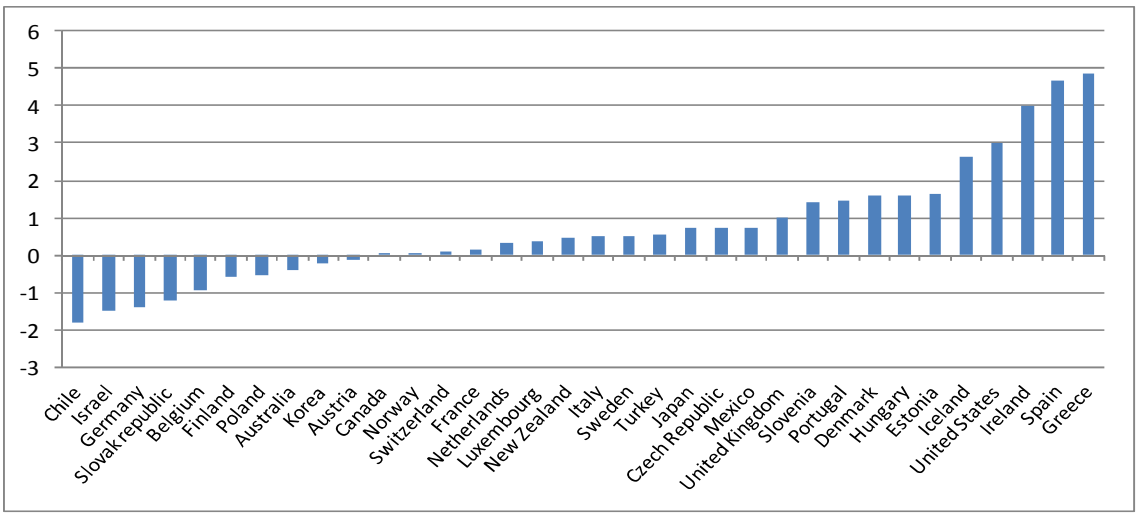


Note: The previous updates correspond to the Economic Outlook 89 NAIRUs. For Germany and the Netherlands the impact of the change in the unemployment series had already been corrected. The standard Kalman filter approach has already been applied to Poland and Slovenia.

Source: OECD calculations.

22. Overall, in mid-2011, three-quarters of the OECD countries were exhibiting a positive gap between unemployment and the NAIRU suggesting disinflationary pressure while the unemployment was below the estimated NAIRU is the remaining countries.

Figure 6. Unemployment gap (unemployment rate - NAIRU) in mid-2011



Source: OECD calculations.

Alternative signal equation

Relative unit labour cost equations

23. For countries in the European southern periphery where the unemployment has a small impact on inflation and/or is barely significant at the 10% threshold (Italy, Ireland, Spain, Portugal), an alternative specification has been investigated.[12] These countries are also among the group of countries where the NAIRU estimation has been revised the most in the pre-crisis period. With inflation expectations anchored by the ECB target, it is possible that excessive labour demand proxied by the unemployment gap had a relatively little impact on consumer price inflation outcomes in the years prior to the crisis, but instead emerged in terms of an unsustainable increase in unit labour costs and continuous deterioration in relative competitiveness. Therefore the Phillips curve equations have been respecified with relative manufacturing unit labour costs as the dependant variable. The intuition is that a stronger influence of the unemployment gap on relative unit labour costs may give a more reliable NAIRU than when the endogenous variable in the signal equation is represented by consumer price inflation.

24. The Phillips curve has been modified into an equation considering the change in the relative unit labour costs in the manufacturing sector instead of the change in inflation as dependant variable (ULCMDR), demand pressures as reflected in the gap between the unemployment rate and the NAIRU and changes in real import and oil prices (used to control for supply shocks). Equation (2) in Box 1 was replaced by:

$$\Delta \log ULCMDR_t = \sum_{j=1}^{m} \chi_j \Delta \log ULCMDR_{t-j} + \beta(u_t - u_t^*) + \sum_{j=0}^{n} \eta_j MGS_{t-j}^{SH} (\pi_{t-j}^{MGS} - \pi_{t-j})$$
$$+ \sum_{j=0}^{l} \kappa_j OIL_{t-j}^{SH} (\pi_{t-j}^{OIL} - \pi_{t-j}) + \beta \ln(pdy / pdypot)_t + v_t \qquad (4)$$

25. While in the traditional specification consumer prices enter in second difference form (*i.e.* the first difference of inflation) to ensure that there is no trade-off in the long-term between inflation and unemployment, this constraint was not imposed in the alternative version using relative unit labour costs. A rationale for this is that if inflation rises continuously over successive years it will likely provoke some policy reaction relatively quickly, whereas in contrast historical experience suggests that relative unit labour costs can continue to deteriorate over many years or even decades without provoking a response.

26. The results obtained on the alternative specification of the signal equation using relative unit labour costs for Spain, Portugal, Ireland, and Italy show a stronger and more significant impact of the unemployment gap on relative unit labour cost for Ireland and Spain, and to a less degree for Portugal (Table 2). The NAIRUs estimated using this approach remains much lower than unemployment over the recent past confirming the large unemployment gaps in these countries. However, the evolution of structural unemployment before the crisis is affected by the change in the methodology (declining more in Ireland and Spain, and increasing less in Portugal). In the case of Italy, the new alternative signal equation created a filter convergence problem and when the model converged the unemployment gap was negative but not significant; the results are not presented here.

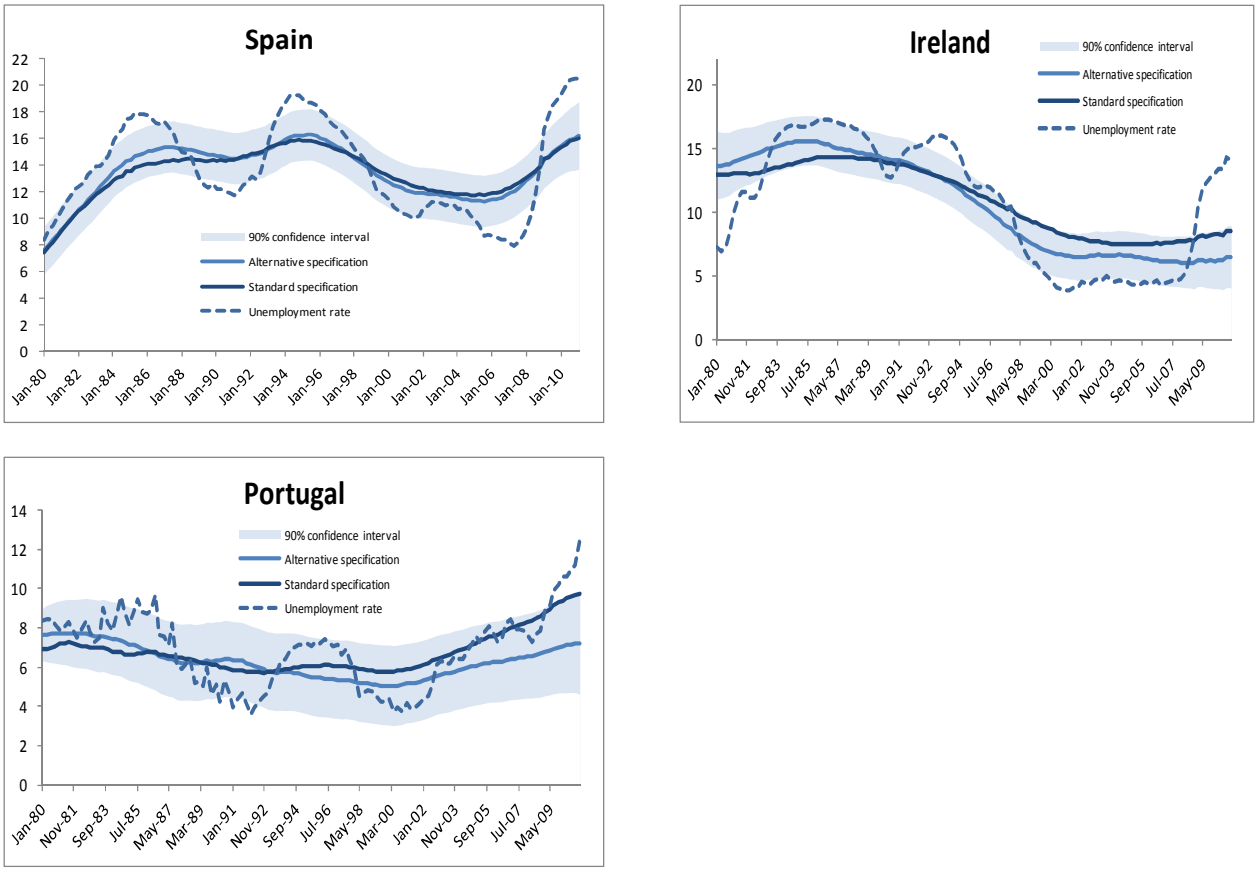
12. This was not applied to Greece due to the absence of reliable data on unit labour costs.

Table 2. Alternative signal equations for Southern European countries

	IRL		ESP		PRT	
Dependent variable ULCMDR growth	1978Q3-2011Q1		1978Q1-2011Q1		1980Q4-2011Q1	
	COEF	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*
Cst	-0.58	-2.61			0.41	2.90
$\Delta logULCMDR(-1)$	0.38	4.22	0.37	4.4	0.24	3.53
$\Delta logULCMDR(-2)$	-0.22	-2.57				
$\Delta logULCMDR(-3)$						
$\Delta logULCMDR(-4)$						
$U-U^*$	-0.16	-2.00	-0.20	-2.5	-0.22	-2.12
$\omega^m*(\pi^m(-1)-\pi(-1))$	-0.70	-2.59				
$\omega^m*(\pi^m(-4)-\pi(-4))$						
$\omega^{oil}(-1)*(\pi^{oil}(-1)-\pi(-1))$	0.33	2.15				
Sacrifice ratio	0.33		0.20		0.22	
Dummies			1986Q1		1982Q3, 1983Q3	
Adj R2	0.28		0.23		0.45	
Avg. standard deviation	1.03		1.16		1.20	

Source: OECD calculations.

Figure 7. Alternative NAIRUs for small euro area countries



Source: OECD calculations.

27. None of the gaps derived from this alternative approach has a significant impact on core inflation. Hence this alternative approach would not help forecasting directly inflation based on the measure of NAIRU. Moreover, the robustness tests show a strong sensitivity of the signal equation parameters to the estimation period. Last, data limitations make the extension to all OECD countries impossible.

Anchoring of inflation expectations on central bank target

28. For the large OECD countries, the anchoring of inflation expectations on the central bank target over recent decades in the large OECD countries was explicitly introduce by including the difference between inflation and an inflation target in the Phillips curve. This allows for the possibility that, ceteris paribus, inflation will be attracted towards the target. Such an effect would help to explain the general finding that inflation appears to be less sensitive to demand pressures than in the 1970s and 1980s, and more recently would help to explain why inflation did not fall more following the crisis despite the large rise in unemployment.

$$\Delta\pi_t = \sum_{j=1}^{m} \chi_j \Delta\pi_{t-j} + \beta(u_t - u_t^*) + \sum_{j=0}^{n} \eta_j MGS_{t-j}^{SH}(\pi_{t-j}^{MGS} - \pi_{t-j})$$
$$+ \sum_{j=0}^{l} \kappa_j OIL_{t-j}^{SH}(\pi_{t-j}^{OIL} - \pi_{t-j}) + \theta DU(\pi_{t-1} - TAR) + v_t \qquad (5)$$

where DU is a dummy taking the value zero before the time inflation expectations are usually considered as anchored on the central bank target (usually taken as starting in the mid-1990s or early 2000s) and one thereafter and TAR is the central bank inflation target.

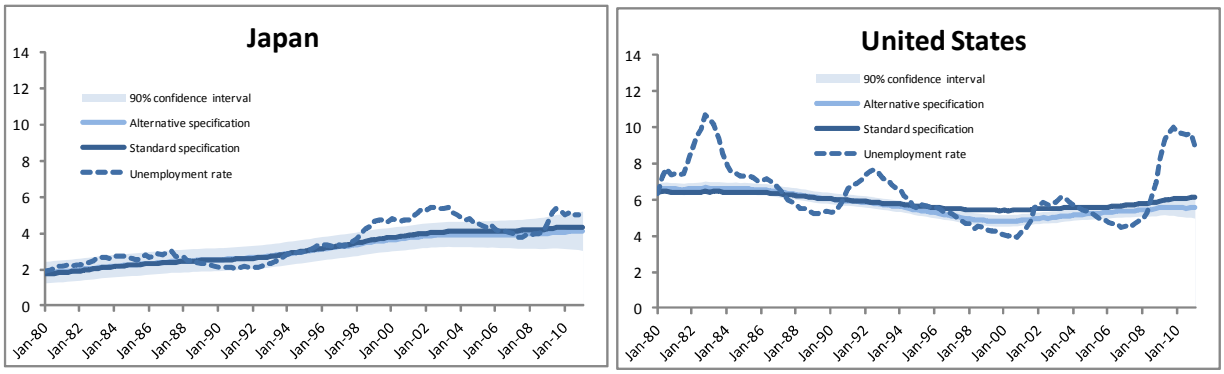
29. In the United States and Canada the target was assumed to be 2% since 1995, in Japan 1% since 1995, in the euro countries 2% since 1997 (using either domestic or euro area inflation), in the United Kingdom 2% or 2.5% on either the CPI or the retail price index from 1997. The gap between lagged inflation and the central bank target was however found significant only in the United States, Canada and to a lesser extent in Japan, but not in the United Kingdom and three large euro countries (Table 3). Moreover this only changes the profile of NAIRU noticeably for the United States and Japan where the NAIRUs appear somewhat lower since 1995 (Figure 7). This alternative specification was not extended to other countries and is not used to estimate the NAIRUs presented in this paper.

Table 3. Alternative signal equations for the large countries

	USA		JPN		CAN	
Dependent variable $\Delta\pi$	1965Q2-2011Q1		1971Q3-2011Q1		1962Q1-2011Q1	
	COEF	*T-STAT*	*COEF*	*T-STAT*	*COEF*	*T-STAT*
$\Delta\pi(-1)$	-0.43	-6.07	-0.16	-2.8	-0.41	-5.51
$\Delta\pi(-2)$	-0.26	-3.45	-0.02	-0.4	-0.3	-3.88
$\Delta\pi(-3)$	-0.19	-2.66			-0.23	-3.05
$\Delta\pi(-4)$	-0.17	-2.46			-0.35	-5.42
$U-U^*$	-0.05	-4.45	-0.11	-1.93	-0.09	-2.82
$\omega^m*(\pi^m(-1)-\pi(-1))$	0.22	2.92			0.11	1.84
$\omega^m*(\pi^m(-4)-\pi(-4))$					0.06	0.92
$\omega^{oil}(-1)*(\pi^{oil}(-1)-\pi(-1))$	0.02	1.86	0.15	1.9	0.06	3.97
$(\pi(-1)-TAR)*DU$	-0.7	-3.83	-0.39	1.69	-0.53	-3.56
Sacrifice ratio	2.56		0.67		1.59	
Dummies			1974Q1,1997Q2Q3			
Adj R2	0.28		0.70		0.40	
Avg. standard deviation	0.20		0.38		0.64	

Source: OECD calculation.

Figure 8. Alternative NAIRU estimates for Japan and the United States



Source: OECD calculation.

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